in Upper Egypt. In Lower Egypt, the summer irrigations, through *sefi* canals, permit of the cultivation of plants whose period of vegetation requires more time. Properly speaking, it is the zone of the summer cultures, the *sefi*, that embraces the space between the months of April and August, and even up to winter for cotton and rice.

When the wheat fields of Upper Egypt have been cleared for a long time, an exuberant vegetation is

their water. With the *sefi* canals the irrigation may be effected during the entire summer.

This system, saving a few new junction branches and a few sections of recent construction for obtaining more favorable water connections, consists in a large part of old and deep *nili* canals. It takes its water mostly from the Nile itself, while the *nili* system is fed by the *sefi* canals when their level is high enough.

If a wise administration cannot substitute a complete

to pass under it in a diving suit, and that the piers are suspended instead of supporting the bridge. Such as it is, the work cost, up to 1861, \$3,400,000, and the engineers demand at least \$5,400,000 to put it in a serviceable state. It remains to be seen whether steam pumps amounting to from \$5 to \$6 per year would not be cheaper.

At present, the Minister of Public Works, judging from a report of Mr. Rousseau, director-general of this service, is recommending the use of steam engines for supplying the chief *sefi* canals, instead of finishing the dam. At the very most, the minister's engineers propose to utilize the dam for distributing the river water at low tide in proper proportions between the Rosette and Damiette branches. This latter branch of the Nile is tending to give out, from year to year, and water would fail were it not for the 5 or 6 foot barriers on the west branches. Originally the dam was to raise the level of the river, at low water, 13 or 16 feet, so as to supply all the *sefi* canals of Lower Egypt. The enterprise was unfortunately unsuccessful. Mr. Rousseau estimates the annual expense necessary to put the irrigating works of Lower Egypt in a proper state, and keep them in repair, at from \$3,000,000 to \$3,200,000. Add \$340,000 for the canals of Upper Egypt, plus an annuity of 134,000 Egyptian pounds for ten years, for a system of sluices designed to replace the annual cuttings in the dikes between the inundation basins. In consideration of such expense, the gangs of fellahs for keeping the canals and dikes in repair might be diminished one-half, while the soil of Lower Egypt daily received, on an average, 50 cubic feet of water per feddan, or 58 cubic feet per acre. Consequently, all kinds of rotary cultivation in use in the country would be possible in this part of the territory, which comprises 2,803,000 feddans, or 2,354,000 acres.

Whoever knows how detrimental it is to the exploitation of a country where agriculture is its only resource, and the harvests of which depend upon irrigation, will understand that the management of the water ought to excite all the solicitude of the Egyptian government. In the later period of the Byzantine domination, and under the miserable administration of the Mamelukes, the neglect of this service reduced the harvests to half an annual average.

Formerly, and in the zone of the inundation basins, and of the *nili* canals, payments in kind and the gangs of fellahs sufficed to keep the river dikes in repair and the canals cleaned.

For the *sefi* canals and the summer and autumn sowings, it requires dredges with perfected machines. The progress of ideas and habits, which disapproves of harsh measures and a resort to beating with a club, renders the execution of the *corvee* difficult. On another hand, the physical conditions inherent to the country require enormous movements of earth in a very short space of time in order to profit by the benefits of the Nile, and to take protection against its inundations. It takes 160,000 men, half in Upper and half in Lower Egypt, to perform the necessary work in the time desired. In presence of the arbitrariness that presides over the applications of this very unequally distributed charge, Nubar Pacha, who is at present at the head of the government, and whose every effort tends to substitute legal order for arbitrary measures, is endeavoring to replace payments in kind by the work of paid contractors.

During the present year he has found a means of devoting 250,000 Egyptian pounds, or \$1,100,000, to the cleaning of the canals by way of enterprise, instead of requisition. His ambition is to sign a decree for the final abolition of compulsory labor. The time for the complete abolition of payments in kind does not as yet seem to have arrived for Egypt, but the establishment of order in the administration will permit of replacing it by redemption in silver on the day when the fellahs will be sure of no longer having to pay the same tax several times during the course of the same year.—C. Grad, in *La Nature*.

SIBLEY COLLEGE LECTURES.—1886-87.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

III.—THE SALE OF STEAM.

By CHAS. E. EMERY, Ph.D., New York City.

As a sequel to the previous lecture on the subject of "The Distribution of Steam," we will consider at this time "The Sale of Steam." This branch of the general subject requires fully as much attention from the engineer as that involved in distributing steam. The difficulties which arise in settling accounts with steam users are very largely of a technical nature. Much patience and study are required to convince a dissatisfied consumer that he has used the quantity of steam for which he is charged, even when the same has been measured by a satisfactory meter. It follows therefore that even the members of the business staff of a steam company must necessarily become familiar with the apparatus of the consumer, its peculiarities and condition, and of course with the general subject of the application and economical use of steam for all kinds of purposes.

As in the previous lecture, the subject will be frequently illustrated by reference to the work developed by the speaker for the New York Steam Company, but much of the information will be of value in the general business of an engineer, independent of the conditions incident to a steam supply system. For the first few years, the New York Steam Company necessarily sold all its steam by estimate of the quantity which would be used for particular purposes or in particular apparatus, and the experience thus gained has been of great value in explaining to consumers how the use of an abnormally large quantity of steam, as shown by an accurate meter, could be explained. It was found impracticable to supply steam at estimated prices, as a general rule, on account of the serious wastes which occurred on the premises of consumers. Porters would leave the steam on all night, so that the premises would be comfortable in the morning without coming early. Janitors would do the same thing because it was the easiest way, and in some locations because the waste heat would keep their apartments in the upper part of the building warm, without the necessity of attending to fires. They frequently also used the elevators at night. Engines operated by contract for a lump sum would be run with their drips open, would not be kept

FIG. 1.—STEAM PUMP ON THE NILE.

everywhere to be seen, thanks to the system of canals. If we are asked why the network of *sefi* canals does not extend over entire Upper Egypt, we shall answer that at low water the flow of the Nile is too small to submit the entire present region of the basins to summer culture.

These basins, moreover, are necessary, in times of high water, for regulating the flow of the water by reducing their output, and for protecting the land of Lower Egypt against accidental inundations, which are the more to be dreaded in that the slope diminishes at the approach to the sea. At the time of low water, the entire water of the river cannot be used for irrigation, both because of the needs of navigation and hygiene, and the necessity of preventing an incursion of the sea to a great distance upstream from the mouths of the Rosette and Damiette.

As for the influence of the basins of the Upper Nile upon the flow of the Nile, that is due to variations in the river shore at Cairo at the time of the filling and

system of *sefi* canals, for summer irrigation, for the inundation basins, it will be at least possible, in the interests of a more perfect method of culture, to convert the *nili* canals of Lower Egypt into *sefi* canals constantly supplied with water. The magnificent dam at the head of the delta has already improved the system of irrigation of this region by giving more water to the branch of the Damiette. Prompt in action, the grand viceroy requested the French engineer Bellefons, in 1833, to at once construct the work that he had conceived the idea of. According to his project, the dam was to keep the level of the river at the same height during the entire season, and dispense with the use of lifting machines for irrigation.

The constructing was done by Mr. Mougel, whose plan differed from that of Linant. The work consists of a double stone bridge of enormous bulk, provided with turrets and built upon piers. Between the two branches of the dam rise fortified works. This structure has an imposing appearance, as a mass of mason-

FIG. 2.—THE NILE DAM.

emptying of the basins as the water recedes. In Lower Egypt, water is not stored in basins, and the land is not inundated for winter cultivation, except over small areas. On the contrary, the region is irrigated by means of a double system of *nili* and *sefi* canals. The first of these are shallow, but wide, and receive water only at a given moment during the rising of the Nile; the second are deep enough to have water at low tide. With both, the section diminishes in measure as they discharge

ry. As a dam, it renders scarcely any other service than to bar the passage to navigation. Up to the present, the arches of the Rosette branch alone have been closed by means of girders moved by cranes. The cracks that have opened in the masonry, under the effect of the mobility of the bottom, threaten the existence of the work, or, at least, interfere with the use of it.

In places the floor is so undermined that it is possible

in order, frequently be not stopped at noon hour, or be kept at work at night. Without going into further detail, suffice it to say that the lump sum system was impracticable in a commercial sense, though the consumers were satisfied. The application of meters was absolutely necessary, and as time permitted, the development of a meter system was proceeded with. The task proved a formidable one, but was finally accomplished, as was stated in the previous lecture. It is proposed at this time to explain the meter system more fully than was possible previously, to add a description of the apparatus used for integrating the diagrams, then to set forth to such extent as is possible in the time allotted the general methods of making estimates adopted before meters were available, the applicability of some of the same to more general use, and the confirmatory results which have been obtained by the use of meters. In developing a meter system, it was first necessary to fix an appropriate unit of measurement. As the density of steam varies with its pressure, it could not be sold by the thousand cubic feet, like gas, without some system of reduction to a constant value based on the pressure actually used. Holly had proposed as a unit for heating systems one thousand cubic feet of steam at atmospheric pressure, but this was wholly inapplicable for a plant designed to furnish steam at 80 lb. pressure for operating engines as well as for heating and miscellaneous uses. It was finally decided to use as a unit the natural one employed in testing engines and boilers, viz., a pound of water evaporated into steam. Here a difficulty arose. The expression a pound of water evaporated into steam was too long for general use, and consumers were continually confusing a pound weight of steam with a pound pressure of steam, and it became necessary to give a name to the pound of water evaporated into steam which would be distinctive in connection with the business of steam supply. The company, in February, 1883, commenced selling steam at a specified price per thousand kals, explaining that the value of a kal was one pound of water evaporated into steam. The considerations which led to the adoption of this name by the writer were as follows: The true value of the steam could only be based on the quantity of heat it contained. The British thermal unit was too small, and a statement in such terms would confuse non-technical persons. Moreover, direct heat was not to be sold, but water energized by heat to form steam. A pound of water evaporated into steam was therefore the natural unit, and it was considered that its general application would be greatly increased by considering that the evaporation took place at a pressure customarily employed in the arts, and from a temperature of feed water ordinarily attainable. The scientific value of a kal was therefore fixed at one pound of water evaporated into steam at 70 pounds pressure from a temperature of 100° F. The pressure and temperature selected form the basis of a "commercial horse power" of thirty pounds of water per hour, as suggested by the writer to the Committee of the Judges which made the boiler tests at the Centennial Exhibition, and this value of a horse power has more recently been adopted by a committee of the American Society of Mechanical Engineers composed of your honored presiding officer, Messrs. Porter, Kent, the speaker, and the lamented John C. Hoadley.

The speaker cannot mention the name of him so recently deceased without diverging from the subject at hand to pay a passing tribute to his memory. This is neither the time nor place for a eulogy. His lovable nature and self-sacrificing, Christian disposition will always make his memory fresh in the minds of his friends. His life was an example to all, and furnishes some particularly applicable and ever appropriate lessons to students.

Born here in Central New York, and circumstanced so that we find him at the early age of 18 in a subordinate position in connection with the preliminary survey of the Erie Canal enlargement, and supporting a mother and six sisters, he achieved success from the first by industry and ability, and rose by customary gradations until he became a wealthy manufacturer of engines and special machinery. During all this period, every spare moment was occupied in study. He not only familiarized himself with technical works bearing on his business connection, but in middle life employed tutors and studied the classics, also to some extent modern languages. His library was large and valuable, and included a wide range of subjects, but every book was used. Yet he was sociable, found time to enter somewhat into public life and accept important public trusts. When business adversities came, his superior information enabled him to take, as you know, a leading position as a mechanical engineer.

[A photograph of Mr. Hoadley was at this point shown on the screen.]

As now we recall his appearance in the prime of life, the students here are urged to more fully appreciate their opportunities. When study seems hard, think how much harder others have studied who had to secure an education and at the same time earn a livelihood. Even after graduation, emulate the example of Mr. Hoadley, and industriously strive to increase your information, so that you may be fitted for a higher calling, and rise far above those whose only object in life appears to be to obtain a comfortable subsistence.

"Let us then be up and doing,
With a heart for any fate,
Still achieving, still pursuing,
Learn to labor and to wait."

[The photograph was allowed to fade out of sight by opening the window shutters with the hydraulic apparatus provided for the purpose.]

Engineers should learn early in life how to keep in mind several matters at once without neglecting the particular one under consideration. This needs a peculiar faculty of concentration, which seems natural to some and may be cultivated by others, so that one subject may be promptly banished from the mind as different ones are brought up, and then at will the first subject be returned to and proceeded with as readily as if no interruption had taken place.

As previously stated, a "commercial horse power" is now authoritatively considered to consist of 30 pounds of water per hour evaporated into steam at 70 pounds pressure from a temperature of 100° F. The unit of this horse power, or 1 pound of water evaporated at the pressure and temperature stated, the writer, for purposes connected with the business of the New York Steam Company, as has been explained, decided to call

one kal. The word kal of course has the same general origin as the English word caloric, used when heat was considered as matter, and the French "calorie," or thermal unit, but is made short and spelled with a k, to wit, kal, simply to make it distinctive. The excuse for, in a partial sense, coining the word arose from the necessities of the case. It has gone into general use in connection with the work of the New York Steam Company, and, curiously enough, parties who know nothing of its derivation or meaning will knowingly explain to each other "That is the way steam is sold, you know!" While it may be convenient in other operations to use the expression "a horse power of steam equals 30 kals per hour," with the various modifications which would be suggested by practice, your speaker has no intention of forcing the use of the word upon others, but states the conditions under which it has been employed, and starts it out as a waif on the cold world to take its chances under the philosophic theory of "the survival of the fittest." It will be used for brevity in connection with some of the investigations and formulæ yet to be explained, and we trust the audience will readily understand what it means.

The lowest price at which steam was at first sold was 50 cents per thousand kals. On this basis a ton of water of 2,000 pounds evaporated into steam would cost \$1, which is equivalent to selling coal at \$7 to \$8 per ton of 2,000 pounds, according as the boiler considered evaporates 7 or 8 pounds of water under actual conditions. Small consumers were charged more. At a later period, arrangements were made to burn small coal, of which a supply could be contracted a year in advance, and prices were reduced to 40 cents per thousand kals to consumers using steam amounting at that rate to \$150 or upward per month. The rate is increased as the quantity used diminishes in a graduated scale, so that when bills amount to only \$11 per month the price is 70 cents per 1,000 kals. A minimum charge, depending upon the size of the meter, and averaging about \$10 per month, is made in all cases if less charge be shown by meter.

In order to treat the subject in a connected manner, it is desirable to refer briefly to the statements and illustrations previously given in relation to meters.

Considerable investigation was necessary to perfect a meter which would answer all the conditions to be fulfilled in measuring steam. It is evident that if a displacement meter were used, its piston development would necessarily equal that of the engines supplied through it calculated to the points of cut-off. For an ordinary slide valve engine, therefore, a meter would have to be practically as large as the engine, or run at very much higher speed, subject to all the difficulties incident to so doing. A small three-cylinder engine has been developed for use where very small quantities of steam are required, it being expected to pass the steam at full pressure through the meter, and then reduce the pressure afterward, thus measuring only at the greatest density and the smallest volume. The conditions of use in the district now supplied require, however, another form yet to be described. Experiments have been made with meters of the velocimeter type, that is, in which the velocity of the current of steam is registered by a series of indices. Mr. Birdsall Holly has designed an instrument of this kind, in which a current of steam controlled by a clapper or valve, to form a jet, strikes the edges of a series of floats, like those of a paddle wheel. The speed of the paddle wheel is controlled by a resistance paddle operating in water of condensation in the bottom of the case. This meter has answered quite well in some locations with low pressure steam. It has precisely the same kind of variations as any other velocimeter. When passing small quantities of fluid, the slip is very large and the record against the supply company. When running at a medium rate of flow, it registers quite accurately, when everything is in order. When operated to the full capacity of the pipe, it is not so accurate. The difficulty with this class of meters lies in keeping the friction constant and preventing wear. The stuffing box on the spindle, necessary to carry the motion outside the case, frequently gets leaky and causes a variation in the friction. The speed of the wheel is quite high and the bearings wear down rapidly, so that it can safely be stated that the apparatus is not a desirable one except for use at comparatively low pressures and moderate velocities.

The speaker, at an early date, made up his mind that a successful meter must be based on the principle of flow through an orifice of known size and with a known loss of head or difference of pressure. Several methods of doing this were tested. In the meter finally adopted, called a "rate meter," the steam flows through rectangular openings, governed by a valve operated by a weighted piston balanced on the difference of pressure between the incoming and outgoing steam, the effect of which is that the steam flows through the orifice at a constant difference of pressure. The size of the orifice is regularly registered on a broad paper strip traversed by clockwork. The result is a diagram showing at any time in the day the quantity of steam used at that time, and the total quantity may be obtained by integrating the chart. When steam is not used, the movable pencil runs on the same line with a stationary one. The paper upon which the meter record is made is printed in divisions of half an inch, numbered from one to twenty-four consecutively, to represent the hours of the day, and in starting the paper, the proper division is set at the corresponding time. The time that steam is turned on is shown by the vertical line made by the movable pencil at the beginning of the diagram, and when it is shut off, by a similar line at the end; and evidently the periods when any particular change is made in the quantity of steam used can be determined from the meter diagrams, as well as the quantity used during the intervals.

The meters and regulating valves are placed in the pipes leading from the streets to the building, and arranged with shut-off and pass-by valves, so that any part of the apparatus may be put in order without stopping the supply of steam to the building.

It was at first considered unfortunate that a reliable meter could not be obtained, which, like a water meter, would show by differences of reading the quantity of steam used for the interval between observations directly without calculation, and without the expense of maintaining a time register at each location and of integrating the charts afterward. The system adopted, however, proved a blessing in disguise. The greatest difficulty in settling with consumers lies in the fact that

employees waste the steam. This is particularly the case during the heating season, when steam for various excuses is left on continuously during nights and Sundays, thus increasing the time of consumption from, say, 60 hours a week to 168 hours. In many cases, too, the rate of consumption keeps uniform during the night as well as during the day, so that it is an easy matter to more than double the bills. The consumers at first naturally attributed the blame to the steam of the steam company, but the meter charts have been the means of enabling the company to satisfy consumers when, and to what extent, the increased bills were due to mismanagement on their premises.

The integration of the several thousand feet of meter diagrams accruing every month involved, however, serious labor, and it was seen that some special apparatus was desirable to facilitate the work. The use of the ordinary planimeter saved considerable time in the integrations as compared with any method of measurement by means of ordinates, and the attention of the writer was directed to designing special planimeters and accompanying apparatus, which would enable the work to be performed still more rapidly. Some difficulties which had been experienced with one of the original Amster instruments, and an erroneous statement in regard to the principles of the device, published in a circular shortly after the instrument was introduced, led the writer to undertake a new investigation of the principles involved in the operation of the instrument, which investigation was published, under the title of "The Polar Planimeter," in Vol. VI., Trans. Am. Soc. Mech. Engrs. Previous investigations in the same direction were not lacking, but the writers treated the subject generally as a mathematical problem or puzzle, without formulating practical rules to enable the instrument to be properly constructed or adjusted when out of order.

It is believed that it will be of interest here to reproduce for reference a summary of the governing proportions and general principles which affect the action of the instrument.

All polar planimeters are provided at one end of the main arm with a "tracing point," at the other end with a joint, guided either in a groove or by a radius arm, which joint we will call the "hinge," and there is pivoted in bearings on the arm a "recording wheel," which is usually placed between the tracer and hinge or in the line of the two, beyond the latter.

It can readily be shown:

1. That if the "hinge" end of the arm be permitted to move in a fixed path in any direction, it is necessary only that it be returned by the same path; that is, the "hinge" end may be guided either by a radius arm or by a groove either straight or curved.

2. When the angle of the main arm is changed less than 360°, and the tracer is moved backward to the original position, the axis of the roller should be parallel to a line connecting the tracing point and hinge, and the only proportions affecting the result are the length of main arm between tracer and hinge and the diameter of the recording wheel. If N = length of main arm from tracer to hinge, D = diameter of recording wheel, and J = number of divisions on the wheel, each representing a unit of area,

$$(a) ND = \frac{J}{\pi}$$

or when $J = 10$, as is customary,

$$(b) D = \frac{3.183}{N}$$

$$(c) N = \frac{3.183}{D}$$

3. When one end of the main arm is guided by a polar arm, and the fixed point or pole is located within the figure to be measured, it is essential that the tracer, the hinge, and the axis of the wheel be constructed in the same straight line, and there is to be added to the area indicated a quantity constant for the particular proportions of the instrument. If N = length of main arm from tracer to hinge, as before, R = the distance of bearing point of recording wheel from hinge, P = the length of the polar arm, and A = the area to be added,

$$(d) A = \pi (P^2 + N^2 \pm 2NR).$$

The minus sign before the last term in parentheses applies when the tracer and wheel are both constructed on the same side of hinge, and the plus sign when they are on opposite sides.

In designing special apparatus for integrating the meter charts above referred to, the shape of the planimeter was adapted to the work, and the hinge end guided in a groove in the edge of a steel rule mounted on a special table provided with devices to depress or elevate the rule and clamp or release the diagram paper as desired.

Formula (a) above shows that the product of the length of the main arm by the diameter of the recording wheel is a constant quantity; and as the diagrams to be integrated were less than 3 inches wide, by reducing the length of the arm between the tracing point and hinge to 4 inches, the proper size of the recording wheel was increased nearly to 0.8 of an inch (exactly 0.79575 inch), which is much greater than in ordinary planimeters, and enabled the scale on the attached wheel to be plainly read. The recording wheel was placed well at one side of the arm, so as to be at all times on the paper and to give three points of bearing for the planimeter, so that it would rest securely. On the axle of the recording wheel is a worm, which operates a worm wheel to move a separate pointer with 1-10 of the velocity of the recording wheel. The handle over the tracing point is swiveled to facilitate its manipulation. It will be observed that the whole planimeter is, when in use, at the right, or under the right hand of the operator, so that the light upon the diagram comes freely to the tracing point without shadow from the hand. The stud forming the hinged end of the planimeter is kept down by a weight, as is customary.

The ruler described sets loosely over two guide points. The front edge is beveled. Just back of edge is a groove, parallel therewith, to guide the hinge end of the planimeter. This groove is made of V section or hemispherical, with the bottom removed to receive the hemispherical end of the stud, forming the hinge end of the planimeter arm. This form of the stud and groove

enables universal motion about the point, either sliding or revolving, when the planimeter is in use and when lifting the planimeter wheel from the paper. The ruler is provided with rear arms, which merely touch the board to steady the ruler as it is raised. On the front edge of the ruler there are also three arms, the inner edges of two of which form guides for the tracing point of planimeter at the extreme limits of its motion. The distance between these edges is made 21 inches, corresponding to 42 hours, so that the instrument has to be applied but four times for one week's record.

One of the arms limiting the motion is made short, so that the recording wheel will pass it when the tracing point is sliding along the edge of the main ruler. The ruler is extended to the right a distance equal to the length of planimeter, and when the latter is not in use, the tracing point is lifted and carried back to a prick punch mark, during which operation the recording wheel rolls upon the third projecting arm of the ruler, which is made with a thin edge, when all three bearing points of the planimeter being upon the ruler, the whole instrument may be lifted with it. The operation of lifting the ruler is performed by arms upon a rock shaft operated by a lever, which passes suitable notches in a stationary arc. Upon the same rock shaft springs are provided, which, when the lever is depressed, bear upon the ruler, and clamp the paper in position. When the lever is in mid position, the paper may be moved longitudinally freely. In operation the ruler and instrument are lifted together, the diagram paper introduced under the ruler, the lifting lever of ruler put in mid position, in which case simply the right of the ruler rests upon the paper, and the latter adjusted so that the base line coincides with the edge of the ruler. The lifting lever is then depressed so that the springs clamp the ruler on paper, the tracing point of the planimeter placed at the beginning of the diagram, the recording wheel turned to zero, the outline of the diagram traced, and the tracing point returned along the base line to the place of beginning. The result is the area of the diagram in square inches. The ruler is graduated to inches and tenths, so that the length of the diagram may be read off, when the mean height may be obtained by dividing the area by the height. Generally, it will answer when diagrams are about the same average height to sum the areas of the diagrams in one column and the lengths in another, and divide the sum of the former by the sum of the latter. When there are a series of short diagrams, they may all be summed together, by running around the first one of the ruler, passing along the latter to the second, and so on, and returning finally to the place of beginning, along the edge of the ruler. The result will give the sums of the areas.

The ruler may readily be lifted off the pins and laid on any drawing, and used to guide the planimeter to measure an irregular surface on such drawing. In this case, if the surface be a large one, it can be measured in a series of belts, each within the capacity of the instrument. The outlines of the belts can be conveniently distinguished by pencil lines and a ruler laid against the one in advance, to guide the tracer accurately, and upon completing the circuit the guide ruler itself may be moved forward to the next boundary. In instruments designed for general use, the ruler may be made of any convenient length, and of course all the lateral arms would be omitted.

The preliminary investigations made by the writer as to the principles of the instrument enabled him to design the apparatus above described complete and ask for prices for its construction, from drawings and descriptive specifications, as confidently as if the work was of an established character. Three of the instruments complete have been made in accordance with the drawings by the Ashcroft Mfg. Co., of Boston, Mass., for the N. Y. Steam Co., and all operated from the first correctly and satisfactorily, saving for the particular work named more than one-half the time required with ordinary planimeters.

[The lecturer then described a watchman's telltale system, in which a valve in the pipe leading to the consumer was connected electrically with a watchman's box on the exterior of the building. The watchman, being provided with a suitable recording apparatus on his person, visited the several boxes in succession, and by sending an electrical impulse from a portable battery through the watchman's box into the valve, received in turn a record which could be interpreted at the office to show whether or not the valve was open. This apparatus was used while suitable meters were being devised and perfected.]

The general methods adopted by the New York Steam Company for making estimates before the meter system was adopted will be found applicable and useful under other conditions, and their value is increased by the fact that the results have been checked by meter measurements. The subject includes, naturally, means for ascertaining the quantity of steam required to heat buildings of various kinds, with different degrees of exposure, under varying management; the quantity required to operate engines of various sizes of different types used for a great variety of purposes under greatly differing conditions; and the quantity required for the very numerous mechanical and culinary operations for which steam is employed in a large city. Steam is used for boiling water for numerous purposes, for "dry rooms" to dry clothing and articles of diet, and even to ripen fruit; also for heating steam tables for the bookbinder, printer, and gilder; also to melt wax, to heat chemicals, candy, and even soap, etc., etc.

The quantity of heat required to heat a certain building depends principally upon the difference of temperature between the inside and outside of the building, the quantity of air actually heated for ventilation, and the nature and extent of the external exposure. The temperature of course varies at different parts of the season. The average temperature at different locations also varies, but may be found set forth in works on heating and ventilation. In Box on Heating will be found elaborate rules for calculating the quantity of heat required to heat a building, based on the number of square feet of glass exposed, the thickness, kind of material, and superficial area of the walls, and the kind of material and superficial area of the roof. The various areas are severally to be multiplied by numbers obtained by experiments on a small scale, representing the thermal conductivity of the particular materials for each degree difference in temperature, and a summation of the mass of arithme-

tical calculations, it is supposed, will give the desired result. Such calculations are not usually employed in practice, for the reason that the allowances to be made by judgment for wastes, due to differences of condition and management, are so large that, practically, it answers in most cases as well to substitute experienced judgment for a mass of detailed figures in the first place, and use the pipe fitter's simple method of proportioning the heating surface and boiler power to the capacity of the rooms to be heated, varying the multipliers to suit the variations in exposure and the different conditions under which different buildings or particular rooms are used. Of course, the capacity, separately considered, has nothing to do with the result; for after a building is once heated, if the inclosing walls were absolutely air tight and heat proof, the quantity of heat required, either for a large or small building, would be zero. The losses are those incident to the leaks around the windows and doors, the radiation through the windows and walls, and the quantity of air heated for ventilation; but the number of windows and doors, as well as the condition of the same, is practically the same for buildings of the same size used for similar purposes, and the quantity of ventilation which is demanded for comfort is practically the same for buildings occupied in the same way, so that the rough and ready rule answers the purpose generally. It has been found that the quantity of steam used in buildings of exactly the same type and dimensions, with similar exposure, varies very materially on account of differences of management, so, to give satisfaction, the apparatus must be made in excess of ordinary requirements. The business is one requiring, continually, the exercise of good judgment based on experience. The student necessarily lacks the experience, and should educate his judgment by elaborate detailed calculations, like those required by the methods set forth in Box, previously referred to; compare the results obtained with those shown by accessible heating plants, and search for the causes of any discrepancies. This work will be valuable even if one expects to go through a course of practical training, for there are some problems, particularly those relative to heating large public buildings, or any structure of an unusual type, to which the only safe way is to apply elaborate calculations, to secure certainty of result with a reasonable expenditure.

The quantity of steam required to heat buildings of various types, under actual conditions, is shown by the following examples, from the books of the New York Steam Company:

BUILDING EXPOSED ON ALL SIDES.

Case I.—New York court-house and post-office. Very large building, occupying triangular lot, exposed on all sides, large plate-glass windows. Material, stone and iron. Space heated, 5,500,000 cubic feet. Heat used from October 1 to May 30, and used on portions of building continuously. Pressure employed, 4 to 5 pounds in mild, 10 pounds in extreme weather. Kals per season, per thousand cubic feet, 5,120.

This building represents very nearly maximum exposure. Still, the quantity of steam used is much less than in other buildings, on account of its size. In large buildings a great quantity of heat is required on the side toward the wind, but this heat is blown through and assists in warming the remainder of the building. The effect of size will be noticed in some of the other samples here presented.

CORNER EXPOSURE.

Case II.—Building on southwest corner of Broadway and a side street, large windows. Material, iron. Space heated, 227,248 cubic feet. Heat used from October 15 to May 15. Steam for heat used about 120 hours per week in December, January, February, and March. Pressure employed, 30 to 45 pounds. Kals per season, per thousand cubic feet, 11,440.

Case III.—Building on northeast corner of Broadway and a side street, stone and brick front, large plate-glass windows. Space heated, 613,000 cubic feet. Heat used from October 15 to May 15. In extreme weather, heat used continuously. Three small radiators in halls, kept on continuously during heating season. Pressure employed, from 6 to 12 pounds. Kals per season, per thousand cubic feet, 7,440.

Case IV.—Large building, northwest corner of Broadway and a side street, small windows. Material, stone and brick. Space heated, 352,452 cubic feet. Heat used from October 15 to May 15, and never out of hours. Pressure employed, 5 to 25 pounds. Kals per season, per thousand cubic feet, 6,900.

Case V.—Building on southwest corner of Wall and a side street, stone front on Wall Street, brick on the side. Small plate-glass windows. Space heated, 97,000 cubic feet. Heat used from October 15 to May 15. No heat used out of hours, even in extreme weather. Pressure employed, 25 pounds. Kals per season, per thousand cubic feet, 3,600.

Case VI.—Building on northeast corner of two medium width streets, small windows, material stone and brick. Space heated, 186,114 cubic feet. Heat used from October 1 to May 30, and occasionally out of hours in extreme weather. Pressure employed from 10 to 30 pounds. Kals per season, per thousand cubic feet, 6,410.

BUILDINGS PARTIALLY PROTECTED BY OTHERS.

Case VII.—Building on west side of Nassau Street. Medium windows, material stone and brick. Space heated, 279,188 cubic feet. Heat used from October 15 to May 1, and kept on continuously for January and February on a portion of the building. Pressure employed, 17 to 23 pounds. Kals per season, per thousand cubic feet, 8,830.

Case VIII.—Large building, forming an L from the east side of Broadway around to south side of a narrow side street. Large windows on the wide street side; material iron. Space heated, 290,435 cubic feet. Heat used from October 15 to June 15, and seldom out of hours. Steam pressure, 6 to 15 pounds. Kals per season, per thousand cubic feet, 8,620.

Case IX.—Building in about the middle of the block, on the south side of Wall Street. Marble front, medium size plate-glass windows. Space heated, 156,840 cubic feet. Heat used from about November 1 to April 30. No heat used out of hours, even in extreme weather. Pressure employed, 20 pounds. Kals per season, per thousand cubic feet, 4,520.

Case X.—Building in block on the west side of Broadway. Medium windows, material stone and brick. Space heated, 251,078 cubic feet. Heat used from

October 15 to May 15, and never out of hours. Great care is taken in this building to save steam, radiators being shut off when not needed, and at times during the season when the weather permits shut off altogether. Pressure employed, 15 pounds.

This may be taken as a minimum, and shows effect of careful and intelligent handling.

Kals per season, per thousand cubic feet, 2,560.

It will be observed that some of the buildings in the middle of the blocks require more heat than corner buildings, and that the variations between buildings not differing greatly in description are considerable. This is explained by the condition of the building, by the greater or less efficiency of the heating apparatus, but to a greater extent by the management. It is frequently necessary to overheat large portions of a building to get some particular part of it comfortable, or the same thing may occur because the tenant in one room requires more heat than those in others, and under practical conditions, on account of size of radiators and cost of management, it is necessary to keep all the rooms nearly as warm as one.

The estimates made by the New York Steam Company as to the cost of heating buildings by gross sum were based on the simple capacity rule. The prices varied from \$2.50 to \$4.50 per thousand cubic feet of space heated throughout the season requiring heat. The lower price applied to buildings well sheltered from the wind and heated by direct radiation from coils in the rooms to be heated. The price was increased by judgment based on greater wall and window exposure, the system of ventilation, etc. The prices for corner buildings were necessarily high.

The average length of the heating season in the city of New York is considered to be 200 days. The examples given show that the average quantity of steam required by meter during the entire season to heat buildings very well protected, and in which steam is used economically, is 3,600 kals per 1,000 cubic feet of space, but other buildings, where no difference can be observed as to style or use, require as much as 4,600 kals.

Exposed buildings and those where steam is used carelessly require as much as 11,400 kals per 1,000 feet of space heated. For business buildings of say 110,000 cubic feet capacity or over, the price by sliding scale would be 40 cents per 1,000 kals. The cost for heating at meter prices varies, therefore, from \$1.44 to \$4.56 per season per 1,000 cubic feet of space, to compare with \$2.50 to \$4.50 as per original estimates. The \$2.50 rate was, however, none too high in practice, on account of the wastes which occurred before meters were applied. In higher latitudes these figures would be insufficient. Well protected buildings economically managed can be heated at even less than \$1.44 per thousand feet of space. In one exceptional case, a building is supplied by meter at the rate of only \$1.05 per thousand cubic feet capacity.

It will be of interest to compare the results above obtained with those derived by other methods. For instance, it is customary to estimate the size of boilers for heating buildings on the basis that one horse power will heat from 10,000 to 20,000 cubic feet of space. While this involves the vexed question of the number of pounds of water which constitute a horse power, it is safe to say that, on the average, large heating boilers will not furnish less than 44,000 kals per hour per rated horse power. This is based on 30 lb. of water per horse power, with one-third surplus and 1100 thermal units per pound. If, then, 10,000 cubic feet of space be heated per horse power, each thousand requires evidently 4.4 kals per hour, or half as much when 20,000 cubic feet are heated. If we suppose that 10,000 cubic feet of space is heated for one horse power during 10 hours per day for 50 days of the year, and that the same space is heated for the other 150 days of the heating season with one-half horse power, or at the rate of 20,000 cubic feet per horse power, the amount of steam required per thousand feet for the season would be 5,000 kals, which, at the rate of 40 cents, would cost \$2.00, which corresponds well with the amount shown by the meters in the business buildings of New York.

Similarly, we may examine the results obtained by using the heating surface as the basis of calculation. As previously stated, steam fitters, by judgment, proportion the quantity of heating surface required to heat rooms according to their exposure, their uses, etc. Interior rooms with small exposure to outside air may be heated with one square foot of heating surface for 200 cubic feet of space, or 1 to 200. Rooms ordinarily exposed, for 1 to 100. Very exposed rooms require 1 to 40 or 50. The latter proportions are probably fully required in many of the rooms of the buildings on this exposed hill, particularly as both the elevation and latitude are higher than at New York city. In the lecture rooms here, where many assemble and the temperature is not kept high, I am informed that a lower proportion is found to answer. It is well known that the heat can be shut off churches and halls when the audience assembles, provided the air and walls have been previously heated, as the natural escape of heat from the persons in the assembly will fully keep up the temperature, and the heat from the lights at night generally makes the room too warm. The proportions given are for direct radiation. When indirect radiation is used, the surface must be increased, as considerable ventilation is needed to insure circulation of air over the coils, and the latter are obliged to continuously heat fresh air. In the direct system, the direct air is usually admitted by leakages of windows and doors only, and in comparatively small quantities. The greater part of the heat is simply transferred by direct radiation and by circulation of the air from the coils to the cooler parts of the room. The value of each square foot of heating surface depends upon the difference in temperature between such surface and the surrounding air, and also upon the quantity of air circulated over the surface. The natural circulation as it may be called, or that produced by the presence of direct radiators in a closed room, produces a condensation of from $\frac{1}{8}$ to $\frac{1}{4}$ of a pound of water per square foot of radiating surface per hour—the variations being due to differences in the temperature of the room, in the facility with which the air circulates over the surface, and, to some extent, the type of radiator employed. Mr. Barrus has obtained a condensation of $\frac{1}{8}$ to $\frac{1}{4}$ pound with steam at 9 pounds pressure and the low temperature of 51 degrees in the room. Mr. Baldwin has obtained $\frac{1}{4}$ pound with air circulating freely over indirect radiators. The speaker generally estimates that ordinarily $\frac{1}{8}$ of a pound of water is condensed per square foot of

radiating surface per hour, which is equivalent to the transmission of 5 thermal units per hour for each degree Fahrenheit in temperature between steam at about 20 pounds pressure and a room temperature of 70 degrees. The experiments of Mr. Chas. B., now Prof. Richards showed a transmission of $1\frac{1}{2}$ to $4\frac{1}{2}$ thermal units per hour per square foot of heating surface, according to the number of cubic feet of air circulated over the surfaces. He, as well as others, has found that pins or projections from the heating surfaces are as efficient as the metal in direct contact with the steam. This involves the same principle as that stated by Rankine, that the resistance of the metal plates of a boiler is so small compared with that of transmission to and from the surrounding fluids that it can be neglected in practice. Assuming that ordinary rooms require about 1 foot of direct radiating surface to each 80 cubic feet of space, 1,000 cubic feet would require $12\frac{1}{2}$ square feet of surface, which, at the rate of $\frac{1}{10}$ of a pound of water per square foot per hour, would condense 2.5 pounds of water per hour, or 5,000 kals per business heating year of 2,000 hours, or about the quantity shown to be actually required by meter for exposed building, and nearly 50 per cent. in excess of that required for well protected buildings. The radiators need to have surplus capacity in order to heat up the rooms promptly when steam is turned on, but a portion of them can be shut off after the temperature is established.

Theoretically there is little difference in economy between using high or low pressure steam for heating. As is well known, the number of thermal units available from high pressure steam is but a trifle greater than from low. For instance, the total heat in steam at 60 pounds pressure, reckoned above 70 degrees Fahrenheit, is only 28 thermal units, or $2\frac{1}{2}$ per cent. greater than the total heat in steam of atmospheric pressure. It is far preferable to use steam at low pressure for heating, for many reasons. Practically there is less loss from leakage, there is less danger from fire, the apparatus is much safer, and, moreover, the rooms are much more comfortable and more healthy. It is frequently stated that the high pressure steam burns the air. This is merely an incorrect expression of a physical impression that something is burning. It is really the organic particles floating in the air that come into contact with the hot steam radiators and give offense. This is not observed nearly as much when the steam pressure is low. Very much of the oppressive feeling due to steam heat is lack of moisture, which may be supplied by opening small pet cocks provided for the purpose and letting a small quantity of steam escape into the room.

In this connection it is well to call the attention of those who are not familiar with the subject to the fact that the only practical way to regulate the heat from steam radiators is to shut off progressively portions of the radiating surface. Small changes may be made by varying the steam pressure, but they will have little influence with low pressure heating apparatus. The temperature of steam at atmospheric pressure is 212° ; at 20 pounds it is only 259° , so the range of temperature above 70° is 142° and 189° in the two cases respectively. If the higher temperature were required to first bring the temperature of the room to 70° in cold weather, the lower one would be too high most of the time, so the necessity of shutting off some of the radiators would become evident. In fitting up a building cheaply, the radiators are frequently made too large. It is better to increase the first cost a little and use more small radiators, which can be shut off progressively as less heat is required. Some establishments construct a radiator so that different portions of it may be shut off separately. It is necessary also for economy to separate the heating systems of the portions of a building which require heat at unusual hours from the general heating system. In many cases it is not possible to keep steam on a particular room which is heated nearly all the time without heating up the main connecting pipes throughout a large portion of the entire building, and the heating surface in these pipes forms so large a proportion of the total heating surface that, practically, the cost of heating a single room becomes a large proportion of that required to heat the whole building.

Estimates of the quantity of steam required for culinary, manufacturing, and other miscellaneous uses involve in some cases great difficulties. To be sure, it is possible even in furnishing heat for such peculiar work as melting wax to ascertain the specific heat of the wax, and from the number of pounds of wax melted obtain the number of thermal units used, but the fact is that the apparatus employed for the purpose would radiate into the rooms as much, if not more, heat than that required for the work done. The probable loss of heat from steam tables has been ascertained by measuring all the heating surfaces and multiplying it by the largest factor previously referred to, without reference to the meats in place on such tables, but, though it was at the best intelligent guesswork, it proved satisfactory in many cases.

The number of thermal units required to heat water say from 60° to the boiling point is easily calculated, when the number of pounds of water heated is known. The water requires 212, less 60, equals 152 thermal units per pound. Steam of 80 pounds pressure will yield, when condensed and cooled to 212° , 969 thermal units per pound. So one pound of steam will heat $(969 + 152) = 1121$ pounds of water. For safety the rule is based on 6 pounds, and is as follows: Number of kals = number of gallons $\times 1\frac{1}{2}$ = number of pounds $\times \frac{1}{4}$ nearly.

The quantity of steam passing through open steam jets discharging against atmospheric pressure was calculated from the following:

If d = diameter of jet, and k , the kals per hour,

For 15 pounds pressure $k = 1,216 d^2$.

For 45 pounds pressure $k = 1,804 d^2$.

For 60 pounds pressure $k = 1,978 d^2$.

Instructions are given to calculate for pressure of 60 pounds except when jet is supplied from the pipes of a low pressure heating system, or when the full opening of the valve would drive employees from the room.

Many calculations as to quantity of steam required for miscellaneous uses were necessarily approximate, and often the results were so uncertain that the use of meters seemed imperative. For instance, many dry rooms were supplied with steam, and, as air was necessarily admitted to become heated and carry off the moisture, the coils were practically indirect radiators, acting under the conditions of rapid circulation previously referred to. If this circulation were continued only long enough to dry the clothes, it would be possible to cal-

culate with some degree of approximation the weight of water boiled off from the number of pieces regularly passing through the laundry, but practically in dry rooms the heat is rarely shut off, so that the greatest possible condensation due to the surface is generally employed. In all these cases, when estimates were made for what was supposed to be average use, it soon became evident that the steam was used freely without any idea of economy, emphasizing the necessity of meters as stated.

The methods adopted for estimating the quantity of steam used by steam engines were developed after considerable study, and gave agreeably satisfactory results in many cases, failing generally only when engines were out of order. It is thought that this branch of the subject will be of special interest, on account of its applicability in other cases, to enable some of you to make estimates of the cost of operating engines practically, by quick methods, giving closely approximate results.

In preparing this branch of the subject for your consideration, it was found to cover too much ground for presentation at this time. The formulae used for making estimates for the New York Steam Company are accessible in a paper by the speaker in the Proceedings of the American Society of Mechanical Engineers, but they were prepared hastily and under great pressure, and a reconsideration indicates that some of them can be materially improved. A presentation of the methods adopted in their development in connection with an analysis of comprehensive experiments to determine economical conditions in the use of steam will, it is believed, be found instructive, and the occasion furnish the necessary pressure on the speaker to consider the subject in a way he has had in view for many years. At this time he can only thank you for your attention; and realizing that the details discussed may have been uninteresting to many, and akin to hard study to those receiving instruction here, it has been thought best to close with a change of thought and scene. Your lecture systems are calculated to bring you in contact with those in varied pursuits in different parts of the country. The speaker has tendered thoughts and experiences arising from his principal business occupation, and would turn to his moments of relaxation, and present a familiar but ever exhilarating view in the harbor of New York, which he trusts you will find as pleasing as the sight of your hills, lakes, and vales to those who have made the not uncomfortable pilgrimage here from that ever busy metropolis.

[A photographic view of the Fall River steamer Pilgrim steaming up the East River, New York, was here shown on the screen.]

[JOURNAL OF GAS LIGHTING.]

THE IMPERIAL STANDARD PHOTOMETER.

I INCLOSE a drawing of a newly arranged photometer which I have designed and constructed. This, after

THE IMPERIAL STANDARD PHOTOMETER.

certain alterations ordered by the gas referees, has been so far approved that it has been fixed; and they have certified it for official use at the testing station on the Gas and Coke Company's district, in Millbank Street, Westminster. They have also directed that another, precisely similar, shall be fixed at the new testing station on the South Metropolitan Company's district, in Blackfriars Road. This photometer is complete in itself; and, like the well known Evans photometer, does not require that the room in which it is fixed shall be entirely dark, as with the Letheby and other photometers of that kind.

The gas to be verified as to its illuminating power, and the candles used for the purpose, are burnt each in one or two square chambers or towers. These towers are so arranged that the heat of the flames of the gas in one, and of the candles in the other, induces a large volume of fresh air to ascend through them, carrying off with it heat and products of combustion together, and projecting them out into the room through a gathering cone and funnel, which covers the whole area of the top. In order that this large supply of fresh air may flow in such a tranquil stream as not in any way to disturb or shake the flames of either candles or gas, it is taken from over the entire area of the bottom of the tower through a fine plate of perforated zinc. By this arrangement the currents of air in the testing room, caused by open windows or doors, or the movements of the operator near the photometer, are prevented from exercising any prejudicial influence upon the flames which are compared. They remain always rigid and still, as if they were cut out of paper, and can be aligned with the greatest ease and accuracy; while at the same time a more perfect change of air is secured than would be the case if they were allowed to burn in the open room without the surrounding chambers. The advantages of this arrangement will be es-

pecially appreciated in hot climates, and even in this country in summer weather.

The towers, standing on a bench, are separated from each other by the length of a graduated bar, made of white varnished pine (cut lengthwise of the grain), on which the calculated divisions of a 60 inch photometer scale are inscribed. One of the extremities of this scale is immediately under the center of the standard burner, and the other directly under a line drawn across and at right angles with the bar, cutting the centers of the flames of the two candles. Exactly parallel to this, the graduated bar, but nearer the top of the towers, two other bars, also of dry white varnished pine, are fixed, one at the back and the other in front of the graduated bar. These serve to carry plumb-lines, which mark the exact position to be occupied by the gas flame at one end, and the candle flames at the other, during an observation.

The standard in one tower on which the gas burner is placed is rigidly fixed. The candle balance, placed astride the end of the graduated bar in the other, is provided with an adjusting screw, enabling the operator to slide it backward and forward sufficiently to bring the center of the flames always exactly 30 inches from the center of the bar, and thus to correct their tendency to get out of this, their true position by the natural turning of the wicks as they burn.

The sighting disk, with its mirrors fixed to it, is pivoted in a metal frame sliding in a metal groove at right angles with and across the photometer bar, so that it can be easily drawn out and replaced when required. In addition to this, the disk and mirrors can be easily turned on their pivots, so as to bring the face of the disk looking toward the gas flame in an exactly similar position with respect to the candles, and thereby enable the operator to correct any variation in the readings of the observed illuminating power due to any difference there may be in the two sides of the disk. The disk thus arranged astride the photometer bar is inclosed by, and forms part of, a chamber; the whole forming the sighting box, as in the Letheby photometer. This sighting box is made to be moved smoothly, and by very small degrees if required, nearer to or further from the candle end of the photometer. This is done by means of a handle fixed on an arbor carrying a pinion, working into a larger wheel, fixed on to one end of a shaft, which drives an endless band attached to the disk chamber. The direct rays from both gas and candles on their way to the disk pass through openings in the corresponding ends of the disk chamber, of such size as to prevent any reflected rays from reaching the disk.

A curtain suspended from a canopy fixed over the head of the operator prevents the general light in the photometer room from interfering with that received on the disk from the gas and candles in the photometer. The scale of the photometer bar is so placed with respect to the sighting box that the readings cannot be seen by the operator while he is bringing the

disk into the position in which he considers the volume of light illuminating it to be equal on both sides; but as soon as he has formed his judgment, he can instantly illuminate the scale by opening a small door in the side of the gas tower nearest the disk. A small mirror fixed within the tower, at a proper angle with the gas flame, projects a ray of light on another movable mirror under the control of the observer. This enables him to direct the beam on to the scale, and also to obtain sufficient light if he desires to record the observation just made without leaving his place.

This photometer is intended to include in itself the improvements which the experience of the last ten or twelve years' practical working in the testing stations under the control of the London gas referees, as well as those in foreign countries and the colonies, have shown to be such. Great attention has been continuously paid to the various points of detail in practical photometry by the gas referees and the different parties to the supply of gas in this and other countries; and defects have been pointed out which I believe are all remedied in this, the latest, instrument. Thus the photometer which I have the honor of placing before the readers of the *Journal* is the outcome of directions given to me by the gas referees, together with suggestions of requirements received from other authorities in almost all parts of the globe, wrought out in the form you have before you. It is on its trial.

Vincent Works, Westminster, S.W., Nov. 15, 1886.

PROF. ORDWAY recommends that water pipes exposed to freezing be covered with glazed cotton batting. It is easily applied, and should be put on to the thickness of one to three inches, according to exposure, being wound around loosely with twine.