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MACHINES FOR WORKING STONE.

In the following article, we propose to give a summary study of the apparatus used for working stone, under nine sections, viz., tools of the stone cutter; machines for sawing stone; machines for rendering the surfaces plane; machines for making mouldings; polishing machines; stone lathes; machines for crushing stones and making sand; comparison between machine work and manual labor; general observations on the operation of machines for working stone.

MACHINES OF THE STONE CUTTER.

The first operation to be performed upon a block is that of squaring. The tool used for this purpose is the pick hammer—a large hammer with a head square at one end and pointed at the other. This operation, called scabbling, gives square, rough-hewn blocks.

When less imperfect surfaces are desired, the work is executed with a hammer or ax having a square head for hard stones and a cutting edge for soft ones. After this comes dressing, the object of which is to render the surfaces plane. This operation is performed with a coarse or fine pick, according to the degree of perfection that it is desired to obtain. When it is desirable to dress the surfaces still more perfectly, recourse is had to bushing. The bush hammer is a tool with two square heads provided with a large number of projecting points, with which the surface of the stone is struck at right angles, so as to slowly remove all roughness. Bushing is adapted to hard stones only. For working stones of medium hardness, a hammer having two toothed cutting edges, or one toothed cutting edge and one rectilinear one, is often substituted. After the stone has been scabbled or rough-hewn, it is given its final evenness with a toothed scraper.

After the stone has been thus prepared, its apparent faces are usually provided with a border formed with a chisel and mallet. This plane and quasi-polished border brings into relief the granular character of the surface that it surrounds.

MACHINES FOR SAWING STONE.

Sawing is applied to soft stones in order to form them into blocks of proper dimensions more economically than can be done by the usual processes of squaring. Sawing is adapted to hard stones when it is desired to be saving of them, or to cut them into thin slabs, as is done with marble. The operation has the advantage of better preparing the surfaces for polishing than can be done by the usual dressing.

Hand Saws.—Two saws are in use, one with teeth, for soft stones, and the other with a simple blade, for hard ones. The first acts like the wood saw, while the second acts by friction and wear, like a grinding machine. The hand saw is maneuvered by two workmen, who act by traction, the weight of the apparatus counting for nothing, and even interfering with the operation.

The saw for hard stones is a blade of iron to which two workmen give a backward and forward motion. The tool acts by friction, *i. e.*, by its own weight, and it is advantageous to increase the latter as much as the muscular strength of the workmen will allow of.

The groove for receiving the blade is started by a hand saw, and from time to time the workman introduces into it some sand and water. The object of the water is to prevent the blade from getting hot, as well as to assist in disintegrating the stone. For soft and middlingly hard stones, coarse sand answers, but hard ones require a fine silicious sand, well washed and freed from all foreign matter.

When the stones are to be polished, it is well to use fine sand, since the work will thereby be much facilitated.

Mechanical Saws.—The to and fro motion of the hand saw is easily reproduced by means of any motor whatever. The essential part of a mechanical saw is a wood or iron frame, wider and longer than the blocks to be sawed, and carrying a certain number of vertical blades, actuated by a pitman that gives them a to and fro motion.

Fig. 1, Plate II., represents a sawing machine devised by Mr. Decamps. A horizontal shaft at the top actuates, through a belt, the driving pulley, A, whose shaft actuates the pitman, B, the length of which is regulated according to the height of the frame by means of the nut, C. The oscillatory motion of the pitman is thus transmitted to the rectangular frame, D, which is guided by the four stanchions, E, that are connected by a stiff frame. The four angles of the frame are supported by a jointed rod, ending in a pulley, F, over which passes a chain, G, one of whose ends is fixed, while the other runs around the drum, H. The chains wind in pairs in opposite directions, and their upward and downward motions therefore accord with each other, and the frame rises and descends in a straight line. The vertical motion is given the chains by the drum, H, and the gearing, K, of cogwheels and pinions, which is actuated by the belts, M or N, according as it is desired to make the frames rise or descend.

Fig. 2, Plate II., represents a high-speed saw devised by the same gentleman. The saw, A, having a single blade, and actuated by the pitman, B, moves in front of the two columns, C, which support it. It is held by a system of jointed rods, D, suspended from chains that pass over pulleys, E, placed at the top of the columns and provided with counterpoises. Yet the saw is not completely balanced; a portion of its weight bears upon the blade, and this overload is regulated by the counterpoise, F, which consists of a large nut movable upon a screw. The block to be sawed is placed upon a movable table, G.

Figs. 3 and 4, Plate II., represent a slightly simpler frame constructed by Mr. Rikkers. The pitman, B, is much longer, so that the longitudinal motions of the frame, due to variations in the inclination of the pitman, are insignificant. The frame, A, is guided by the four columns, D, and is supported by four chains that wind round the drums, E. The up and down motions of the frame are effected through the winch, F, which, through a pitch chain, actuates the endless screws and the wheels keyed to the axle of the drums, E. One workman can run several frames, as he has merely to feed the groove with sand and water and occasionally let down each frame by means of the winch, F.

Circular Saws.—Circular stone saws are disks of forged iron or of steel, provided at the edge with detachable teeth. They are naturally thicker than saws with straight blades; they cut wider grooves, and have to attack and destroy a larger bulk of stone in order to produce an equal surface of cutting.

The mounting of these saws is analogous to that of planing machines. The saw shaft is fixed, or, at least, can only rise or descend, and the stone is carried by a very strong table, which is usually of cast iron, and moved either by a screw or a counterpoise. The circular saw acts rather by pressure than by friction.

Messrs. Hunter & Cooke have obtained some success

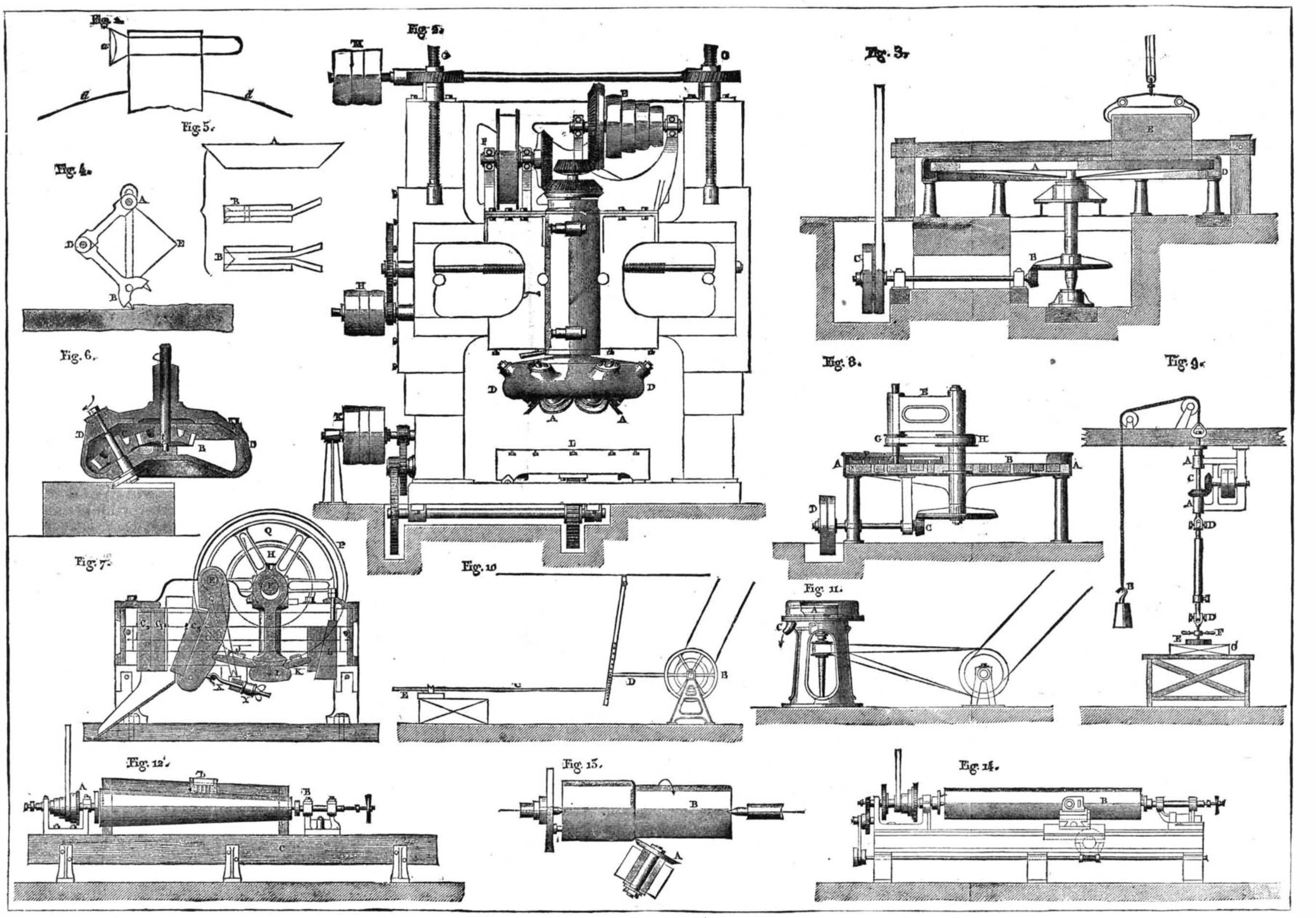

FIG. 1.—Teeth of Circular Saw. FIG. 2.—Surface Dresser. FIG. 3.—Grinding Machine. FIG. 4.—Mechanical Chisel. FIG. 5.—Teeth of Circular Saw. FIG. 6.—Details of Tool of Surface Dresser. FIG. 7.—Blake Crusher. FIGS. 8, 9, 10, 11.—Stone Polishers. FIG. 12.—Polishing Lathe. FIG. 13.—Details of Tool. FIG. 14.—Stone Lathe.

PLATE I.—MACHINES FOR WORKING STONE.

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with the detachable tooth shown in Fig. 1, Plate I. It consists of a steel bolt whose head, *a*, is forged in the form of a cup, whose rim is accurately turned and tempered. During the work, this tool is held by two jaws inserted in the disk of the saw. When that part of the edge that attacks the stone becomes dull, the bolt is revolved in its socket, in order to put a new and sharp cutter in contact with the stone.

The simplest tooth is made of a trapezoidal blade of steel, A, which is slightly curved in the center before putting it into the jaw, B (Fig. 5), fixed to the periphery of the disk, B. These teeth are the same as those which, mounted in helicoidal form on a revolving cylinder, serve for dressing the surfaces of stones.

The main objection to circular saws is the wear of the teeth and the necessity of frequently changing them.

Helicoidal Saw.—As well known, the endless saw, consisting of a steel band stretched over two pulleys, one of which is a motive one, is rendering great services for sawing wood thin. The principle of it has been applied by Mr. Gay to the sawing of stone. In his apparatus the band is replaced by an endless cord, formed of three strands of steel wire, and mounted upon two pulleys. [This apparatus has already been described and illustrated in the SUPPLEMENT.]

Application of the Black Diamond to Sawing.—In America, circular saws armed with black diamonds appear to have given some good results. The Emerson saw, for example, is a disk 3 ft. in diameter, provided with 40 diamond teeth, held by copper clamps, which are themselves held by steel jaws. The disk has a velocity of 30 ft. per second at the circumference, and is capable of sawing 13 square yards per hour.

MACHINES FOR DRESSING PLANE SURFACES.

The object of these machines is to replace the bush hammer and the chisel, so their inventors have in the first place endeavored to imitate the operation of those two simple tools.

FIG. 1.

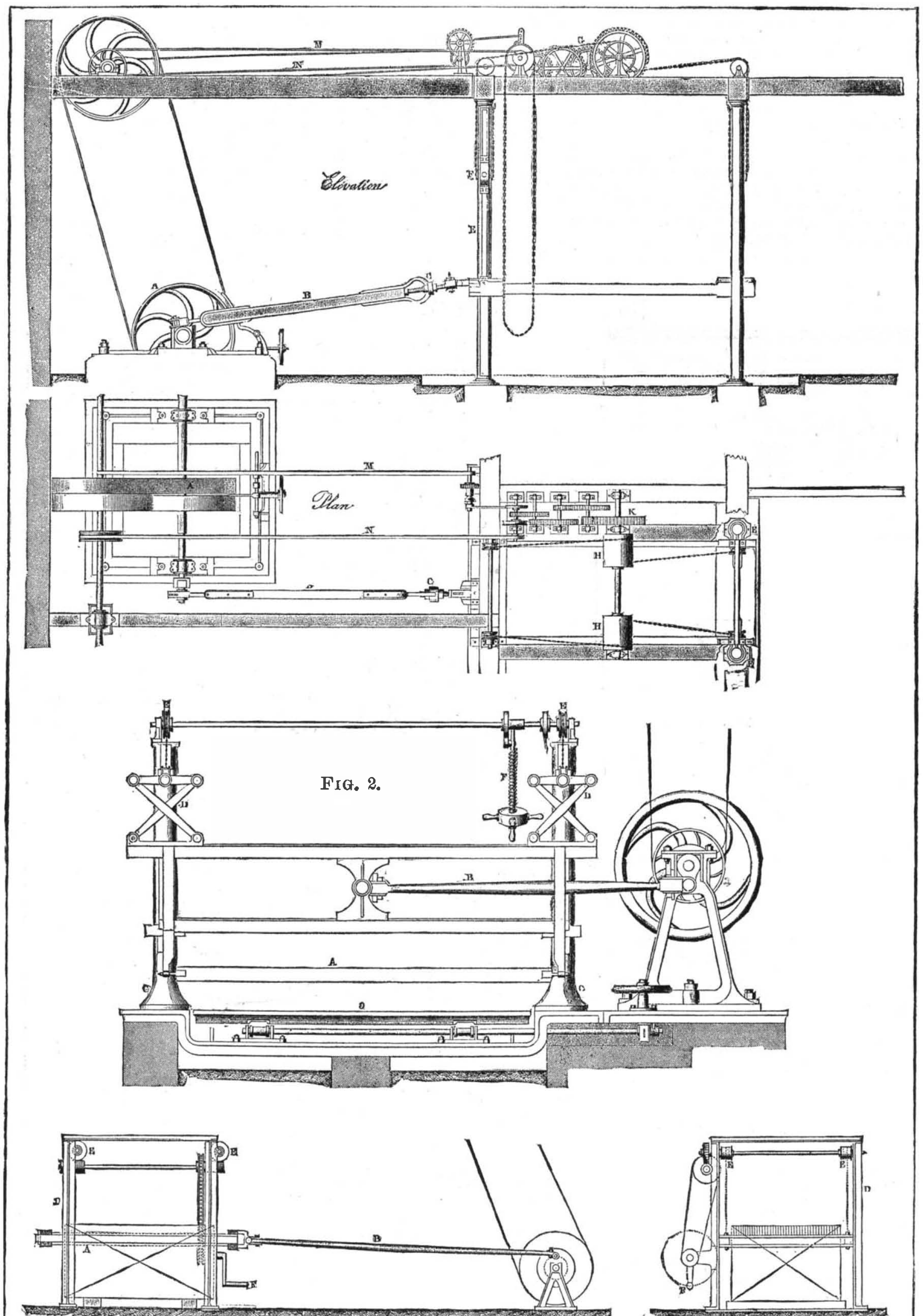

FIG. 3. FIG. 4.

FIG. 1.—Plan and Elevation of a Stone Sawing Machine. FIG. 2.—High Speed Stone Saw. FIGS. 3 AND 4.—Elevations of Saw Frame.

PLATE II.—STONE WORKING MACHINES.

Fig. 4 (Plate I.) represents a mechanical chisel devised by Mr. P. Bale. The rod of a lever, acting at A, communicates its oscillatory motion to the jointed chisel, A B D. At every oscillation the tool makes an incision in the stone to a depth regulated by the oscillation of the motive rod. The tool is stationary, and the stone moves toward it upon a traveling table.

When they reach the end of their travel, the arms of the tool are shifted from D to E, and it is the second point that, in its turn, attacks the stone. This tool has scarcely more than a historical interest.

The Brunton & Trier machine is based upon an entirely new principle. It is shown in its entirety in Fig. 2, and the arrangement of the tool is shown in Fig. 6.

The tool, A, is a circular kinfe mounted upon an inclined axle, C, that carries a small cogwheel, to which the wheel, B, mounted upon a vertical axle, gives a rapid rotary motion. The tool carrier, D, is provided with several of these knives, and is itself given a rotary motion around its vertical axle, and such motion is independent of that of the knives, and has a direction contrary to that of the latter, as shown by the arrows in Fig. 6.

The knives are revolved by the pulley, E, which acts upon a series of bevel wheels. The pulley, E, is of several diameters, thus permitting of modifying the rotary velocity of the knives. Through another system of bevel wheels, the pulley, F, causes the rotation of the tool carrier, which has but one rotary velocity. Through an endless screw and cogwheel device, the pulley, M, causes the entire tool to rise and descend, while the pulleys, H, give it a motion in a horizontal direction. Through cogwheels and pinions, the pulleys, K, actuate a rack situated beneath the table, L, which moves upon Λ-shaped slides.

The object of the inventors has been to combine the rotary speeds of the knife and tool carrier in such a way that the cutting edge shall roll without friction upon the surface that it is making. Only a slight extent of surface is attacked by the tool at the same time, and the power of the knife is thus concentrated at one point.

The machine is excellent for all kinds of stone, and gives a perfect surface to all, except certain granites.

MACHINES FOR MAKING MOULDINGS.

Mouldings upon dressed stone are still almost everywhere cut by hand, the work being done with a chisel, and finished by a polishing with sand or emery. The use of machinery is evidently indicated for such work, just as it is for wood mouldings and metal planing. The apparatus for doing this work are analogous to planing machines. The most recent devices consist of cylinders revolving upon a vertical or horizontal axis, and provided with solid steel knives. The stone is fixed immovably upon a traveling table. These revolving tools are designed, as a general thing, to begin the moulding. The work is finished by means of a stationary tool that presents, in a matrix form, the profile of the moulding desired, and that acts upon the movable stone after the manner of the tool of a machine for planing metals

MACHINES FOR POLISHING STONE.

The polishing of stones is a very important operation. The process requires the surfaces to be first ground, and the machines for this purpose are heavy and run slowly.

Polishing machines, although like grinding ones, do not have to effect so much of a wear. The principal substances used to produce a wear in grinding and polishing machines are the following: (1) in a compact form, the whetstone, oilstone, charcoal, and a composition of emery; (2) in the form of powder, the diamond, crystallized quartz, emery, sand, powdered flint, glass, tripoli, slate, pumice stone, chalk, oxide of iron, colcothar, and tin putty.

Grinding Machines.—The simplest of such machines is Rikkers', and is shown in Fig. 3. It consists of a horizontal cast iron disk, A, which is revolved around a vertical axle through the bevel wheels, B, and the driving pulleys, C. The block, E, suspended by hooks from a crane, is laid upon the disk, upon which it bears with all, or nearly all, of its weight. The result is a friction that causes wear. The disk is supplied with water and sand which as they escape are received in the annular gutter, D. As the diameter of the disk is 16 feet, several stones may be worked at once.

Polishing Machines.—The true polishing machine is the doubly rotating one. Fig. 13 shows a model constructed by Mr. Rikkers. This consists of a cast iron table, A, firmly fixed upon columns. To the surface of this table is firmly fixed, by plaster, the pieces, B, to be polished. Driving pulleys, D, through a bevel gear, C, actuate a vertical shaft that revolves the arm, E. The vertical axle of the polishing plate, F, runs through the arm, E, with slight friction. The pulley, H, is connected by a belt with the pulley, G, keyed to the axle of the polisher, so that the latter has two motions—a rotary one around the axle of the table, and a contrary one around its own axis.

Thus the surfaces in contact and the direction of the rubbing are continuously changing direction. It will be seen that the plate, F, is provided with a rim with apertures on its upper surface. It is through these apertures that the sand and water enter,

Fig. 11 represents a polisher for small pieces. A vertical shaft, actuated by a belt, revolves the disk, A, upon which lie the pieces to be polished, and the surface of which is supplied with water and sand. The latter afterward run into a gutter which carries them to the conduit, C. The disk, A, is of cast iron or of fine-grained stone, according to the hardness of the material to be polished. The disk that produces the final wear makes as many as 180 revolutions per minute. Fig. 9 shows a polisher having a circular motion. It consists of a vertical shaft that traverses a telescopic tube, A, and is consequently capable of being lengthened or shortened at will. This shaft, which is supported by a cable and counterpoise, B, is actuated by the bevel wheels, C. It is provided with two gimbal joints, D, that permit of its being bent in all directions, and supports the cast iron polishing disk, E, which is hollowed out and provided with apertures. The handles, F, are used for bringing the apparatus over the piece to be polished.

The rectilinear polisher shown in Fig. 10 consists of a horizontal shaft mounted upon two cast iron supports and actuated by a pulley. This shaft carries a fly wheel, B, provided with a tappet that moves the pitmen, D and C. The latter of these carries a cast iron polishing plate, E, which contains apertures, and is hollowed out to receive sand and water. This plate, then, has a to and fro motion, and polishes the stone upon which it rests. By changing the position of the tappet on the fly wheel, and the points of attachment of the pitman on their one rod in common, the extent and velocity of the travel may be varied to any degree.

STONE LATHES.

Stones, like wood and metal, may be worked in the lathe. The general arrangement of the apparatus is always the same. Fig. 14 represents one of these lathes, and Fig. 13 shows the details of the cutting tool. The apparatus is very strong, and is designed to be run at a high speed. It is actuated by a pulley of several diameters. The tool is a wheel, A, of cast steel, making with the axis of revolution an angle of 25°. It is loose upon its axle, and revolves in contact with the stone, which it attacks through a very limited portion of its cutting edge.

The tool carrier at the same time receives, through an endless screw and a cogwheel, a side motion whose velocity is regulated by a pulley of several diameters connected with the main shaft. The ratio of the rotary to the horizontal speed has to be determined experimentally for each kind of stone.

Stone columns are finished upon a polishing lathe. The apparatus (Fig. 12) consists of a face plate, A, with a pulley of several diameters, and a tail stock, B, mounted upon a wooden frame, C. The whole affair is very solid, and the stone itself is firmly held in place. The cast iron piece, D, moves along a wooden bar. This piece is hollowed and provided with apertures, and being fed with sand and water, is slid along the bar in order to make it act in succession on the various parts of the stone. The final polish is given by a bundle of rags covered with emery flour or tin putty.

MACHINES FOR CRUSHING STONES.

The occupation of stone breaking has always excited

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compassion, for in fact it is a monotonous and laborious one that it would be humane to replace by mechanical processes. The increasing rise in the price of manual labor will soon necessitate the substitution.

Machines for crushing stone are scarcely used in France, but are, on the contrary, in extensive use in England and America, where they have been put to numerous applications.

The Blake Crusher.—(Fig. 7.) This apparatus consists of two jaws; one of them, C_1 C_2, vertical and stationary, and the other, C_3, inclined and having an oscillatory motion around the fixed axis, E. The spacing of the jaws is regulated according to the size of the fragments to be obtained. The blocks to be crushed are thrown between them, at the upper part, and the crushed stones fall at the bottom into a cylindrical screen that separates them according to their sizes, as it revolves upon its axle.

The jaws are provided with longitudinal channels of chilled cast iron, so arranged that they can be easily replaced by others as they wear out. The various parts of the mechanism are supported by a frame cast in a single piece. At Q may be seen the driving pulley, which is actuated by a belt connected with a steam motor. The shaft, F, is, in addition, provided with two heavy fly wheels; it makes 250 revolutions per minute, and actuates the connecting rod, H I. This latter transmits the motion to the jaws through the jointed rods, J K. The recoil of the jaw is obtained through the rod, X, which terminates in a spring, Y.

The distance apart of the jaws is regulated through the wedges, L, that are maneuvered by nuts.

Other well known apparatus of this kind are the Loiseau and the Carr crushers.

COMPARISON OF MANUAL LABOR WITH MACHINE WORK.

Is there any need, from an economical standpoint, to compare manual labor with machine work? From the moment it becomes a question of a continuous operation, constant experience has shown, and simple reflection proves, that the machine works the more cheaply. This is a rule easy to verify in every industry. Moreover, the machine does perfect and regular work, and does not become exhausted or heedless, as the best workman sometimes does. Hence, it is preferable in every respect.

We shall now give some results taken from Mr. Bale's book on stone-working machinery, and which may inspire confidence, since stone-working machines are not so widely used in France as in England.

1. Under ordinary circumstances, a good machine will dress from 8 to 10 superficial feet per hour. The expense, for two men and a child, is about 45 cents. Manual labor would cost at least $1.13. There is, therefore, a wide margin for wear and interest on the machine.

2. A moulding machine for operating upon Portland limestone has made 10 square yards per day; and the expense, for two days' work, cost of tool, the motive power, and interest at 5 per cent., was $6.23. Manual labor would not have cost less than $3 per square yard, say four times more than machine work, while the latter was done better and more quickly.

3. As regards sawing, it is difficult to give precise figures, since the superficial production depends upon the nature of the stone; with soft stone, the cost of sawing by machine does not amount to 20 cents per square yard, which is half the cost of hand labor. Where it concerns hard stones, the difference is greater.

The figures relative to circular saws have not as yet been obtained. These tools work more quickly than straight saws, but they require more power and cause more waste.

GENERAL OBSERVATIONS.

England and America have long taken the lead in the use of stone-working machinery. Thus, the mechanical preparation of stone has entered into the current practice of American builders. Mr. Malezieux mentions some immense quarries near Chicago, which as long ago as 1870 substituted mechanical processes for manual labor, of which there was an entire dearth. The machines that serve to prepare the stone in these quarries are situated under a long shed, at one end of which is located a steam motor. The machines consist of saws, polishing machines, and planers. The saw consists of five blades mounted upon one frame in common. The teeth are at the upper part of the blade, and the saw rises instead of descending. The polisher is suspended from the extremity of the horizontal arm of a crane, and bears upon the rough surface of the stone, carried by a revolving table beneath. But the principal work after sawing is planing.

The principal thing to be considered where it concerns machine tools in general, and especially those for working stone, is whether they have been constructed in view of the work required of them. Every machine should be adapted to the special nature of the material that it is to work. Experience alone will, in each case, permit of determining the form and arrangement best adapted to the proper working of the tool.—*Abridged from Annales des Ponts et Chaussees.*

A NEW STYLE OF PUMP VALVE.

WHATEVER may be the value of its practical application, it is always interesting to call attention to a new *principle*, and that of the pump which we figure herewith appears to us to be such.

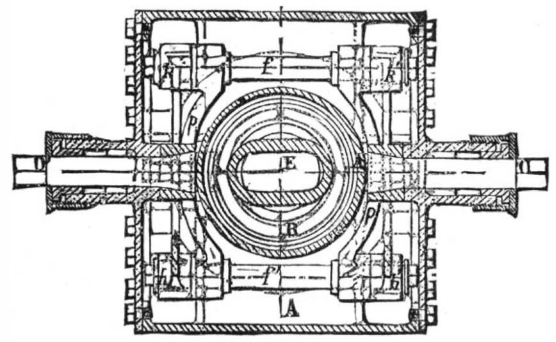

FIG. 3.

Numerous efforts have been made to overcome the inconveniences of the ordinary piston pump, which has not, as yet, been dethroned. On the one hand, the friction, in the chamber, of the tight or loose packing of the piston causes the loss of considerable power; and, on another hand, the choking of the valves, which are usually too small, not only presents an obstacle to the free passage of the liquid, but leads to an obstruction of the pump when the liquid contains solid substances.

Along with centrifugal pumps (the only apparatus differing from the piston pump that give practical results, owing to which they are well adapted to certain special uses), we may mention the suck pump as the application of an original principle. This pump, which has scarcely got out of the domain of theory, is based upon the principle of substituting the flexibility of a membrane for the friction of the piston. By this means the volume of the pump chamber is alternately decreased and diminished, thus producing a suction and expulsion.

An analogous principle has been applied by Mr. Michel in the construction of a pump which he has recently patented, and which, according to its inventor, would allow a hop pole to pass through it. The valves consist of bottle shaped rubber vessels without a bottom, the necks of which, by reason of their elasticity, open or close like lips, according as they are submitted to internal or external pressure. In the double acting pump, which is the one here illustrated, these bottle valves, E F, are mounted in tubular pistons, B G, and these latter move in the cylindrical pump chamber, A. It is easily seen that it is only necessary to alternately separate and bring these pistons together to produce a suction and expulsion of the liquid, one of the valves closing while the other is opening. The assertion of the inventor is thus explained; for a cylindrical or nearly cylindrical rod would easily pass through the lips of the valves without interfering with the suction of the liquid, whose motion it would follow.

The mechanism (Fig. 3) which actuates the pistons is wholly external, and presents no obstacle to the passage of the liquid. It consists of two short, fixed axes, *o* and *o'*, arranged upon the same straight line, *a b*, on each side of the pump chamber. These each carry a lever, *p p'*, having a rocking motion. These levers are coupled by cross pieces, *f* and *f'*, with which are connected the rods, *h h'* and *k k'*, that actuate the tubular pistons, B and C, and give them a to and fro motion.—*Le Genie Civil.*

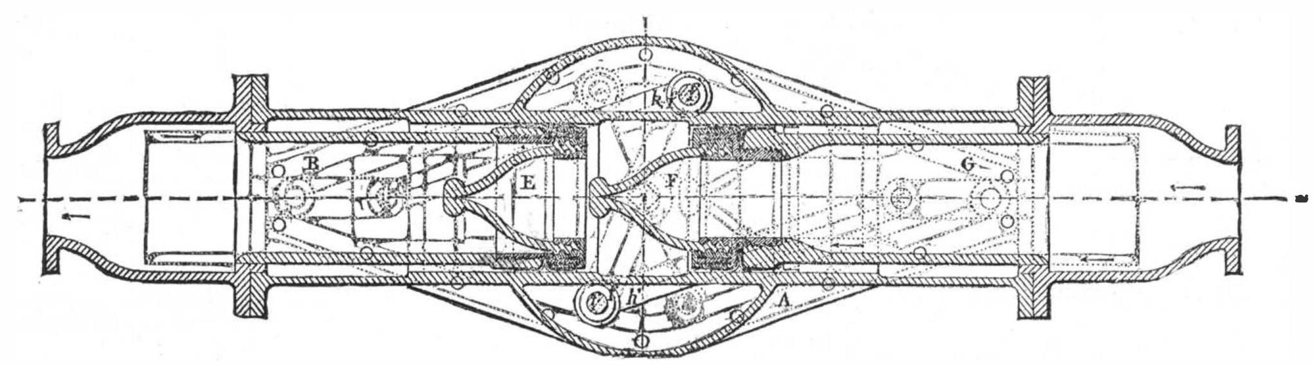

FIG. 1.

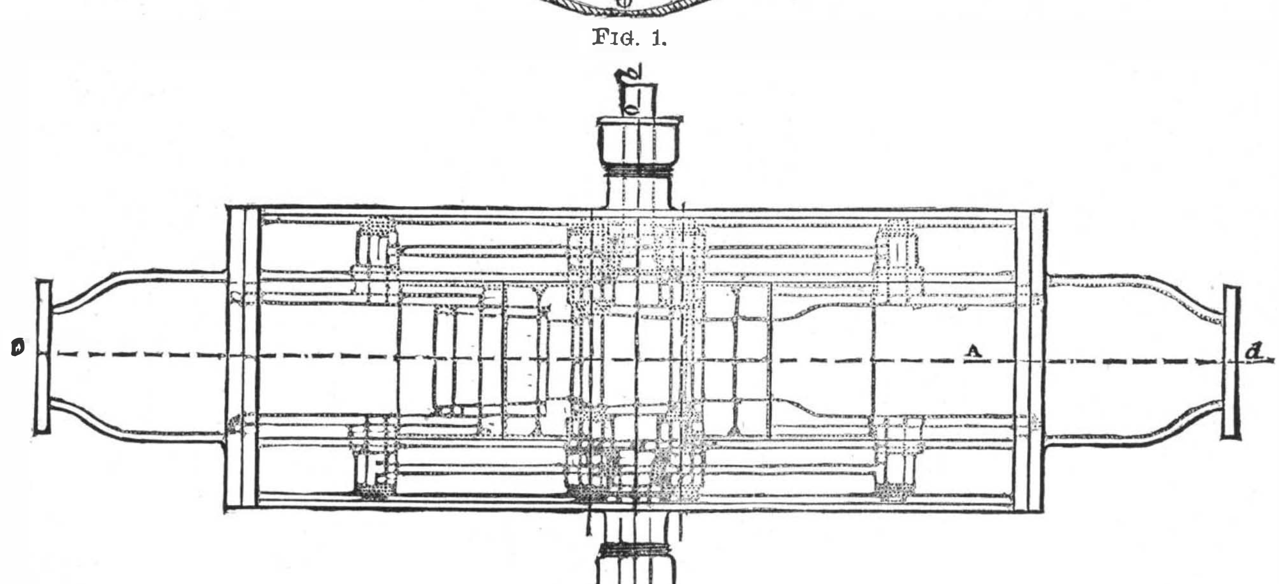

FIG. 2.

[Continued from SUPPLEMENT, No. 575, page 9177.]

FRICTION.*

By Professor H. S. HELE-SHAW.

Lecture IV.—Delivered February 8, 1886.

THE METHODS OF REDUCING THE RESISTANCE OF FRICTION.

(2.) THE PREPARATION, CHOICE, AND USE OF SUITABLE SURFACES.

The previous preparation of surfaces which have to work in frictional contact with each other is a far more important matter than many people are aware. It is frequently regarded as a correct thing to allow the result of the bad fitting of parts, which causes the imperfect contact of such surfaces, to come right in the course of time by wear, and to leave such surfaces imperfectly prepared to be worn smooth in this manner. I cannot do better than quote the opinion upon this subject of an eminent Belgian engineer, which recently appeared in the columns of the *Engineer*, November 6, 1885. M. Van den Kerchove had his attention directed to this subject by the action of a large planing machine made by Sir J. Whitworth & Co. This machine has been doing good service in M. Van den Kerchove's works for the last fifteen years, and is still giving the greatest satisfaction, without ever having undergone the slightest repair. In the driving gear of this machine there is a shaft which, while planing, runs at 375 revolutions per minute, and which makes more than 1,000 revolutions per minute during the return of the table carrying the work; and although this shaft runs in solid cast iron bearings of small length without bushes, there is not the least sign of wear in these parts. "It would almost lead one to suppose," says M. Van den Kerchove, "that these surfaces are so perfect that they slide over each other without coming into contact. Indeed, as is well known, when one examines into the action of two correctly made surfaces, properly lubricated, sliding one upon the other, it follows that if they are well proportioned to the load they have to carry, they do not touch, since the lubricant is constantly interposed between them; and if perfect lubrication is assured, there naturally results an exceptional preservation of the rubbing surfaces, especially if one can protect them from dust, and by careful cleaning from time to time prevent the formation of dried oil." The results obtained with his machine tools M. Van den Kerchove has striven to realize in his engines. In doing this, he arrives, as he states in a small pamphlet he has distributed, at a durability of the various working parts of his engines equal to that observed in the Whit-

* Lecture recently delivered before the Society of Arts, London.

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worth machine tools, and thus he has considerably enhanced the value of his engines.

A steam engine, says the *Engineer*, is as much a machine capable of being made with accuracy as a lathe or a plane, and should be so made; and M. Van den Kerchove holds that those who have not had practical experience of what minute accuracy will accomplish have no idea of the benefit it confers. Take, for example, the boring of cylinders; in nine cases out of ten, cylinders are neither bored truly round nor quite parallel. "A conicity," says M. Van den Kerchove, "of one-fiftieth of an inch in a cylinder will suffice to ruin a piston. To give an example: It is not unusual to have to replace piston rings once a year. This is due simply to the fact that the rings do not fit the cylinder all around. They wear where they rub. Then they cease to be true circles, and so does the cylinder, and fretting begins; whereas, if the surfaces were what they ought to be, they would, so to speak, float over each other." With perfect workmanship, M. Van den Kerchove has had one set of piston rings last for sixteen years in daily work, and at the end of that time the piston was quite tight. In another case, a horizontal engine piston worked for twelve years, at 66 strokes per minute, and at the end of that time the greatest inaccuracy caused by wear did not exceed $\frac{1}{500}$ of an inch. "These are incontestable examples which prove that good workmanship, aided by continual care on the part of the engineer in charge, are able to augment the life of these parts of a steam engine, which have most to do, to an extent almost incredible."

I have recently come across results from two entirely different sources which illustrate in a striking manner the importance of well fitting parts and well prepared surfaces. A very able and experienced mechanical engineer expressed his objection to the use of the worm and ordinary cast iron worm wheel, for transmitting power, unless they are very carefully made and fitted, and told me the result of an experiment he had made with such a worm and worm wheel in combination with a nut and screw, in which the loss was actually more than $\frac{97}{100}$ of the *whole power transmitted*, that is, the efficiency of the mechanism was *only* 3 *per cent.* It is true the gearing was raw and new, but still such a loss is striking, especially as the makers of the gear are a firm well known for high class work.

In contrast to the above result, I will now give the results of a series of experiments made, and kindly furnished to me, by Mr. Reckenzaun, upon the worm and worm wheel. In these experiments a dynamo electric motor was employed to drive the worm, which was keyed upon the shaft of the motor. Upon the shafts both of the motor and of the worm wheel were attached the pulleys of ordinary Prony brake dynamometers. The worm was of steel, and turned with a treble thread and pitch of six inches, the diameter of pitch line being also six inches. The diameter of the worm wheel at pitch line was 15¼ inches, the angle of the teeth being 18°. Calling the shaft of the worm wheel A, and that of the motor B, then the following is a table of the results actually obtained:

TABLE OF EXPERIMENTS UPON THE FRICTION OF WORM AND WORM WHEEL.

	Weight on Brake in kilos.	Revolutions per minute.	Current ampères	E.M.F. volts.	Kilogrammetres per minute on brake.	Efficiency.
A	27	38	30	56	4504·14	·843
B	4	304	30	56	5338·24	
A	28	86	30·48	101·2	10571·12	·896
B	4	672	30·48	101·2	11800·32	
A	22	96	26·4	102·8	9271·68	·916
B	3	768	26·4	102·8	10114·56	
A	15	114	19·92	105·2	7520·99	·954
B	2	896	20·16	105·2	7881·24	

The worm was kept in gear the whole time with the worm wheel, and if they had been thrown out of gear the efficiency would have been lower, also the pressures transmitted are not very great. Still these figures, which give an average efficiency for the combination of 90 *per cent.*, show in a very significant manner what may be done by careful workmanship and the proper fitting and preparation of working parts.

We now come to the last two points in my lecture, viz., the choice and use of the most suitable surfaces for frictional contact, and I may at once say that the experience of the last fifty years has only confirmed the view enunciated by Morin, and which has sometimes been called the fourth law of friction, that when lubricants are used, the extent of frictional resistance depends almost entirely upon the nature of the lubricant, and not upon the nature of the surfaces of the solid bodies between which it is interposed. Astonishing instances might be quoted, such as that mentioned previously, by M. Van den Kerchove, of the wear of such surfaces as cast iron upon each other* when the lubrication is efficiently maintained, and what I have now to say is, therefore, chiefly concerning the choice and use of lubricants. I will first remark that although lubricants of some kind or other are always used where sliding contact takes place, their use does not appear to diminish the resistance to the rolling of two surfaces over each other, and to secure the least amount of frictional resistance to rolling contact the surfaces must be as hard and smooth as possible.

In the choice and application of lubricants, a great advance has been made in recent years. A vast number of substances have been carefully examined with reference to their lubricating properties, among them being lard and the oils of sperm, neat's foot, fish, olive, cotton seed, rape seed, cocoa nut, elaine, castor, linseed, etc., as well as mineral oils of all kinds, and the properties of solid substances, such as graphite, asbestos, and soapstone. Fluid lubricants have been tested for density, specific gravity, viscosity, gumming, and drying; by fire tests, by means of "oleography," and by specially constructed testing machines.

I have recently given a brief sketch of what has been done in this direction,* and have shown how carefully lubricants are now prepared and tested.

It may be necessary to ascertain what an oil or lubricant actually is, but it is much more frequently required to know whether it is pure or not, and the work of the above mentioned chemists and others has resulted not only in a knowledge of facts, such, for instance, as that chlorine turns animal oils brown and vegetable oils white, but also in certain systematic methods of test. The first step is to place the lubricant in one or other of certain defined classes; next, by other tests, to place it in its proper subdivision, and finally to analyze it, with a view to the determination of its constituent parts. It must be remembered that by far the greater proportion of lubricating oils are ostensibly mixtures, vendors of such oils holding (as, for instance, Mr. Veitch Wilson, in the paragraph previously quoted) that such mixtures produce the best results. Thus chemical tests, though sometimes employed for examining the actions of lubricants on metals, chiefly tell what the lubricant *is*, and are of little practical importance compared with physical and mechanical tests, which tell rather what the lubricant *does*.

The chief physical tests are the determination of (1) density, (2) the effect of heat, (3) the gumming and drying properties of a lubricant.

(1.) The density or specific gravity of an oil is sometimes an important matter, as there is a considerable difference between various oils, but the determination is easily effected by ordinary methods.

(2.) The effect of heat on the nature of a lubricant must not be confounded with the effect of rise of temperature on frictional resistance. The application of heat is important rather in connection with mineral oils, which vaporize, and compounds into which mineral oils largely enter, than with animal and vegetable oils, which thicken and decompose.

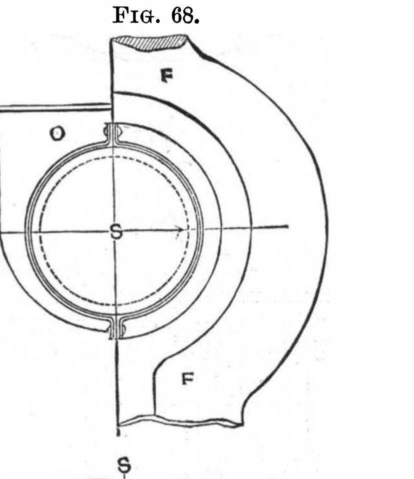
There are two points for consideration in connection with the former class of oils, one being the amount of evaporation taking place at temperatures not exceeding the boiling point of water, the other the actual point at which the ignition of the vapor given off takes place. Mr. Wilson, in his paper, states that though many oils considered good lost 5 per cent., and one or two samples 10 per cent., in a 10 hours' test at 212° F., yet, on the other hand, many oils lost nothing at all. The second point is, however, much more important, and there are strong reasons for attributing several recent conflagrations, and consequent destruction of mills, to the ignition of the lubricants used in them. The "fire test" thus becomes an important one. There are several pieces of apparatus for the purpose, the principle of them all being simply to heat the oil until the vapor given off ignites on the application of a light, the temperature of ignition, or "flash point," being observed by means of a thermometer. The neatest instrument for the purpose is that of Bailey, in which the oil is heated in a copper vessel about three-quarters full, the vapor from which, issuing laterally, comes in contact with the flame of the heating lamp or Bunsen burner. This is a more satisfactory arrangement than the application at intervals of a light to the orifice. There are many oils which flash at 180° F., some at 150° F., but an oil should never be used for lubricating purposes which flashes at a point below 250° F., some of the best mineral oils vaporing at 600° F.

(3.) The gumming and drying properties of oils may be simply tested by allowing samples to flow down an inclined plane, when the nature of the oil becomes manifest by the rate at which it travels and the distance it moves.

Other modes of physical tests are employed, but which I need not refer to.

I will now very briefly explain the action of such of the various testing machines as I am able to exhibit to you, which machines really show what the working properties of a lubricant are, by running a portion of it under various conditions of pressure, velocity, and temperature, with results such as I have already referred to in my second lecture.

FIG. 68.



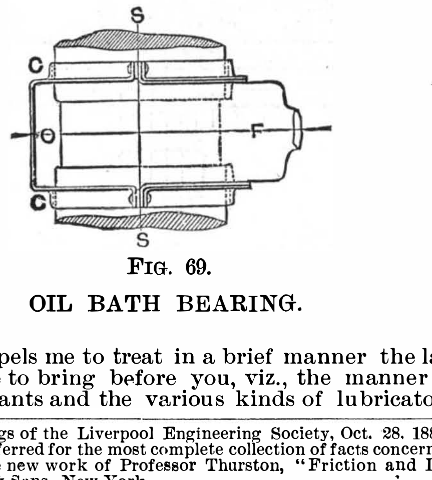


FIG. 69.

OIL BATH BEARING.

Time compels me to treat in a brief manner the last point I have to bring before you, viz., the manner of using lubricants and the various kinds of lubricators, of which there are now so many varieties, and in the design of which much ingenuity has been expended.

The great advantages of a continuous supply of lubricant were fully proved by Mr. Beauchamp Tower's experiments with the oil bath bearing. Fig. 68 shows an elevation and Fig. 69 a plan of an oil bath bearing designed by Mr. Edward Shaw for a journal 3" diameter by 1¼" wide, in which a pressure of 1,200 lb. acts in the direction of the arrow (Fig. 68). FF is the frame of the machine, of cast iron, against which the cast iron shaft, SS, works, the lubricant being contained in the box, O, and prevented from escaping along the shaft by the adjustment of the sides of the box at CC. This shaft has been working for several months with neat's foot oil, at a surface velocity of 150 feet per minute, and does not show any signs of wear.

As a rule, however, oil bath bearings are not possible, and arrangements must be made to supply the lubricant either continuously or at regular intervals. A number of "sight feed" lubricators have been introduced, in which the amount of the supply can be watched. Figs. 70 and 72 show two views of one of the simplest

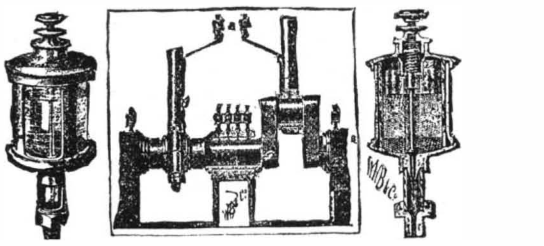


FIG. 70. FIG. 71. FIG. 72.

SIGHT FEED MARINE ENGINE BEARINGS.

lubricators of this kind for marine engine bearings. This lubricator, in which the falling drops of oil can be seen as they pass through the glass tube in the neck, is the invention of Mr. Baird, and is manufactured by Messrs. W. H. Bailey & Co., to whose illustrated catalogue I am indebted for the figures of the various lubricators. Fig. 71 shows the way in which these lubricators are used, four of the lubricators being shown on a small scale fixed to the main shaft bearing, two above them being used to lubricate the crank pin bearing.

The "oleojector" (Fig. 73) is a very ingenious lubricator, the invention of Mr. Royle. The principle of action is that a small jet of steam taken from any high pressure part of the engine is allowed to play into the cylinder, into which it carries the lubricant even against considerable pressure.

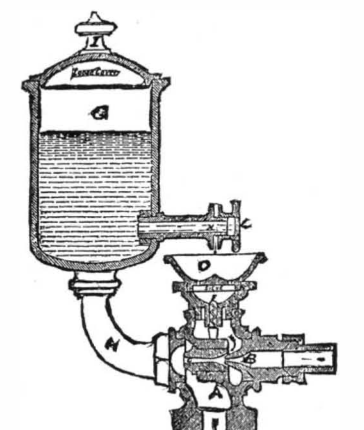


FIG. 73.—THE OLEOJECTOR.

A is the body or injector portion provided with the cones, B and C, which are fixed in position and require no adjustment. The inlet cone, B, is connected to the main steam pipe or other source of steam supply, and the rear of the outlet cone communicates with the engine cylinder about the middle in horizontal engines, and the upper end in the case of vertical engines. The suction produced by the small jet of steam passing these cones as the piston reciprocates on the cylinder is utilized to draw the lubricant into the cylinder, which falls on to the cup, O, in a measured quantity. A valve, F, is arranged to prevent the return of the oil. G is a cistern or receiver for containing the lubricant, and which is provided with a loose cover, I. The regulator, L, controls the quantity of lubricant (falling drop by drop out of the cistern, G, on to the cup, O) to the greatest nicety. At each successive period of low pressure in the cylinder a jet of steam passes through the cones, B and C, and the effect thereby produced opens the valve, F, and draws in any oil or other lubricant that has been fed to the cup, O, and carries it into the cylinder in the form of a fine spray. At the period of high pressure in the cylinder, the valve, F, closes, and so prevents the oil returning.

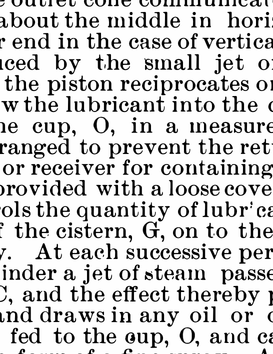


FIG. 74.—CYLINDER LUBRICATOR.

Figs. 74 and 75 represent two cylinder lubricators o Mr. W. H. Bailey.

In Fig. 74 the oil reservoir, V, communicates with an upright glass gauge tube, G, by means of two passages, one at the top and one at the lower end. A passage

* Mr. Goodman, in the paper I have already referred to in Lecture I., states that on the Brighton Railway there are many cast iron eccentric straps working on cast iron sheaves, which have been running constantly for twelve or thirteen years without requiring the slack to be taken up, their surface velocity being 900 feet a minute, representing in thirteen years a distance of at least 100,000 miles passed over by the surfaces. This result, the author remarks, being due to the thoroughly good system of lubrication adopted.

* "Proceedings of the Liverpool Engineering Society, Oct. 28, 1885." The reader is referred for the most complete collection of facts concerning lubricants to the new work of Professor Thurston, "Friction and Lost Work," Wiley & Sons, New York.

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leads through the neck, S, of the lubricator and terminates inside the reservoir, near the top, in the form of a tube, which widens out to a slight extent. The screw plug, J, is for filling the lubricator, and H is for regulating the supply of oil through the neck, S. The oil floats on top of the water in the lubricator, and the gauge glass, G, shows the level of the division.

Fig. 75 shows a sight feed lubricator, which is used to supply oil to the main steam pipe. This lubricator consists of a main reservoir, communicating at the bottom with a glass tube, through which the oil passes upward on its way to the steam. A steam pipe, on which is a hollow globe (shown on right hand of figure), leads to the lower end of the lubricator, and the oil is by this means forced out of the reservoir up the glass tube, in the form of drops, the rate of supply of which is regulated by the small stopcock, shown in the right hand lower corner of the figure. The value of a lubricator, such as the above, in which the oil supply can actually be seen, is too obvious to need explanation.

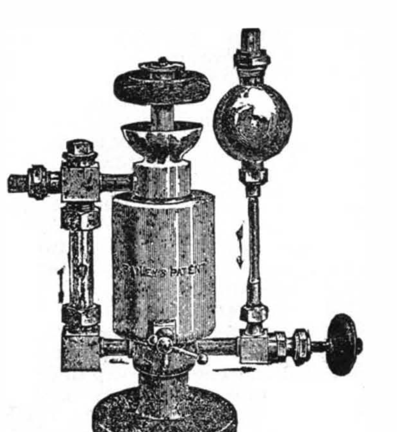


FIG. 75.—SIGHT FEED LUBRICATOR.

Fig. 76 represents Threlfall's lubricator for motion bars of locomotives.

The oil reservoir, O O, has an inner chamber containing a brass valve, B, which fits on a concave seating. Leading from the oil reservior to the inner chamber is a passage terminating in the center of the ball valve seating. From the inner chamber another passage leads through the shank of the lubricator. The pipe running from the valve chamber through the lid is for the purpose of admitting air and for flushing the lubricator and oil passages when the machinery is at a standstill. The aperture in the lid at C is for filling the lubricator with oil, both this and the pipe mouth being protected by the hinged slide, K, so that dust, ashes, or other deleterious substances cannot get into the lubricator. The valve, B, regulates the supply of oil passing from the reservoir into the valve chamber. When the locomotive is in motion, the ball rolls loosely on its seating, thus allowing oil to pass down the shank, P, of the lubricator, and so passes on to the part which is to be lubricated.

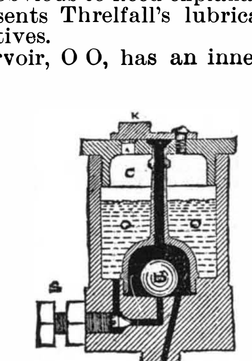


FIG. 76.—LUBRICATOR FOR LOCOMOTIVE MOTION BARS.

A form of bearing used in a cotton mill at Darwen, in Lancashire, is shown in Fig. 77. The mill is six or seven stories high, and, like most of the mills in that country, was geared with massive gearing, a vertical shaft being employed with a pair of bevel wheels at each floor. This shaft was 9" diameter at bottom, and finished with a 5 inch shaft at top. Altogether the weight of shaft and gears was very excessive. They tried several plans to make a footstep that would not heat, and finally adopted this one. The idea was to get a hydraulic pressure on the bottom of the shaft by means of hydraulic pumps and accumulators, and provide a stream of cold water in the annular space, so as to cause circulation and cool the bearing. Whatever pressure was needed on the end of the shaft was got by regulating accumulator and pumps, the shaft being relieved from the bearing to that extent. The use of the disks of different metals was, as will be understood, to prevent the surfaces from cutting, and at the same time, if one disk should cut, any one of the others could begin to operate. Mr. Walker, who is a member of the American Society of Mechanical Engineers, described this bearing, and says, "I know of no bearing of this kind so large and at the same time so successfully applied."

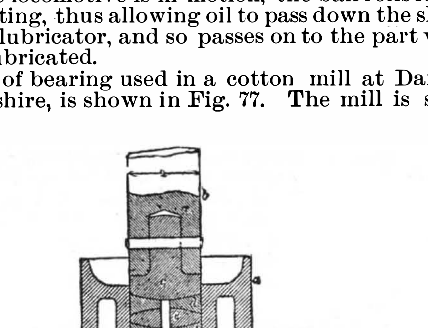


FIG. 77.—METHOD OF LUBRICATING FOOT STEP.

Fig. 78 shows a bearing described by Mr. Durfee before the American Society of Mechanical Engineers. The bearing and footstep are supposed to be formed of cast iron, with an oil well. Directly through the center of the support, B, on which the shaft, S, revolves, a vertical hole, H, is drilled, intersecting a horizontal hole, I. On the end of the vertical revolving shaft, S, there is a groove, F, cut right across the center of the shaft. The oil well being full of oil, as the shaft, S, revolves, the centrifugal force tends to throw every particle of oil out of the groove, F. The consequence is, that there is a continual circulation of oil through the holes, H, I, and the groove, F, being cut across the shaft, distributes the oil over the upper surface of the shaft support, B, at every revolution.

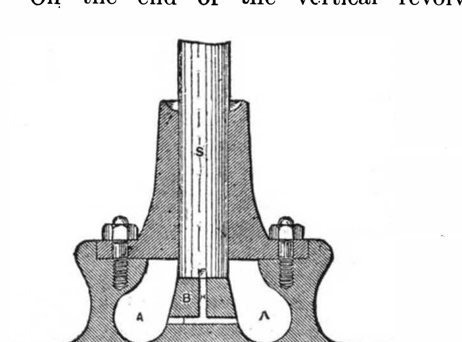


FIG. 78.—METHOD OF LUBRICATING FOOT STEP.

The brief sketch I have given of the subject of lubricants, and their mode of application, does not, I am afraid, do justice to its importance; but no general treatment of the question of "Friction" would be complete without some attempt to show the advance which has been made toward raising the subject of lubrication to the dignity of a science.

Indeed, in bringing this course of lectures to a close, I must confess that, so far from having exhausted the subject, I have only been led to realize its magnitude, and if I am encouraged to think that the labor bestowed upon the preparation of these lectures has been of any value, I am, at the same time, led to realize how imperfect my treatment of the whole subject has been. My thanks are due to a number of gentlemen for assistance of various kinds, which I have, in the course of the lectures, endeavored to acknowledge. But I wish specially to thank Mr. Lionel Pearce, for enabling me to exhibit to you his friction still and for illustrations of it; Mr. P. Louis Renouf, for procuring various samples of bicycle and tricycle ball bearings; and my students, Mr. A. Simms and Mr. Robert Holt (Whitworth scholar), for their kind and valuable aid.

IMPROVED FRICTIONAL DRIVING GEAR.

WE illustrate below some arrangements for transmitting power by friction devised by Professor Ewing, of University College, Dundee, and the late Professor Fleeming Jenkin. Figs. 1, 2, and 3 are respectively an end view, a side view, and a plan of the gear with a tightening sheave, *f*, hung in a well below the rest of the mechanism. In these illustrations, says *Engineering*, A is the low speed and B the high speed shaft, a large drum, *a*, being mounted on the former, and a small drum, *b*, on the latter. On each side of these central shafts are two others, C C, on each of which are fastened two drums, *c c* and *d d*, which are kept in rolling contact with *a* and *b*. Sufficient pressure between the surfaces to enable them to transmit power is produced by means of an endless band or rope passing around the grooved drums, *e e*, and kept tight by means of the sheave, *f*, held down either by a weight, as shown, or by a spring. The intermediate shafts turn in slotted guides, or are provided with sliding bushes, so as to enable them to approach the line of centers. The small drums, shown partly in section in Fig. 3, are made of compressed paper, and the large ones are of cast iron, a combination which works well and is nearly noiseless. This system of transmission has been used with success in driving dynamos and other high-speed machines.

NOTES OF A VOYAGE ON THE NILE.

ON land that the inundation of the Nile does not reach, or which has to be irrigated after the retreat of the water, irrigation is effected by means of lifting apparatus. The fellahs were formerly content to raise water with *chadoufes* and *saghiehs*, to which has now been added the stationary or movable steam pump on large plantations. The *chadoufe* is a scoop or large basket performing the functions of a pail, suspended from the end of a lever provided with a counterpoise and supported by a pole or two branches tied together. One or two nearly naked men operate this primitive apparatus, which is quite similar to those that serve for drawing water in the fields of Alsace. They plunge the vessel into a hole connected with the river, and empty the water into a canal two or three yards above. When the banks of the Nile are high and the water is low, three or four of these *chadoufes* may be seen placed one above another, in order to raise water to the level of the fields. This is laborious business for the poor fellahs, who are exposed all day to a burning sun, and whose food our peasants or even our European beggars would not desire. One *chadoufe*, or a series of superposed *chadoufes*, will not irrigate more than a half feddan—say 23,920,920 square yards.

The *saghieh*, which is more efficient than the *chadoufe*, consists of a wheel and pots with a whim set in motion by a pair of oxen or buffaloes, and capable of irrigating several feddans at once. As a usual thing, the pots arranged around the wheel form a frame that elongates in measure as the water lowers. In Fayoum I have seen *saghiehs* with buckets or paddles moved by the current of the canals instead of by a whim. In this case, the pots were fixed alongside of the paddles, and emptied into a small channel, as before. Every evening, we heard the plaintive grinding of these machines, like the call of a cultivator in distress. In the extensive plantations belonging to the state, and in those of Daira Sanieh, the *chadoufes* are replaced by steam pumps located upon the bank or upon a flatboat floating in the river. In the latter case, instead of elongating the frame of pots, as in the *saghieh*, a French engineer, Mr. Bouillon, director of the Herment sugar works, has conceived the idea of gradually elongating the light pipe by means of a series of tubes adjusted to one another. A pump of this kind does for sugar cane plantations (which use much water) the work of a number of *saghiehs*, and with greater regularity.

With the exception of the plantations of Daira Sanieh, and of the high shores of the river, or of the small isolated plains, the irrigation is effected through inundation basins in all Upper Egypt, from Assouan to Cairo and a little beyond the dam at the head of the delta.

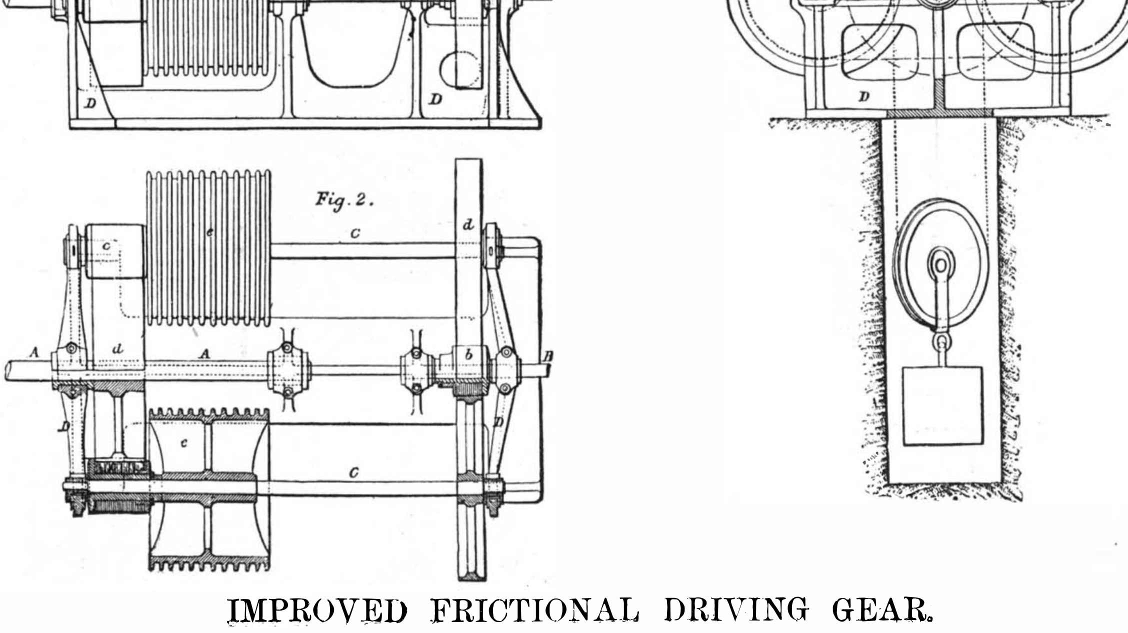
This was the system of storing up water that was applied all over the country up to the end of the last century. It consists of a division of the cultivable zone into a series of superposed basins separated by transverse dikes, and bordered in the direction of the valley by the desert terraces or by the longitudinal dikes of the Nile, or by parallel dikes. Some of these basins, belonging to a single tenant, cover more than 60,000 acres.

The villages of the fellahs, on the higher land, communicate through the dikes during the period of inundation. When the river has risen sufficiently, the basins fill, one from another, through shallow, but wide, channels starting directly from the Nile.

In this way there is obtained a moistening of the earth which renders it fitted for bearing seeds, and a fertilization thereof through deposits of slime. The water remains in the basins for two months or more, and afterward flows to the Nile. Then follows plowing and sowing, without any further work until the harvest. This mode of operating, called *chitoni* culture, for the raising of cereals, dates back to the times of the first Pharaohs. What it renders does not equal the product afforded by the vigorous culture practiced in the most advanced agricultural regions of Europe.

Irrigation through basins, in the provinces of Upper Egypt, is practiced over an area of 1,512,000 acres or 1,800,000 feddans out of a total cultivated superficies of 2,220,000 feddans or 1,864,800 acres. On the high river banks, in the zone of Sahel, *nili* culture goes on during the rising of the water, the irrigating being done through *chadoufes*, and the crops raised being usually dourah or maize. Usually, maize remains on the stalk but from 70 to 90 days.

When the Nile rises too rapidly, infiltrations destroy the crop before the harvest, so that this culture is based upon a contingency. At the end of February, the harvesting of the winter crops, or *chitoni*, has terminated



IMPROVED FRICTIONAL DRIVING GEAR.

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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.

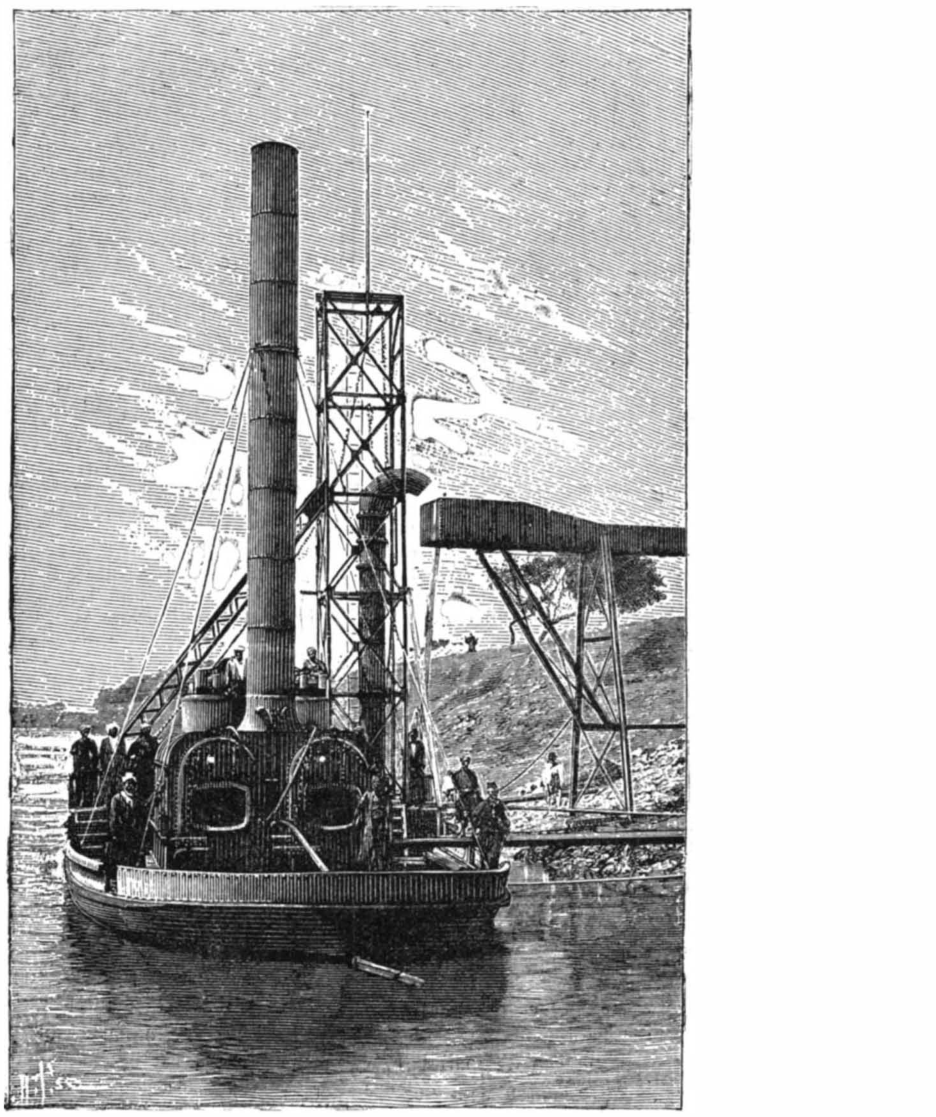

Fig. 1.—STEAM PUMP ON THE NILE.

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

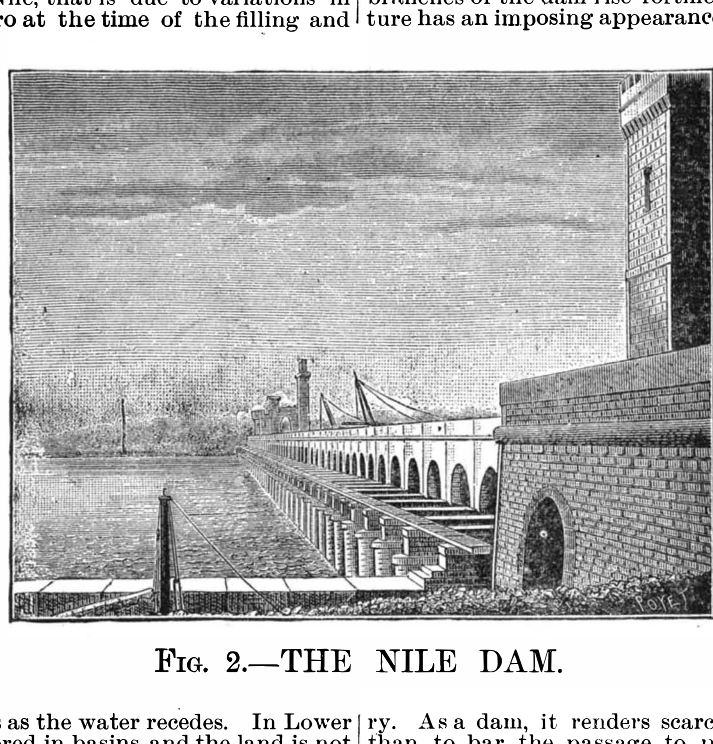

Fig. 2.—THE NILE DAM.

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 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 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 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 Bellefonds, 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 masonry. 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 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

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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 employes 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 Amsler 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,

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

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

$$\text{(b) } D = \frac{3{\cdot}183}{N}$$

$$\text{(c) } N = \frac{3{\cdot}183}{D}$$

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,

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

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

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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 arithmetical 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,[illegible]00 kals, which, at the rate of 40 cents, would cost $2.20, 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 $\frac{1}{10}$ to $\frac{4}{10}$ 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 $\frac{3}{10}$ to $\frac{4}{10}$ pound with steam at 9 pounds pressure and the low temperature of 51 degrees in the room. Mr. Baldwin has obtained $\frac{1}{2}$ pound with air circulating freely over indirect radiators. The speaker generally estimates that ordinarily $\frac{2}{10}$ of a pound of water is condensed per square foot of

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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 $1\frac{1}{4}$ to $4\frac{6}{10}$ 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 $\frac{2}{10}$ 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 =) 6·4 pounds of water. For safety the rule is based on 6 pounds, and is as follows: Number of kals = number of gallons × $1\frac{1}{3}$ = number of pounds × $\frac{1}{6}$ nearly.

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

If d_0 = diameter of jet, and $k_,$ the kals per hour,

For 15 pounds pressure $k_, = 1{,}216\, d_0^2$.

For 45 pounds pressure $k_, = 1{,}804\, d_0^2$.

For 60 pounds pressure $k_, = 1{,}978\, d_0^2$.

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 employes 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 calculate 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.

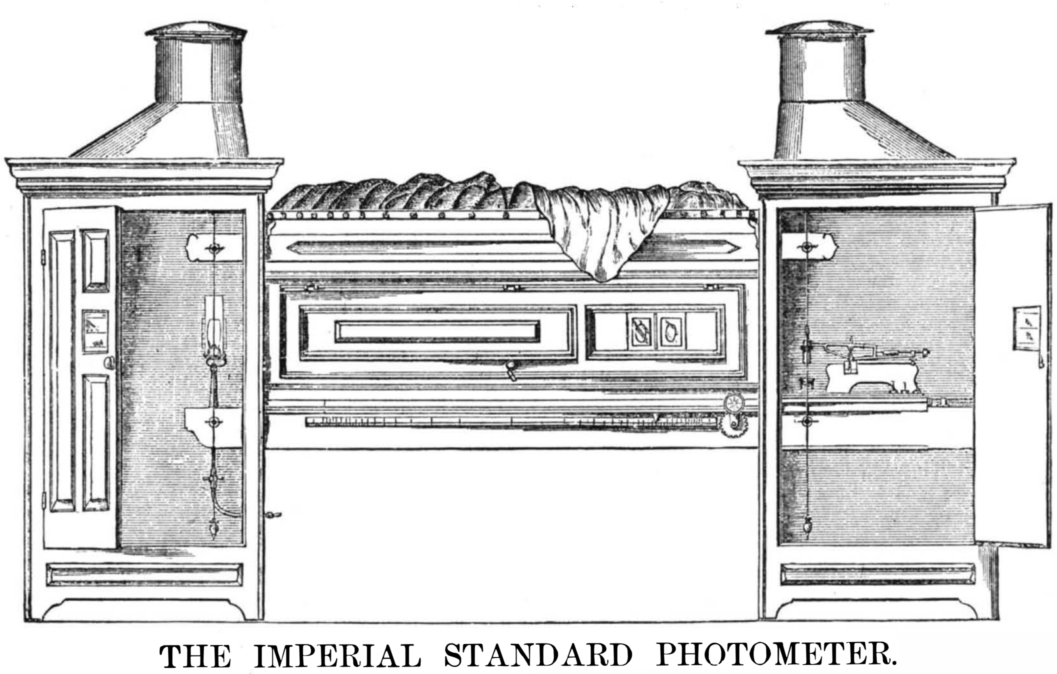
In preparing this branch of the subject for your consideration, it was found to cover too much ground for presentation at this time. The formulæ used for making estimates for the New York Steam Company are accessible in a paper by the speaker in the Proceedings of the American Society of Mechanical Engineers, 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 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 IMPERIAL STANDARD PHOTOMETER.

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 especially 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.

W. SUGG.

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.

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[Continued from SUPPLEMENT, No. 575, page 9182.]

[THE INLAND PRINTER.]

SOME TYPE WRITERS—THEIR ORIGIN AND USES.

By J. B. HULING.

A TYPE WRITER at once new and old is the Hammond. The inventor, Jas. B. Hammond, formerly of New England, but now resident in New York city, says he conceived his ideas years ago, before he knew any device of the sort had occupied the attention of others, but it is only within a comparatively few months that the arrangements for manufacture have been such that anything like sale to the general public could be attempted. The first patent was awarded in February, 1880, and the design of the machine was practically completed several years ago. Here and there a sale was effected afterward, as instruments could be made with the facilities possessed, till last fall. Mr. Hammond professes to have had from the first a standard that other inventors would seem to have discovered only after exposing their wares to use, and to have persevered to attain it, notwithstanding influences brought to bear to induce earlier sale and gradual improvement at the expense of the public. It is not to be denied that his type writer, though complicated, is constructed unusually well mechanically, and has more than ordinary claims for its execution. It has been put to tests based on experience with the best known among competitors, and satisfactorily endures criticism. At the cotton centennial exposition at New Orleans, last year, it received the highest medal. The illustration (Fig. 12) is large enough so that by reference to its parts it may be clearly understood. The apparatus is in a wooden case, with a removable cover. It is twelve inches from front to back, fourteen and a half inches from side to side, and six inches high, weighing gross about sixteen pounds and a half.

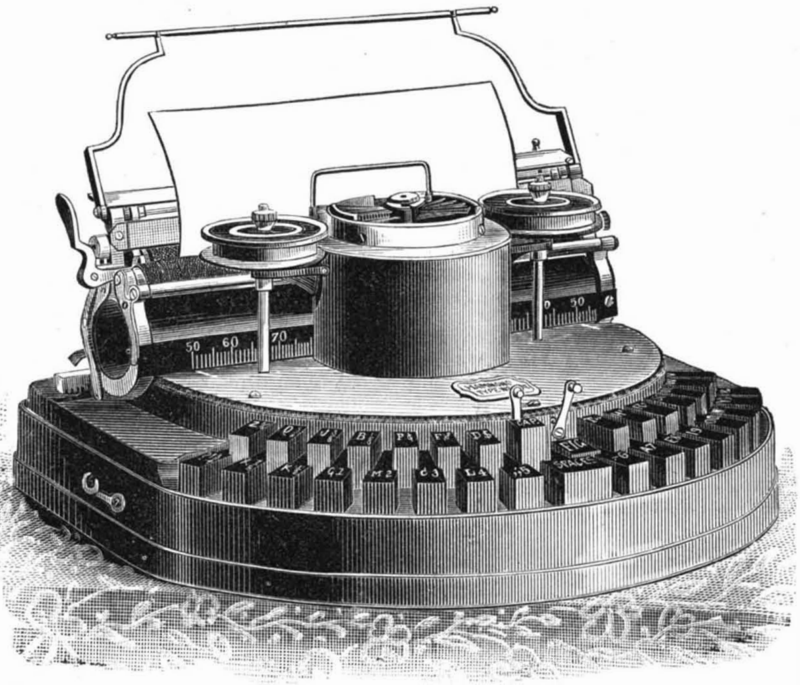

FIG. 12.

There are two banks of keys, and each of the thirty printing keys ordinarily carries three characters, two shifts being employed, one for capitals principally, and the other for figures and fractions. The keys are secured to levers, arranged in the bottom of the case, resting on a knife edge, and converging under the turret-like center piece shown in the center of the machine in the cut. This center piece is open at the top and at the side furthest from the operator.

Around its closed sides, hidden from view, is a frame holding a pin over each lever, and each pin has a spring about it to return it to position afteraction by its lever. In the middle of the center piece is an upright shaft, with two hard rubber sectors of a circle at the top, facing right and left respectively. These sectors are designated the type wheel, and the outer edges are flanged, the faces thus made having the characters in use produced on them. Fig. 13 is a reproduction of one style

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!ZXQKJGBMPCFLD; -TAHERISOUNWYV&
¾%⅞⅝½⅜1⅛2¢3℔4$5 6"7"8'9[0]¼*⅓†⅔

FIG. 13.

of type, and shows the size of the faces of the wheel, and the location, number, and nature of the characters on them. One type wheel is instantly transferable for another style. Below it, lying horizontally, is a stop arm, with one end passing over the row of pins described. The under side of each type segment has pins, which are acted upon by the vertical arm of the driver, the horizontal arm of which lies over the key levers. On each side of the center piece will be seen spools carrying the inking ribbon, which passes before the open side, and moves for impressions as in other ribbon-using machines, being reversible in action as well. The paper is carried in the horizontal tube behind the center piece, which is open at its upper side, and mounted on proper supports. On its front side, before the operator, this tube carries a scale to show the location of printing spaces. It derives motion from right to left from a coiled spring in a drum. Above and lengthwise of the tube are two rubber-faced rollers, one on each side of the opening, which may be pressed together to firmly hold paper. They are so adjusted as to move the sheets vertically and permit variable spacing between lines. Being open at the ends, the width of paper to be printed on is not restricted; and as they move with the tube in its entirety, a roll of paper may be set in and be unwound from. The carrying apparatus is immediately adjustable to any position on the line of printing, and may be set to print short lines. Back of the paper tube, rising from the center of the machine, and curving toward it, is what is termed the impression hammer, which holds an alarm bell. Above the rear roller on the paper tube is stretched from side to side a half inch tape of rubber, and over that is a metal plate to run the work to for corrections; and, higher than all, is the adjustable frame, shown in the cut, to support long sheets after printed on. To print, depress a key; this raises up the other end of its lever, lifts the corresponding stop pin, actuates the driver to work around the post its type segment as far as the stop arm and stop pin will permit, exposing the letter to be printed in the center of the open side of the center piece. The inking ribbon is opposite, and in front of that is a metal shield, with an orifice the size of a single character. The paper rises between the rollers described, and separates the rubber tape and the shield.

Behind the tape is the hammer, which is tripped by the furthest depression of the key, after the letter is brought and held to position, and springs forward, driving the paper through the shield against the ribbon and the letter on the type segment. The key released, the paper moves a space along the line by suitable mechanism. All of these actions are much quicker than may be imagined from the length of the description, for any single key may be operated eight or ten times per second. The longest printed line is eight inches and three-quarters, and has ninety-seven spaces. The type segments are cut specially, and all characters print in equal spaces. Unusual care being exercised in this regard, the work is close, and has an appearance of letterpress work not so visible in the printing of other machines similarly arranged. The space key is in the center of the board, and above it are the two shift keys, which may be locked for continuous printing of their characters. On order a machine is made with a third shift, adding thirty more signs to print from. Seven styles of type are offered, and one has two other sets of additional characters for the third shift. The machine is made in New York city, and the retail price is $100, including an extra style of type. Additional styles are sold at $5 each. The impression hammer is adjustable, to afford more force when manifolding is undertaken. The characters on the right and left sides of the key board are correspondingly arranged on the type segments, and touching two or more keys at once brings to the impression point only the character nearest the center. A distinguishing feature, as compared with other lever machines, is the nature of the touch. That of the Hammond the inventor defines a legato, and others are properly staccato. The Hammond's keys may be worked more nearly like those of the piano, the fingers resting on more than one key at a time, and no misadjustment occurring. In other lever type writers a quick blow is necessary, and but one key at a time may be touched lest some parts collide.

The Herrington type writer (Fig. 14) was patented several years ago by Messrs. Millison & Herrington, of Wichita, Kansas, the former gentleman being an old printer resident there. It was designed at first as a toy for the instruction and amusement of children, but recent improvements have increased its usefulness so that in the hands of some older folks it may do their work as well as might some type writers of more pretentious design. The cut shows the apparatus in case. The paper is inserted flat, and remains so. The ways carrying the type wheel, as shown, are hinged at one end to raise and admit paper, which they hold firmly when printing is in progress. The characters, forty-six in number, are arranged alphabetically on a strip of rubber, and put in the machine with their faces protruding through the rim of the wheel. Inside the strip, exposed to the operator, is a paper index, showing the location of the letters at the printing point.

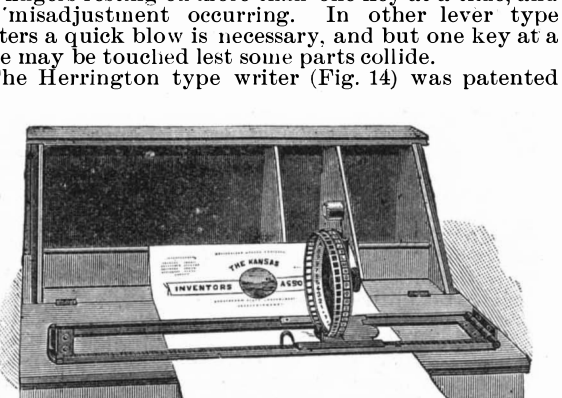

FIG. 14.

Ink is held on the felt roller at the top of the wheel. The printing is effected by twirling the wheel around by the button on the right side until the letter desired is at the under side, when pressing down completes the work. The paper is pushed or drawn forward by the hand, and the type wheel is actuated to successive spaces in the same way. The line of printing is eight inches in length, and paper may be held up to ten and a half inches wide. The whole device in box weighs a pound. The type wheel stands three inches high. The retail price is five dollars.

The "writing ball" of H. R. M. J. Hansen, of Copenhagen, Denmark, appears to be the only foreign competitor American type writers have. It is the invention of a clergyman, whose experience in having it made and put in the market has been about the same as our own inventors undergo. Patents were awarded it here in 1872, 1874, and 1875, but none has yet been manufactured on this side of the Atlantic. It was shown at the Philadelphia Centennial, and a gold medal bestowed for its merits. The only ones that may be seen are those sent for securing the patents, or which have been brought from abroad by tourists. The apparatus stands six inches high, seven and a half inches deep, and eleven inches wide—the paper carriage frame and its parts; and the weight is about eight pounds. The principal parts are brass, made by hand, rather too strong, we think, for the necessary purposes, unduly increasing the weight. A hemispherical shell is mounted on the mouth of a conical shell, inverted, and from the surface of the "ball" protrude the ends of a number of pistons, penetrating the interior, surrounded by springs, and directed toward the point of the cone, which is open an inch or so square. There are fifty-four of these rods, each of which has a cap for fingering, and on the lower end has a character cut. There are one alphabet, figures, points, and miscellaneous signs. These are necessarily cut each at its own angle on its rod, so that when pushed down it will print squarely and in line at one spot—the point of the cone. The framework underneath supports an "anvil" to receive the impression on. The pistons act swiftly, noiselessly, and easily, striking through an inked ribbon held on reels on either side of the letter orifice. The "ball" is supported by arms from the base, and hinges on one side, so that it may be lifted to adjust the ribbon, clean the letters, or examine the work in progress. The paper is held in a frame, which rests on guides, and is propelled by a coiled spring connection, being controlled and adjustable substantially as in other type writers. The length of the printed line is seven inches, and the paper may be eight and a half inches wide. The "ball" falls slightly under each impression, and releases the letter-spacing action. The machine has been modified a number of times in the paper holding and moving parts, having originally been arranged to take the unprinted sheets around a cylinder, which was actuated for letter spaces and lines by electricity. A number of these machines are said to be sold annually, principally in Continental countries. The work appears similar to that of ribbon-using machines generally. The top of the "ball" and all the keys may be covered by the two hands of the operator. A bell is attached to sound automatically four spaces from the end of a line. A scale is mounted behind the machine to show the location of impressions. Imported, singly, the cost has been nearly one hundred dollars each.

We cease our descriptions, having now given space to all of those machines which may be bought in the market, some of them, even, not being obtainable without much delay. It will be noticed that the oldest practicable American machine is just in its teens, yet knowledge of it is world-wide. That perfection is attained, those most familiar with type writers as they are would be the last to say. Distribution and exposure to general test and criticism have been most beneficial, as shown, spurring on older inventors to strengthen and increase the utility of their devices, and raising up a crop of new designers. Since 1875 the number of recorded patents in the United States in connection with type writers has increased from fifty to two hundred or more, and a goodly part of them are for complete machines, not for improvements only. The preliminary papers are filed on at least fifty more inventions in the same direction. Those later machines which are not in the market are, no doubt, kept back for the same causes that operated against the introduction of their earliest predecessors, some of which causes are now emphasized by the presence in the field of operating instruments. Existence of competitors enlivens the trade generally. Each new aspirant seeks to profit by the costly advertising of those who have gone before and helped to establish the universal demand, which was never so great as it is to-day. The facilities of all who can make any machines whatever are pushed to the utmost, and even then the foreign field cannot be canvassed for orders, for the entire output seems to be required for the trade of our own country. It is estimated that 50,000 machines of all kinds have so far been manufactured, and that about seventy-five per cent. of that number are in current use, the rest having been worn out or otherwise destroyed. The capacity of factories now employed in building type writers is from 10,000 to 15,000 machines per annum. With all the large demand, the expenses of creating it, and the cost of experimenting to bring the instruments even to their present excellence, have been so great that original investors have lost fortunes, and, with perhaps one exception, those financially interested now are depending on the future for returns. The defects yet to be overcome are considerable, though slight, of course, in comparison with the first obstacles. Experiments are in progress for the improvement of every style. Each passing day they are exhibited to new critics, and new standards of perfection are set up. There is less inclination to make allowances for weaknesses, however trivial, when the machine and its work, as a whole, are taken into account. One machine is measured by another, and combination of special merits asked for. Exaggerated and questionable claims of rival salesmen unduly excite expectations in the public which may never be gratified, as physically impossible. Some enthusiasts cry, "The pen must go!" which carries the matter to an absurdity, for type writers have a limit to their usefulness, not less than the printing press, and the pen is necessary notwithstanding. Others say that a perfect machine must be one which will print words in the usual characters as rapidly as shorthand notes are now made, not considering that the known type

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writers already are not operated so fast as they will act, principally from inability of the workmen alone.

Where the type writer has once been found really requisite, it will never be dispensed with. In the earlier years of their introduction the price seemed a barrier to many; and then every meritorious invention is at first looked at with skeptical eyes by a majority of observers. Like all complicated devices, type writers do have intrinsic weaknesses at first, and their advancement is often retarded by frequent changes in business management, and consequent shifting policies, while getting a place in public favor; but by improvements in construction and persistent offering in the market, their serviceability and usefulness become universally recognized, and honest criticism is vastly diminished. If a purchaser of any machine finds it not suited to his tastes or purposes, he seeks satisfaction among others on sale, always requiring one of some kind. One machine will not carry paper so wide as another; or it is not so portable; or it is easily disarranged by operation; or, while it will receive paper with facility, it does not envelopes or postal cards; or it inks by a ribbon, which fills up the type and lessens the sharpness of the print, besides being a source of some care and expense; or it is too costly in itself; or it calls for long practice to derive benefit from its possession—all these considerations, and more, have to be digested.

It may hardly be credited that most type writers sold and bought are with a single point of excellence obscuring nearly every other feature, and that point one which can never be accurately tested and positively asserted about. We refer to the matter of the "speed" of a machine when mentioned to convey an idea of the possible work an operator may turn out. Purchasers of any other machines, particularly those necessarily driven by muscular power, understand that there is a wide distinction to be made between maximum and average efforts. The power will slacken anyhow, if the machine, indeed, will endure running at its highest tension constantly. Then the character of the job in process of execution will affect the capacity of the machine and the application of the power. But buyers of type writers usually are those whose occupation has never brought them to make any investigation of machinery, and, therefore, their credulity is the more easily imposed on by designing salesmen, and their expectations of benefit from the possession of a writer are often destined to be very imperfectly gratified. Type writers are valuable and are bought for two reasons: 1, to do away with bad penmanship, and 2, to turn out work faster than with the pen. Ninety buyers out of a hundred, before purchase, may have the latter object in view to a greater extent than the former; after purchase, they find they have deceived themselves by believing too much what they have heard of exceptional performances, and they must rest content principally with the first specification. A square look at the facts in cases like this would reveal to venders that disposing of machines on extravagant and unwarranted representations will react to the injury of them and their wares, and be detrimental to all working in the same field as well; for a deceived customer will surely vent his feelings, and the machine stands to prove what he says. One of the first experiences of those undertaking to put a new type writer on the market is the receipt of anxious inquiries from individuals who own, or have owned or seen, earlier machines, and have personal knowledge that claims and promises have not been borne out. About the next experience is the receipt of requests from such correspondents for privilege to test the new candidate without pay, the natural inference being that the first machine was paid for before it was known, and afterward redress for complaints was not to be had at all, or only with further expense. Now, as such requests are frequently from distant points, and to meet each one would temporarily lock up a machine from possible positive sale, in the condition of limited output and inability to fill cash orders promptly, gratuitous trial has to be declined. Almost inevitably, by that necessary course, suspicions are aroused as to the worth of the new type writer, it being judged by its predecessors, and an opponent is thus made for all instruments of the sort. It is true that the adjustments of type writers vary, so that some will act more than twice as quickly as some others; for instance, one will cover about seven hundred spaces in a single minute when the space key alone is struck, while another will not cover over three hundred, similarly operated. Of course, continuous application with the care of composition obliges these figures to be largely discounted, as all familiar with type writers well know. If, however, an inexperienced intending customer hears, without details, the statement that a certain operator printed on a certain machine at the rate of one hundred and forty words in a minute, he would not willingly believe that average operators, taking average words, and using the same make of machine, can only maintain an average of from thirty to forty words a minute for any length of time, doing their work acceptably; yet the testimony of many competent observers stands in support of the accuracy of the latter assertion, and there is nothing definite or trustworthy to gainsay it. If a locomotive, under favorable conditions, may be run a mile in a minute, is it sold and bought to run sixty miles an hour? If a trained horse will run a mile in one and two-thirds minutes, may any horse run thirty-six miles an hour? The construction of one and the endurance of the other will fail. Why, then, should type writers be marketed as they are, with the implied promise that any purchaser may do, under any circumstances, continuously, what exceptional persons do under chosen conditions momentarily? The range and appearance of its work, the first cost, and the expense of maintenance, the facility of learning and operating, the simplicity of construction and likelihood of durability under steady use, these should be looked at first, and then if a purchaser has the advantage of clearness over handwriting, with less effort and an increase of output depending on circumstances for the amount up to double pen work, he has all he should expect. An examination of a machine will usually reveal its principal claims, and any machine may be had to examine on reasonable conditions.

Type writers have been of particular benefit to professional men, such as clergymen, lawyers, editors, and litterateurs, who usually are the most persistent pen-users; but in facilitating commercial correspondence they find their greatest usefulness, and thence arises the demand now not able to be met fast enough. Business men, in particular, have special reasons to wish for clearness in their papers, as monetary loss may often be caused by slight obscurities. When they can get more legible work in greater quantity, the gain is all the more appreciated. No large business house may be found in these days without a type writer of some kind. In public offices, for a long time, they could not be employed, except on certain work, owing to the fact that aniline inks were used on the ribbons, and the comparatively evanescent nature of these colors precluded their use in printing papers of permanent record; but this obstacle is out of the way, through the introduction of a special ink, and the number of machines in such service is daily increasing. To lawyers they have been of most marked aid, mainly through the ability to produce manifold copies at a single impression. If type writing has, in any direction, conflicted with printing, it is in executing legal work, where ordinarily but few impressions are desired. Out of the larger cities, attorneys have not been so ready to buy type writers, because of their original cost, and from the fact that operating them most efficiently requires constant practice; but newer inventions are doing away with those reasons, thus extending the distribution, and henceforth printers are more likely to be affected than ever. Will the time come when each printing office has a type writing machine, and executes jobs on it as well as on any other printing apparatus? Already several founders have cut letters in imitation of the imperfect ones of the type writers, so that printers may do jobs in the style of type writing, which are light in composition, but to have more numerous impressions than can be economically done otherwise than on printing presses. These fonts are not effectively used as they might be, for want of knowledge of the features of type writing on the part of printers, and frequent neglect of founders to supply proper directions for composition.

`This paragraph is printed with type cut in imitation of one used on the Remington type writer. The edges of the letters are a trifle rounded, to contribute to the thick appearance of work printed through a ribbon, and some of each letter in the font are cast out of line, either above or below, making the print to resemble work done rapidly on the type writer. While each line may be started even, time is not taken to calculate so that it will end so; hence type writer work always has a ragged appearance on the right side of the page. The space between lines is equal to that allowed for a line.`

Most conspicuously, the existence of type writers has contributed to encourage the study of shorthand, so that opportunities for instruction in that difficult art were never so numerous before. There are ten teachers for one formerly, and no institution educating in commercial matters is without one, while they find employment in many public schools also. Note-taking clerks are demanded in every branch of trade, and their services have been most potent in swelling the bulk of general correspondence and increasing the volume of professional papers. It is gravely stated by the justices of one of the higher courts that, so much easier is it to dictate to a shorthand clerk, documents submitted for examination nowadays are far more prolix than is necessary, and than they used to be prepared by attorneys themselves with the pen. And on account of the more time necessitated to comprehend their contents, decisions cannot be rendered so promptly as is desirable, and more officials should be had to reduce the docket.

The type writer has been used to record telegrams, but is not generally available therefor yet, owing to a variety of reasons. The noise of operation interferes with the telegraphic sounds, and the necessary attention to the writing mechanism retards reception. Then the frequent insertion of blanks is delaying, and the first cost of machines and the necessity of extended practice to become sufficiently expert, are the most important considerations in the way of wide adoption. Here and there operators are very successful, indeed, their individual abilities chiefly contributing thereto, however.

By making a suitable change of ink, original copies from any machine may be transferred to a gelatine pad, or to a lithographic stone, for extraordinary duplication. The common work is mostly copyable to a limited amount in the ordinary letter press and copying book.

In all of the larger cities a great many persons are employed as copyists in type writing altogether, usually in connection with shorthanders, who solicit all kinds of dictation jobs in the courts and offices, and even going to small business houses by the hour, where a permanent clerk could not be maintained. To become most proficient in this kind of work requires as much intelligence and practice as to pursue the common branches of printing, and but few operators really attain a high standard of excellence, principally for want of criticism such as is given by a proof-reader. One writer recommends those who would be nearest perfect to serve at least six months at printing. Much allowance has to be made in nearly every case for what would not be tolerated a moment in a job of letter-press work. It is a radical fault of the oldest key and lever machines, which are most in use, that they may be run much faster than is compatible with good work, and the operator cannot control this by any mechanical device. Hence the appearance of all their writing is more or less uneven. Part of a job or a page, or even a word, may not compare with the immediate context. The impression depends on the operator's touch, and that never is with exactly the same force successively. The broadest faced characters resist the touch the most, and may be fairly shown, while the thin faced ones and the points sink deeply into the paper, if, indeed, they do not actually perforate it. Then rapid work as may be done affects the stability of the working parts of the machine, and for the time being gives the printing an out-of-line appearance. If the machine is worked in that way for any considerable time, the parts become permanently misadjusted and the printing is all untrue. The work printed through a ribbon is necessarily thicker in its lines than that printed direct from type, but experiments have diminished criticism on that score. Nor is printing direct from type yet so perfect as experiment will make it. The greatest difficulty is in re-inking letters used in frequent succession, so as to maintain a uniform color in the job. Latest machines undertake to obviate this fault, and accomplish it fairly well.

Nearly every style of type writer has been used by blind persons. Whatever the special differences in construction, the ingenuity of the unfortunate operators has comprehended and overcome them all for the purposes designed.

Manifolding, or producing duplicate copies at once, in all type writers, depends on the ability to impress with force from hard faced type. It strains the construction of a machine according to the number of copies being taken. It is professed to be a capability of any style, yet, if to be done with any frequency, manufacturers want to be advised in advance of the delivery of the machine, so that it may be strengthened. A book of alternate white and colored leaves is made, and put in the type writer as a single sheet. Black is the ordinary color used. A paste, principally of pure carbon or lamp-black and tallow, is smeared on one side of a tough tissue paper, and hence arises the common designation of all transferring sheets as carbon paper. The colored side is put against the leaf to be printed on. The first or outside leaf is printed through the ribbon, and the inner white leaves receive a set-off from a colored one with each impression. Very thin or soft paper makes the best copies, and from three to six is the ordinary production. For special purposes thin oiled paper is employed altogether for duplicates, with double carbon sheets, setting off on both sides, the work being readable through the oiled sheets. The ribbon is removed to save its interference with the sharpest impression. From twenty to thirty good copies have been secured thus. Occasionally the set-off sheets are colored with some aniline dye.

Type-writer inks have a glycerine body, and usually are dyed with anilines. Purple is the brightest and most penetrating hue, and is the commonest seen. A pure jet black is very desirable, but has not yet been produced to work under the necessary conditions. Aniline colors fade, according to the exposure they have to light. In brightest sunlight an hour or two may see an impression vanish, while in a drawer or desk it might endure for years. Ribbons are sometimes used impregnated with black and glycerine, but the printing through them is not copyable. An "indelible copyable" ribbon is employed to some extent, the color of its work being a greenish blue.

It will have been seen that all type writers carry paper the width of half letter, at least eight and a half inches. As time is lost from writing whenever a sheet is returned for a fresh line, it is in the direction of economy to have the line the full length always. For that reason, half note sheets, if used, are written on sidewise, and printed headings set to correspond. A moderately sized paper shows general type writing best, the ink penetrating spongy surfaces, and not taking readily on heavy, hard finished stock. But letters copy in books best from the hard paper. On but one machine of consequence can writing be done on ruled paper readily and accurately, and even there is time lost comparatively with that. Therefore, ruled paper is not desirable for exclusively type writer work.

Every style of type writer will give some degree of satisfaction to somebody. For every one it cannot be said that the highest in price is the best, or that the cheapest is the worst. More depreciate from abuse, through unduly harsh usage or neglect to keep clean, than from defects in design and construction. The employment of mere boys and girls to run type writers in many offices, before they have had any training whatever in neatness and economy, is good for manufacturers for the time being, while they are making expensive repairs; but in the end the reputation of the machine suffers, for any business man who keeps incompetents engaged is certainly not reflecting enough to discriminate between good and bad treatment of a comparatively fragile piece of mechanism. He will blame the machine for the carelessness of the operator.

Contrary to the impression of many intending patrons,

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the purchase of a type writer carries with it no special qualifications to the buyer. If he writes slowly with a pen, he will not do work fast and well with a type writer. His thoughts will not flow more readily, if, indeed, the attention to a machine does not interfere with their usual fluency. He will not receive an education in grammar or spelling. His mistakes of all kinds in composition will be more apparent; and if he has forgotten any part of his early learning, and is sensitive, he will feel forcibly reminded to "brush up." For the information of those who may some time use a type writer, and are disinclined to recall or learn how to spell and compose, we will say that one with a fellow feeling has adopted the custom of putting "dictated" somewhere on his letters, thus conveying to correspondents the impression that he is rich enough to hire a clerk, and any errors are to be attributed to that person.

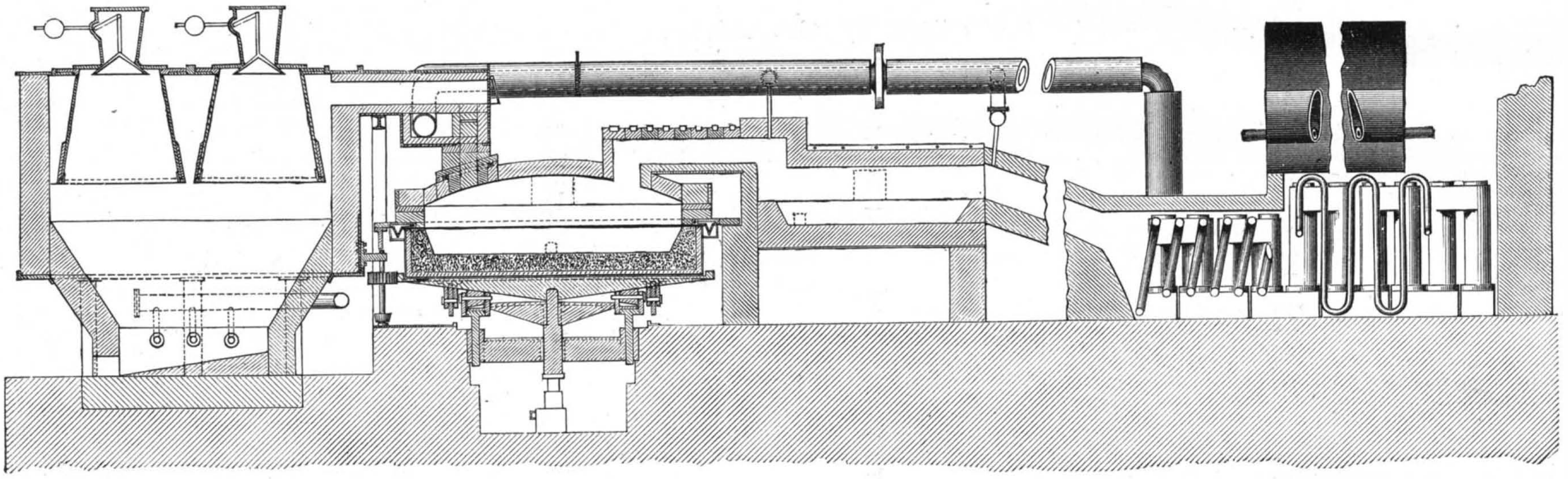
The use of type writers for private purposes is extending with the production of low priced machines, even if, as some argue, there is no personality in a letter in print. We predict that the time will come when seventy-five per cent. of the correspondence of the country will be done with type writers. When gummed envelopes were first introduced, challenges were sent by some who received them, on the ground that persons had no right to send their spittle to others. It was an insult. The fact that letters are printed, not written, will be forgotten by those who may now object, in view of the fact that what they read is clearer and not to be mistaken in any way.

IMPROVED DIRECT ACTING GAS FURNACE.

By James Henderson.

The principal parts are the gas producer, from which the flue of the inlet neck of the furnace is the outlet for the resulting gases, as well as the inlet into the heating chamber of the reverberatory furnace from which the gases escape by the outlet flue of the outlet neck of the furnace to a second heating chamber, and thence to the chamber containing an air and steam superheating apparatus beneath the boiler, and thence by the chimney to the external air.

The interior of the gas producer is formed of two fuel chambers; the upper one is fed with coal through the hoppers into two cast iron retorts, partially covered with fire brick, with a water circulating pipe at the bottom to prevent burning away. The retorts are attached to the covering plate of the producer, and project far enough down into the producer to meet the fuel in the state of incandescence. In these retorts the bituminous substances are distilled off, and the coal is coked by the time it reaches the lower part of the retort, by reason of the heat of the gases made below, acting on the outside in their passage to the furnace, and the radiation of heat from below. The fuel is seven to eight hours in passing through the retort, during which time there is a regular distillation of the bituminous substances of the coal; the moisture of the fuel and carbonic acid given off from the limestone pass through the highly incandescent coke at the bottom of the retorts, and become decomposed into heating gases, and mix with gases made from the coke by the air forced in at the tuyeres below.



HENDERSON'S DIRECT ACTING GAS FURNACE.

In operating the apparatus, kindling is charged in the producer hearth and coal is charged in by the hopper. The kindling being ignited, the fuel blower or blast engine is brought into action. The air from the blower passes by a pipe surrounding the producer, through branch pipes to the tuyeres leading into the hearth or lower fuel chamber of the gas producer, and acts upon the fuel in the gas producer, decomposing the fuel. The gases from the decomposition, rising up through the interstices of the fuel, escape by the gas flue and gas channels into the reverberatory chamber. The heat incident to the decomposition of fuel in the lower fuel chamber acts upon the fuel in the retorts, effects a distillation of the fuel, and causes the fuel to evolve gases, which pass around the retorts into the gas delivery flue and serve as an admixing supply to the gas from the lower fuel chamber. The lower fuel chamber is contracted at its bottom, so that a contracted hearth is formed, and the tuyeres are arranged to deliver air into this portion of the gas producer only, so that the fuel in the wider portion of the fuel chamber above the air inlets projects horizontally over the inlets for the entrance for air, thus insuring the passage of the air upward through the mass of the fuel.

The use of flux is a very important adjunct in working the gas producer, as it keeps the fuel free of ash and clinker at the point where it comes in contact with the air blast, so that the air constantly acts upon a clear surface of incandescent coke. This, combined with the use of a positive blast blowing engine and the retort in the top of the producer, which gradually distills off the volatile hydrocarbons, enables the working of the producer with precision as to the volume of gas made, which enables the determination of the amount of air required to burn it to produce the kind of flame required. Enough limestone or blast furnace slag is used to form a slag with the ash and clinker of the coal, to contain three parts of silica, two parts of lime, and one part alumina.

When it is desired to increase the production of hydrogen in the gas producer to the proportion of about one-third by volume to two-thirds of the volume of the carbonic oxide—which will be the case with fuels that do not produce hydrogen in this relative proportion—superheated steam is injected into the gas producer in a measured volume, at about one foot above the air tuyeres among the incandescent fuel, and is decomposed thereby to carbonic oxide and hydrogen. Perfect combustion of carbonic oxide cannot be obtained unless it is mixed with at least one-third of its volume of hydrogen, and as carbonic oxide burnt with air, under these conditions, gives greater intensity of heat than when solid carbon is burned with air, the advantages of its perfect combustion are readily seen. In order to produce the required quantity of hydrogen to mix with the carbonic oxide, with exactness, a small pump is attached by a belt to a pulley on the fly wheel shaft of the engine that supplies the air to the gas producer, so that at each revolution a known quantity of water is pumped, which is in exact relative proportion to the air supplied. More water is used with fuel like coke, which does not contain hydrogen, than with anthracite, which contains three per cent. The water thus pumped is conveyed through a pipe to the flue of the boiler, and through the flue to the chamber underneath it, and there connects with an iron coil and gradually passes into superheated steam, leaves the boiler chamber at the end nearest the furnace, and thence underground to the gas producer.

The combustion of the gases passing through the outlet neck is effected by air supplied by a distinct blast machine, from which the air passes to a receiver near it, to equalize the pressure, and thence to rows of iron pipes placed alongside the walls underneath the boiler. These pipes are highly heated by the spent gases issuing from the furnace to the boiler chamber, and the air becomes highly heated, and passes by a pipe overhead to the flue in the outlet neck of the gas producer. This flue, which is the outlet for the gas producer and the inlet for the heating chamber, is divided into a series of channels by means of walls of fire clay. Grooved recesses are made in the sides of the channels, and from these external air passages tuyere orifices are pierced vertically and obliquely forward, with their exit orifices opening into the central gas channels, so that the jets of air shall be projected toward the reverberatory chamber, so as to impel the gases toward said chamber, the air being discharged into the gas while the latter is in the gas channels. A branch pipe connects the furnace with the blast pipe, leads horizontally and turns vertically, carrying the air, to make it flow through holes in the roof at the end of a flue connecting the first reverberatory with the second reverberatory chamber. A valve is placed in the pipe, which, when opened, allows a portion of the air delivered to enter the second chamber, which, when the exact amount is supplied to give perfect combustion of all the gases produced, causes the flame in the first chamber to become reducing, and the unconsumed carbon in them is burnt by the residue of the air supplied to the second chamber; the temperature of the first reverberatory heating chamber and the proportions of reducing gases burned therein are thus regulated. The spent gases of the furnace are utilized for heating iron, raising steam and heating air and superheating steam, and contain more heat than can be utilized for purposes directly connected with the working of the furnace.

The improvement herein described. according to which the blast machine that supplies air to the gas producer and the blast machine that supplies the air for the combustion of the gases may be driven at variable speeds, enables the operator to produce a neutral flame, with the highest temperature that can be attained practically, by the use of the precise amount of air for perfect combustion, with the capacity of obtaining an oxidizing flame with an excess of air, and also of obtaining a reducing flame by supplying less air than is required for perfect combustion, and it also permits the variation of the air supply when the fuel varies in character.

The combination of the retorts in the upper part of the gas producer (which insures a regular supply of gases of uniform composition and temperature) with the gas channels, with diagonal air tuyeres arranged to burn the gases by means of air preheated in pipes by the spent gases, and supplied in exact and measured quantities for the production of gas and for its combustion, produces a great economy of fuel, accompanied with great intensity of heat, and realizes all the savings that are deemed possible in theory. With heated air in the exact amount for complete combustion, the temperatures obtained are probably those of theoretical calculation, viz., 4,350° Fahr., and a neutral flame is obtained, which enables the production of ingot iron. With one-half more air than is required for perfect combustion, the temperature is about 2,950° Fahr., by which articles exposed to such temperature appear dazzling white, and the flame is oxidizing. The use of this flame in this furnace, impinging on the metal, produces rapid decarbonization, so that gray pig becomes decarbonized to wrought iron in about twenty minutes after it melts in the furnace, while pig iron and desiliconized cast iron are converted to malleable iron if exposed in this flame and kept below the point of fusion, which is readily effected by adding just enough air to keep it at the required temperature.

The furnace shown in the drawing is arranged with a movable revolving hearth, which is rotated on wheels placed on a platform, which is raised in its position by a hydraulic jack. The revolving of the hearth exposes the whole of it uniformly to the flame as it issues from the gas delivery flue, and produces uniform temperature in all parts of the hearth, which insures uniform quality.

As in revolving hearth furnaces the brick above the joint, between hearth and roof, melt and drop on the hearth lining, and cause trouble, unless a small space is left for clearance between roof and hearth, which it is desirable to seal, as too much heat and gases escape outwardly through the joint; it is desirable to have this joint sealed, so that there can be no passage of either air or gases to or from the furnace. This is obtained as shown in the drawing, wherein the joint is closed by the V-shaped downwardly projecting lip filled with water and connected with a water chamber in the cast iron ring plate on which the roof rests. The rapid circulation of water in the ring plate prevents injury to it when the flame passes to it through the open joint; the lip dips far enough into the sand box on the side of the top of the hearth to seal the joint.

The hearth is revolved about once a minute by a small engine, and is horizontal, and rests upon wheels in brackets on a platform, and revolves upon them. There are wheels also on the hearth, which, when the platform is lowered, rest on tracks, over which the hearth can be run out sideways.

A spare hearth is desirable, though not essential, so that one may be used with sand when the purer sorts of metal are used, and the other may be lined with ore or lime when it is desired to dephosphorize the metal; it is kept in repair with same facility as in stationary hearth furnaces, as there is no wash or friction from the metal as in furnaces that puddle the iron mechanically, and there is consequently the saving of time for repairs, which obtains with mechanical puddlers with hearths revolving at angles, amounting to several days in the Pernot furnace.

The vapor of water in the state of dissociation in the flame of this furnace effects the conversion into steel in less than one-half of the time it can be machine-puddled on an inclined Pernot hearth, with the flame of a regenerative Siemens furnace.

The roof is arranged so that repairs may be made without stopping the furnace during the week, if it is preferred to use an overhead traveling crane to attach to the ring plate and lift the whole of it away and replace it with another ready for use, kept in reserve; or, as soon as work is over on Saturday, the roof, when worn out, may be removed and another put in its place and got ready in time for use the following Monday. Twelve hours suffice to heat the roof hot enough for use. The entrance flues are arranged so that repairs may be made to them with short delay. During the week these bricks may be removed without disturbing the other part of the roof, which is held in place by the cast iron water frame shown in the drawing, into which lining vertical flue bricks fit to correspond to the flues in the neck of the furnace. These bricks stand the heat of the furnace, if made of fire clay, about nine days; if made of sand, about three months. About the equivalent of 170 bricks of common size are used. The water ring plate is covered with two courses; the lower course is 5¾ inches thick, with a 3 inch lip which overhangs the water plate of the roof and protects it from flame. There is another course of 3¼ inches, which, when removed, enables the brick under it to be replaced by another, so that when unusual or irregular wear takes place, these bricks may be removed separately without disturbing others or stopping the furnace, and may be done at casting time. These bricks average two weeks' use, of which there are, with outlet flue bricks, which last about the same length of time, about 1,765 equivalent to common size. Fire clay bricks are here estimated.

The roof requires 1,975 bricks, and lasts about four weeks, with good fire clay brick. The part of the second chamber, three feet from the exit flue of first chamber, lasts about six weeks and requires about 560 bricks. The remainder of the roof of this chamber remains good for three months, and requires 1,070 bricks for renewal. These relate to the use of vapor fuel. When coal is used in the gas producer the hearth lining requires about 1,500 bricks for renewals every six weeks. When pig and ore are used the hearth requires 2 cwt. of sand per ton of steel, and when pig and scrap are used about 1 cwt. for renewals of hearth.

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The cost of refractories, then, for this furnace is about 20 cents per ton of steel with pig and scrap, and 40 cents where pig and ore are used.

When it is preferred to use natural combustible gas or vaporized petroleum, the gas producer outlet flue may be bricked up and the gas introduced into the flue, or the gas may be delivered into the producer, which should be hermetically closed and the flue opened, the producer being used as an expansion chamber when gas is introduced under high pressure. These kinds of fuel are fed in measured volume to the furnace, and are ignited in the flues leading from the producer to the furnace with measured volumes of heated air heated in the blast pipes, as hereinbefore described.

The gas producer should always be attached to the furnace to prevent stoppages from any failure in the gas supply, and to regulate the price of natural gas below the cost of the cheapest available coal and labor of fueling of the locality.

This furnace gives exceptional facilities for the production of steel castings, as the metal may be tapped from the hearth just as it is wanted, leaving the remainder hot in the furnace, which is desirable for small castings. It can be built of any required capacity ranging from 2½ to 12½ tons per cast.

THE FLAME PROCESS.

This invention is founded on the discovery that the purification of iron may be obtained by flame alone when combustible gases are supplied in the exact chemical proportions in which they are required for combustion, and brought together in such a manner that the different molecules which have to enter into combination may readily do so. This is accomplished by the arrangement of the furnace previously described, which produces a homogeneous flame in the connecting flues of the producer with first heating chamber, and by causing the inflamed gases to impinge on the iron, produces dissociation to their original elements, and thereby rapidly effects the purification of the iron. Pig iron exposed under these conditions below the melting point becomes decarbonized and partially dephosphorized without being melted, which, if continued long enough, will become oxide of iron, without any change in size or form; but for practical use it is more economical to melt the iron, and thus make homogeneous iron or cast steel, which may be poured or run from the hearth and cast into ingots, which roll direct, without blooming, to required shapes. This is done in one-fourth the time with flame alone, or in one-eighth the time when reagents are also used, that is required in the regenerative furnace, and all of the carbon, silicon, sulphur, and phosphorus may be removed, and the phosphorus and sulphur be recovered as by-products, and the heat produced by the chemical reactions be used for heating uses.

Four patents were granted to me for flame processes in 1883, of which No. 283,483 is for the flame with basic reagents, with or without basic lined hearths. No. 283,484 is for the use of flame alone, without basic reagents, and with or without basic lined hearths. No. 284,550 is for annealing iron or steel exposed in this flame. No. 284,551 is for "purifying solid iron and steel, producing therefrom malleable iron or steel without fusion."

Further information may be obtained by addressing the author, Mills Building, New York, care of Chas. G. Francklyn.

PHOTOGRAPHY UPON WOOD

VARIOUS processes of direct photographing upon wood have been much used for some time past, which permit skillful engravers to perform their work directly, without the intermedium of a drawing.

In the *Bulletin de la Societe de Photographie*, Mr. E. Frewing describes the following method, which he says gives excellent results.

The wooden blocks are prepared as follows:

Preparation.

Gelatine	180 grains.
White soap	180 "
Water	21 fl. ounces.

The gelatine is allowed to soak in the water for a few hours, and is then dissolved in a water bath. Then the soap, cut into small pieces, is added, and the whole is stirred with a glass rod so as to make a perfect mixture. Next, powdered alum is added until the froth disappears, and the liquid is finally strained through muslin.

The block of wood is covered with this mixture and a little zinc white, and is afterward wiped off so as to leave but a very thin film. The operation is finished by a gentle rubbing, so as to render the film very even. After the film is dry, the following composition is applied with a badger's hair brush. This latter should be quite wide, since sometimes, if great care be not taken, and the operation be not performed quickly, lines are visible on the finished image. It will suffice to give one coat by passing the brush from one end to the other. After this the surface is allowed to dry.

Composition.

Albumen	13 fluid ounces.
Water	10 " "
Sal ammoniac	270 grains.
Citric acid	75 "

The albumen is whipped to a froth, and then allowed to settle. It is the limpid portion that is used. The water is added, and then the sal ammoniac, and the whole is carefully stirred with a glass rod. Finally, the citric acid is added. When the block is dry, it is ready to be sensitized.

Sensitizing Solution.

Nitrate of silver	750 grains.
Distilled water	13 fluid ounces.

A small quantity of this liquid is poured upon the block and spread with a glass rod, and the excess is placed in a bottle, to be used again after filtration. When once dry, the block may be exposed under a negative. The print should be exactly of the tone desired, since the image loses nothing in the following operations. When the print is obtained, the wood is placed face downward for three minutes in a bowl full of very salt water.

This operation slightly weakens the image. The block is next washed under a stream of water, and the image is fixed in a saturated solution of hyposulphite of soda by placing the block face downward in a bowl containing the liquid. After this the block is washed for about ten minutes under a stream of water, and is next dried, when it will be ready for the engraver. If desired, the image may be reversed by any of the methods generally used. In practice, this process will be found to be good, rapid, and simple, and to give fine results. It is well adapted for engraving on wood, in that it offers no perceptible layer, and that the image is clean and sharp.—*Le Genie Civil.*

FUEL CALORIMETRY.

By B. H. THWAITE, F.G.S., C.E., etc.

ALTHOUGH instruments for the precise value measurement of most of the agents of our industries have long ago been utilized, the heating value of the great natural source of power—coal—is rarely tested even by the largest consumers.

Occasionally quantitative analyses are obtained, but this method is expensive, and is neither so practically exact from a thermic estimation point of view, nor so useful, as a careful calorific estimation by actual combustion would be.

At present the different qualities of coals are known by the name of bests, seconds, etc., whereas a calorific estimation might show that the seconds, or even qualities more inferior, possessed a higher calorific efficiency than the firsts. By the utilization of fuel calorimetry, a user of coal would be able to ascertain exactly the financial value of the definite amount of heat energy of different fuels. He would also be able to compare the heat energy possessed by the fuel with that economically evolved in his steam generators. For the character of his fuel the user would not have to rely on the *ipse dixit* of his boiler firemen, who are not always proof against tempting bribes. If his steam generator was of the usual wasteful kind, he would realize the cost of the defect in a most telling manner. Consequently, fuel calorimetry would prove a strong inducement to the adoption of more perfect combustion arrangements, and thus aid the laudable objects of the Smoke Abatement Society. Dulong was the first to design a scientific calorimeter, in which the fuel was consumed in a current of oxygen. This instrument was greatly improved by Favre and Silbermann.

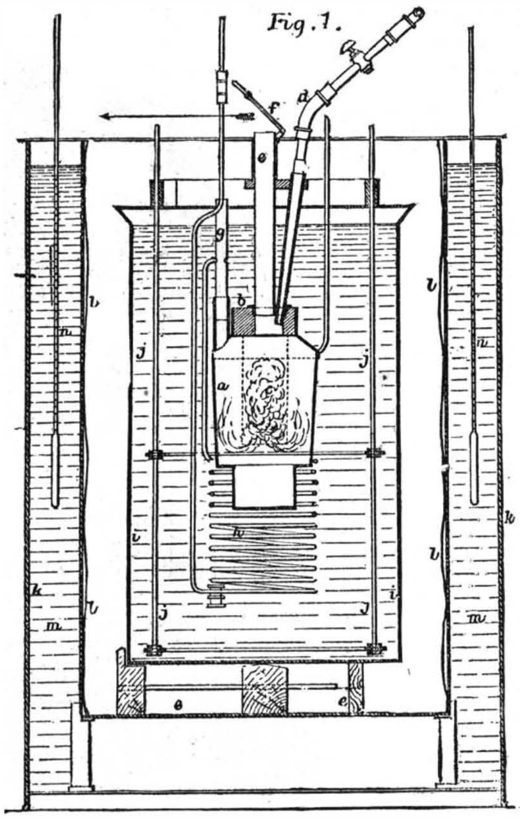
The disadvantage of Dulong's system is that the combustion absorbs a considerable period of time, and consequently requires a notable correction for re-cooling; besides, owing to the fact that unless the oxygen is applied by compression, the instability of carbon dioxide in the presence of carbon prevents the entire oxidation of the carbon, and part of the gases escape as carbon monoxide with a consequent loss of heat energy. Owing to the defects enumerated of the Dulong calorimeter, his, Dulong's, measurements are not so exact as one might desire.

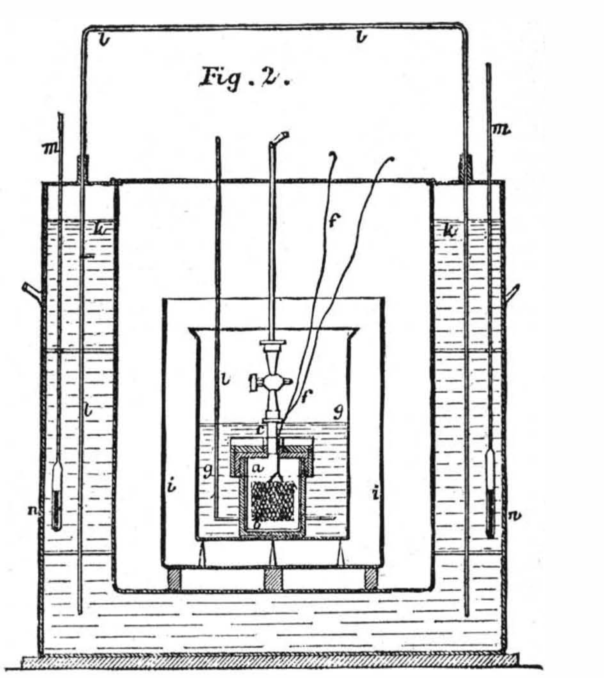
In the ingenious and carefully designed apparatus of Messrs. Favre and Silbermann, the gases resulting from the combustion of fuel are deprived of the carbon dioxide and passed over cupric oxide for the estimation of the weight of carbon monoxide, but even this supplementary estimation does not allow of an absolutely exact correction to be made. Nevertheless, the arrangement of Favre and Silbermann's calorimeter reflects high credit on these distinguished chemists, but the complication and delicacy of the instrument render it unsuitable for ordinary fuel calorimetry.

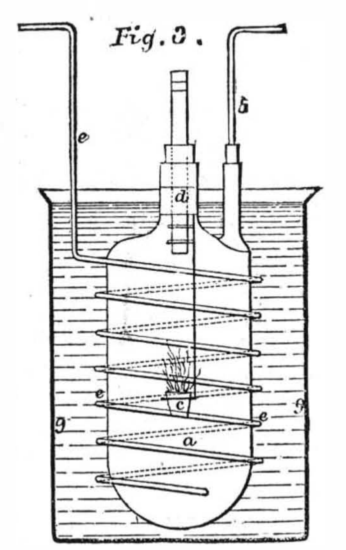
Referring to the engravings, Fig. 1, which shows a section of Silbermann's ingenious calorimetric instrument, *a* is the combustion chamber of thin copper, silvered internally; the cover, *b*, allows the insertion of the platinum cage, *c*, in which the fuel to be tested is placed. The oxygen for supporting combustion is supplied to the fuel by means of the pipe, *d*.

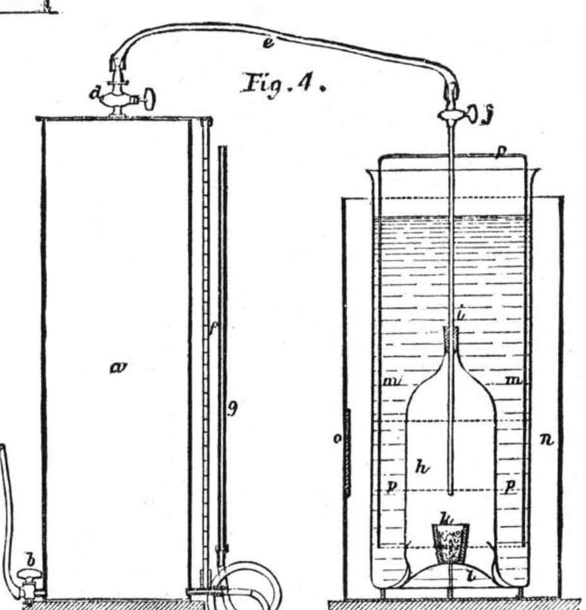
The progress of combustion can be watched by means of the ignition tube, *e*, and reflector, *f*.

The products of combustion escape by means of the outlet tube, *g*, and their sensible heat, resulting from combustion, is absorbed in the passage of the gas through the copper coil condenser, *h*, finally escaping by means of the pipe, *p*. The whole of the parts enumerated are submerged in a thin copper vessel, *i*, silvered internally and filled with water, which is well circulated by means of the agitator, *j*.









This copper vessel, *i*, is placed in an external annular vessel, *k*, lined inside with swan's down, *l*, the annular space, *m*, being filled with water. Openings in the covers are provided for the insertion of thermometers. The ignition can be effected either with an electric spark, the combustion of a given length of fine iron wire, or by a fuse; and as soon as the ignition is effected, the supply of oxygen is commenced and continued until the fuel is entirely consumed. The difference of initial and final temperatures of water and the weight of the water are then noted, and the calorific estimation is thus attainable.

Mr. Lewis Thompson, M.R.C.S., designed some time ago an exceedingly ingenious apparatus by which he obtained the oxygen for fuel combustion from potassium chlorate and potassium nitrate intimately mixed with the fuel in a finely divided condition. The mixture is ignited with a fuse.

Ingenious as this process undoubtedly is, it nevertheless contains serious defects, inasmuch as the dissociation of the potassium chloride generates heat, and heat is, on the contrary, absorbed by the expansion of the oxygen from a solid to a gaseous condition to the normal atmospheric pressure, and the dissolution of the residual potassium chloride also absorbs heat, so that to arrive at accurate results considerable corrections have to be made.

Berthelot mentions that in the hands of Mr. Stohmann the solid oxygen arrangement has been greatly improved and increased in accuracy; indeed, the concurrence of the results of Mr. Stohmann's experiments with those obtained by Berthelot with his compressed oxygen apparatus are confirmatory of this.

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Berthelot and his confrère Vieille mention the use of potassium perchlorate, intimately mixed with the fuel, the combustion to be effected in a confined atmosphere of oxygen. By this system the intervention of the heat of the dissolution of potassium choride would be avoided, and combustion would have been effected at constant volume; but after serious consideration Messrs. Berthelot and Vieille decided to confine themselves to the use of oxygen *per se* in a gaseous form as the oxidizable agent in their calorimeter. In the use of gaseous oxygen the single difficulty to be overcome is the realization of the complete oxidation of the fuel without the production of a trace of carbon monoxide or of hydrocarbons. This difficulty has been successfully overcome by the use of pure oxygen compressed to about seven atmospheres, and with a weight of combustible such that the proportion of oxygen consumed does not surpass 30 or 40 per cent. of its initial quantity. The air is forced into the small combustion and strongly formed mortar-shaped vessel by means of a force pump.

Referring to Fig. 2, representing Berthelot's latest form of calorimeter, *a* is the special gaseous explosion or combustion bomb or cylinder of steel internally lined with platinum; *b*, a special screw-down cock, allows the oxygen to enter the bomb by the pipe, *c*, when it is compressed by means of a force pump to a pressure of seven atmospheres.

A special key is provided by which the head of the bomb can be rigidly forced on it. The fuel to be tested is placed in the platinum basket, *e*, suspended by thick platinum wire; the fuel is ignited by an electric current passed by the conductors, *f*. The combustion bomb is immersed in a platinum vessel, *g*, provided with a lid or cover, *h*, perforated to allow the insertion of a thermometer. The outside of the annular casing is lined with felt, *n*.

Berthelot's first experiments, embodied in his "Essai de Mecanique Chemique," were obtained with a different arrangement of combustion vessel, shown in Fig. 3. Into a vessel of glass, *a*, a tube, *b*, also of glass, led the oxygen for the combustion of the fuel, which was placed in a cage of platinum, *c*. The ignition was effected through a special corked opening, *d*, through which the fuel cage could also be passed; the products of combustion released their sensible heat in traversing the serpentine coil condenser, *e*, to the water in platinum vessel, *g*, the products of combustion finally escaping (for subsequent analysis if desired) by the pipe, *e*. The whole apparatus was placed in an ordinary external calorimetric vessel, as shown in Fig. 2.

The advantages obtained by this new arrangement are that the calorimetric measurement can be performed in from three to four minutes, while the actual combustion only occupies a few seconds. A very small quantity of water is required, so that the temperature attains the highest degree, and this increases the precision of measurement. The residuum is not, judging from critical analysis, found to contain any residual gases. The ignition is effected by the passage of an electric current through a platinum wire and to a platinum cage in which the fuel is placed.

With this instrument Messrs. Berthelot and Vieille have established the calorific value of the most important heat-generating hydrocarbon elements. The figures are given in the *Comptes Rendus* for May 31 last. The disadvantage of this exceedingly precise instrument is its cost, which is very high. This calorimeter can be obtained from M. Golas, of Rue St. Jacque, Paris, who makes Berthelot's splendid instruments of precision.

Mr. W. Thomson, F.C.S., of Manchester, has lately improved the Lewis Thompson calorimeter. He also utilizes gaseous in preference to solid oxygen, and applies this agent in a very simple manner; and so far as the author can judge, the instrument appears the most satisfactory for popular use, as it will be decidedly inexpensive. It may not be entirely free from the defect mentioned in the use of oxygen at atmospheric pressure, *i. e.*, the incompletion of combustion; but for every practical purpose, the instrument is all that could be desired. Referring to Fig. 4, showing a section of the calorimetric apparatus designed by Professor William Thomson, F.C.S., *a* is the oxygen holder of galvanized iron and also internally black varnished.

The displacement of the oxygen is effected by means of water (under pressure or from an elevation) which enters the holder through the tap, *b*. The oxygen displaced escapes at the top of the large tap, *d*, from which it is led to the calorimetric apparatus by the India rubber tubing, *e*. The volume of oxygen displaced in holder is indicated by the gauge glass, *f*; the second glass tube, *g*, is intended to show the pressure of gas by the difference of levels in the two tubes.

The oxygen enters into the calorimeter combustion vessel, *h* (which is simply an inverted bell glass), by means of a brass tube, *i*, of a small caliber, and provided with a regulating tap, *j*. The fuel to be tested is placed in the platinum crucible, *k*, which is in its turn placed on a pipe-clay support resting on a spring framework, *l*, which is attached to the sides of the inverted bell glass, *h*. The latter is placed in a thin glass beaker, *m*, of a capacity of 2,000 c. c., filled with water, which of course cannot enter the inside of inverted bell glass until the tap, *j*, is opened and the oxygen tube disconnected.

The beaker is set on corks inside a bright tinned sheet iron outside vessel, *n*, which has in its side a glazed orifice, *o*; through this the progress of combustion can be watched. The water in the beaker can be well circulated by means of the agitators, *p*. The ignition fuse is prepared as follows: Two or three strands of lamp wick are soaked in a solution of potassic nitrate and dried.

The *modus operandi* when using the Thomson calorimetric apparatus is as follows:

One gramme of coal having been weighed, it is then placed in the platinum crucible; 2,000 c. c. of water are then poured into the beaker, and the temperature taken.

The crucible is now placed on a spring clip frame which is attached to the mouth of the bell glass; the ignition fuse is then lighted and the apparatus is then immersed in the water. The oxygen supply is commenced and continued until the completion of combustion. During the test the water should be well circulated by means of the agitators. The oxygen supply tube is pushed into the mouth of the crucible toward the termination of combustion, and a circular motion is given to the tube by the hand until the fixed carbon of the coal is entirely consumed.

The water in the beaker is now allowed to enter the inside of the bell glass, by which the heat from the crucible frame and oxygen supply pipe is abstracted, and after the water is well circulated the final temperature reading may be taken. The difference between the final and initial temperatures of the water represents, of course, the heat due to combustion; and without any deduction for recooling or for imperfect agents having to be taken into account, it will be seen that this process is adaptable for the use of unscientific persons.

The author suggests that the standard marketable or sale value of coal should be expressed in the weight of fuel in decimals of a pound required to raise 1 lb. of water to 212 deg. Fah. or 100 deg. Cent. from an initial temperature of 77 deg. Fah. or 25 deg. Cent.

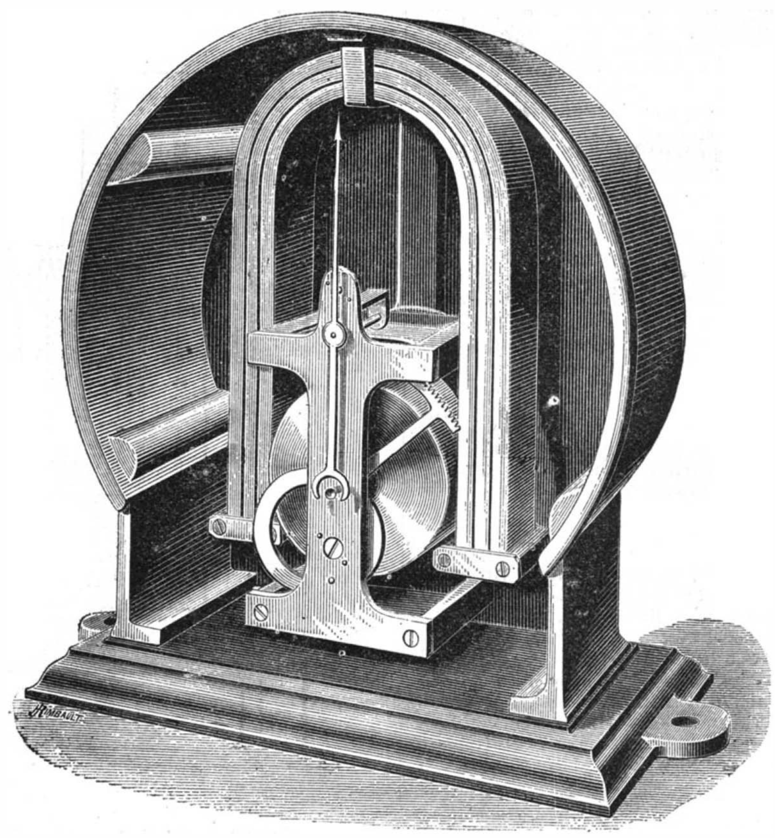
An instrument such as that designed by Professor Thomson ought to be adopted as the standard calorimeter to be used. The general adoption of this fuel calorimetric system would undoubtedly conduce to greater economy in the use of fuel and in the prevention of smoke and fogs, and these desiderata would be attended with sanitary and other self-evident advantages.—*Engineering.*

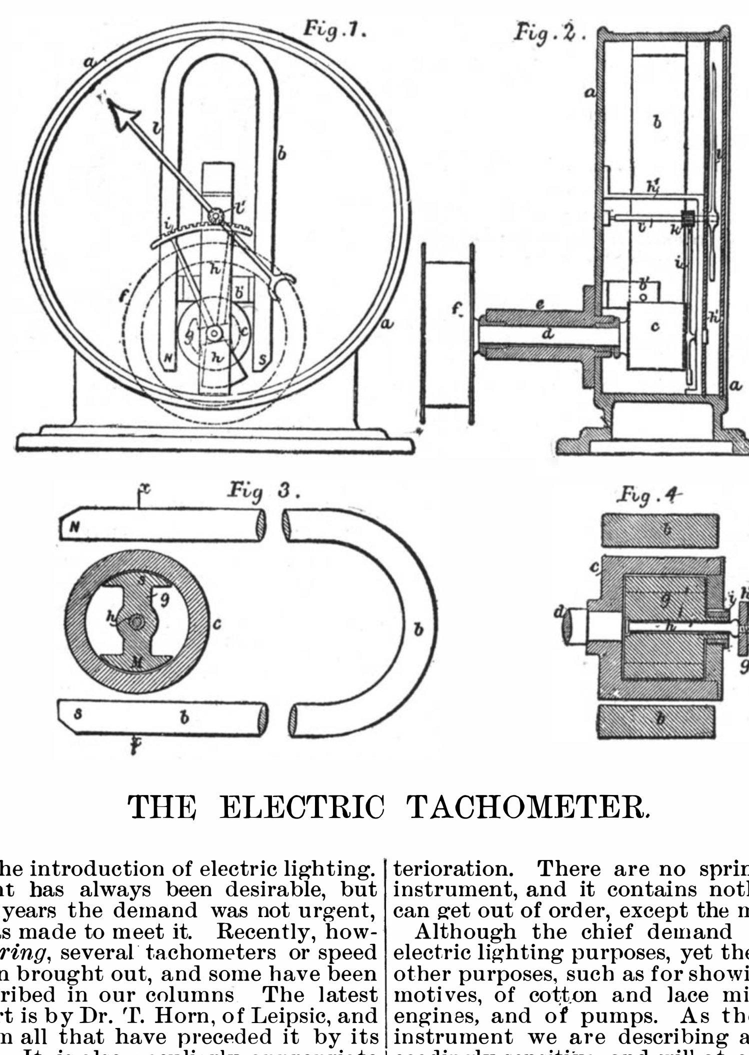
AN ELECTRIC TACHOMETER.

THE need of an apparatus which will show at a glance the speed of a rotating shaft has been greatly emphasized since the introduction of electric lighting. Such an instrument has always been desirable, but until the last five years the demand was not urgent, and little effort was made to meet it. Recently, however, says *Engineering*, several tachometers or speed indicators have been brought out, and some have been illustrated and described in our columns The latest invention of this sort is by Dr. T. Horn, of Leipsic, and is distinguished from all that have preceded it by its extreme simplicity. It is also peculiarly appropriate for use in an electric light installation, in that it is itself a simple form of dynamo machine. We illustrate its construction by the engravings above, the perspective view showing the indicator with the dial and index removed, and the other views giving details of its construction. A powerful horseshoe magnet, *b*, stands astride of an armature, *c*. This armature consists of a ring or pulley of copper (Fig. 4) mounted on a spindle, *d*, which is driven by a band from the shaft the speed of which is to be measured. Now when this armature is rotated within the field of the magnet, electric currents are formed in its body, just as in the case of a Gramme ring, except that here they circulate in the solid metal and not in insulated conductors. Within the copper ring there is mounted on the spindle, *h*, a soft iron bar, *g*, the section of which is shown in Fig. 3. This bar is constrained by the magnet, *b*, to take up an axial position between its poles, and to form a direct path for the lines of force between the poles, N and S. But immediately the ring, *c*, commences to revolve, another force is brought to bear on the bar. The currents in the copper tend to rotate the bar, *g*, on its axis, *h*, and thus it moves from its horizontal position until it finds a point at which the influence of the magnet is exactly balanced by that of the current. An arm on the spindle, *h*, carries a curved rack, *i*, which gears with a pinion on the index spindle, *b'*, and thus the movement of the bar is greatly magnified upon the dial. The strength of the currents is proportional to the speed of rotation, and the divisions of the dial are uniform.

The accuracy of the indicators is not dependent (within limits) on the strength of the magnet, because the two forces acting upon the bar are derived from the same magnet, and vary together, decreasing together if the magnetic power should suffer any deterioration. There are no springs or weights in the instrument, and it contains nothing whatever which can get out of order, except the main bearings.

Although the chief demand for tachometers is for electric lighting purposes, yet they are useful for many other purposes, such as for showing the speed of locomotives, of cotton and lace mill engines, of marine engines, and of pumps. As the moving parts of the instrument we are describing are very light, it is exceedingly sensitive, and will at once disclose the faults of a bad governor. It is also made as a tachograph, and produces a diagram of speeds on a continuous ribbon of paper. Dr. Horn's tachometers have been used at the Colonial and Indian Exhibition, by Mr. W. H. Preece, at Woolwich Arsenal, and at various other establishments, and have given great satisfaction. The proprietors are James Thorne & Co., 85 Gracechurch Street.





THE ELECTRIC TACHOMETER.

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SOME FEATURES OF THE RECENT EARTHQUAKE.

By W. J. McGEE.

SOME knowledge of the local topography and geology in the vicinity of Charleston is essential to a complete understanding of the effects of the great earthquake.

The seaboard portion of the coastal plain, upon which Charleston, Summerville (twenty-one miles to the northwest), and the other towns most seriously affected by the recent catastrophe, are situated, is a nearly uniform plain from ten to thirty or forty feet in altitude, slightly inclined seaward, and diversified by broad, irregularly meandering, and inosculating troughs and pondlike depressions from five to fifteen feet deep. The depressions, or "low grounds" as they are termed colloquially, are frequently swampy, and toward the ocean merge into the tidal channels of the coast; but when above the reach of the tide, they are lined with a rich semi-alluvial soil, either supporting luxuriant arboreal vegetation or producing abundant crops; while the uplands constituting the plain proper (the "high grounds" or "pine barrens" of the rural population) have a light, sandy soil little charged with humus, and are naturally forested, chiefly with pine. This slightly accented topography is not the product of sub-aerial erosion and deposition, but was fashioned by oceanic waters as the land emerged from the sea; the high grounds representing the slightly sloping beaches, and the low grounds the tidal canals and estuaries of an epoch during which the land stood from ten to thirty feet lower than now. Summerville is an aggregation of suburban residences irregularly scattered about in a pine forest on the uplands, and is probably the most elevated point in its longitude between Cooper River on the northeast and the Ashley on the southwest. Ten Mile Hill (midway between Charleston and Summerville) is on the eastern margin of the same upland, overlooking an irregular depression connecting these rivers; while Charleston is located on the extremity of a peninsular prolongation of the plain, bounded on the northeast and southwest respectively by the Cooper and Ashley rivers, which, by reason of the seaward tilting, is elevated but a few feet above tide.

The geologic structure is remarkably simple, and when the formations have been thoroughly investigated and definitely correlated with those of other portions of the coastal plain, will doubtless be found wonderfully uniform over a considerable area. The superficial deposit in the uplands is obscurely stratified fine yellow sand or (rarely) mottled clay, reaching a depth of from five to fifteen feet. Beneath this member, and frequently immediately beneath the soil in the low grounds, occurs a bed of fine clayey sand or silt, generally bluish in color. This stratum commonly contains sulphurets and various salts, either free or quickly liberated on oxidation. It is from ten to thirty or forty feet thick; the precise thickness being difficult to determine, partly because of the local thickening due to depressions in the subjacent surface, and partly because of the impossibility of separating it from the superjacent member; indeed, the superior sand appears to differ from this mainly in the greater amount of oxidation which it suffered. In the low grounds, and along the coast generally, these sands are overlain or replaced by estuarine alluvium consisting of fine blue silt or clay, locally designated "pluff mud;" for the land is now subsiding (and apparently most rapidly southwestward), and sedimentation is advancing upon the land. Beneath these superficial deposits occurs the commonly recognized "marl bed," at the summit of which the South Carolina phosphates are found. The superior strata of this marl bed in some isolated areas have been referred to the later tertiary by Holmes and others; but by far the larger portion of the mass represents the formations made classic by Tuomey under the names of "Ashley and Cooper beds" and "Santee marls." These formations consist of a somewhat variable but nevertheless remarkably uniform succession of marls, clays, and sands, extending to a depth of about six hundred feet, where they are underlain by petrographically similar cretaceous deposits, increasing in heterogeneity somewhat downward to two thousand feet below the surface. At this depth a good supply of artesian water has been obtained. The structure at greater depths is not certainly known; but, according to Hall, the fossils from the lowest strata reached by the artesian borings indicate that a considerable thickness of cretaceous strata are infraposed, while there is reason to believe that these, in turn, rest on precretaceous beds.

To one traversing the disturbed area, the effects of the earthquake are themselves no more conspicuous than the indications of inequality and intensity, and variability in character, of the disturbance; and it is this phase of the subject that will be dealt with in the following paragraphs.

1. From the early commencement (Friday, Aug. 27) and the long duration (up to date) of the seismic disturbance at Summerville, from the frequent repetition and great intensity of shocks, from the frequency of detonations and their simultaneity with tremors, and from the vertical direction of the vibrations, that place may be regarded as the center of disturbance. The predominant effects of the shock of Aug. 31 are, *first*, fissuring of the surface of the earth; and *second*, crushing of foundations and chimneys; together with, *third*, slight displacement in different directions (and sometimes torsional) of buildings.

The fissures are irregularly distributed throughout the village and over the surrounding plain. They are generally confined to the high grounds, but appear to reach maximum abundance about the peripheries of the more elevated lands. They are so numerous that sometimes not an acre in a square mile is free from them, and, three days after the great shock, were two inches and less in width, and from four or five feet to as many hundreds in length. From the testimony of the citizens, as well as from the sand and mud stains in their vicinity, it appears that sand-laden water welled from these fissures in vast volumes, and continued to flow for some hours, and even, in some cases, days; indeed, water was observed to flow freely from one on the highest ground in Summerville up to the fifth day after the great shock during which they are said to have been formed. The local streams were flooded by the water from these fissures, and the floods had not completely subsided a week afterward. The sand and clay washed from them was evidently derived mainly from the uppermost member of the superficial deposits, although in some cases the blue sand of the inferior member predominates. These fissures extend in all directions, and occasionally cross and bifurcate at various angles.

The architecture in Summerville is characteristic; the houses are generally of wood, lightly framed, either partially or wholly surrounded by wide verandas, and supported on slender pillars from four to six feet high, either of wood set in, or of brick built upon, the ground; while the chimneys usually rest on independent brick columns built up from the ground. Few if any of them have suffered injury, save by the great shock of Aug. 31; and the injury to the houses themselves is astonishingly slight, and generally confined to racking of frames, shaking down of plastering, and occasional crushing of roofs by falling chimneys. Much injury was done, however, to furniture, which was overturned, tossed about, and in many cases broken. When the supporting pillars were of wood, the buildings have sometimes been displaced, and the entire structure, including the supports, has evidently swung to and fro in all directions, as indicated by the annular crevices surrounding the pillars; and in such cases the chimneys have almost always toppled over, generally to the north or south, the direction having been determined to a large extent by the slopes of roofs. When, however, the supports were of brick, they have been crushed at top and bottom, and fissured obliquely in all directions, as if by blows of a pile-driver, and in some cases the pillars have been driven into the ground, depressing and concentrically fissuring the surface about their bases. The crushing of the pillars is invariably greatest beneath the heaviest parts of the building; indeed, in some cases the heaviest pillars have completely collapsed, and the buildings are now supported by the piers beneath the verandas and the lighter parts of the floors. The heavy bases of the chimneys are similarly crushed and fissured; and in numerous instances they, too, have completely collapsed, and all that portion of the chimney beneath the roof has crumbled down into a mass of loose bricks, sometimes leaving the projecting portion intact and in place upon the roof. An example of the manner in which structures have been crushed vertically with little lateral displacement is found in the center of the village of Summerville, where two apparently fragile chimneys, left in position when the building to which they were attached was destroyed by fire years ago, have been crushed and obliquely fissured, but have not been overturned, or displaced laterally to the slightest degree.

The writer experienced half a dozen or more shocks in Summerville, and heard four or five times that number of detonations. The individual shocks were of very brief duration; the longest observed (and from the testimony of the citizens it appears that this was second in severity only to the great shock of Aug. 31) was over in less than thirty seconds. The motions of furniture, etc., during this shock were carefully noted. It was found that during the first two-thirds of its period, the vibration appeared to be directly vertical; that a wrenching, torsional motion, turning objects in the direction of the sun, followed; and that this was succeeded by a few gentle east and west rolls. The movements were identical in all the lighter shocks, when of sufficient duration to permit of observation, save in intensity. Ordinarily, however, the lighter shocks were simply spasmodic quivers of but an instant's duration, the direction of which it was impossible to determine. The shocks were invariably accompanied by sensibly simultaneous detonations resembling slightly muffled thunder peals or heavy cannonading, commonly compared by the older residents, who remembered the bombardment of Charleston, to the booming of siege guns a mile or two away; but the detonations were three or four times as frequent as the tremors. It may be mentioned that no two individuals, even among trained observers, agreed as to the direction whence the sound came. This fact, and the simultaneity of detonation and observed tremor, together suggest that the sound came directly from the earth, either as sonorous vibrations or as soundless pulsations of such period as to be converted into sound waves on passing from earth to air.

2. The principal physical record of the great shock at Ten Mile Hill is found in the craterlets, or "sand spouts," which there attain maximum size and abundance. They are simple circular or elongated orifices from which water has welled forth with such violence as to flood the entire surface over hundreds of acres to depths of from one to two or more feet, to carry out hundreds of tons of the yellow and blue sand overlying the marl bed, and to spread this sand over scores of acres to depths varying from a fraction of an inch to two or three feet. These crateriform orifices are now surrounded by their solid ejecta in annuli attenuating peripherally, in which the shrinking streams from the dwindling fountains have worn channels and gullies, and most of them are now filled with water up to within a foot or two of the natural surface. By residents the waters are reported to have gushed forth during, and for some hours after, the great shock, sometimes by jets, but generally continuously, to the height of trees; and, since they sometimes contained sulphurous compounds, they gave out characteristic odors that added much to the terror of the people. The volume of water extravasated was sufficient to flood many of the minor drainageways above even the highest freshet marks; and five days after the great shock, water still flowed from some of the craterlets, and yet retained the odor of sulphureted hydrogen. There is no indication that the orifices extend, or that the water flowed from, below the base of the superficial sands (in which the mean depth of permanent ground water is ten or fifteen feet), either at Ten Mile Hill or elsewhere; and, indeed, at the phosphate works nearest Ten Mile Hill, in the immediate vicinity of which both fissures and craterlets occur, the marl bed was so slightly disturbed at depths of sixty or seventy feet that the water slowly percolating into the shafts was neither increased nor discolored. Nevertheless, these fountains, issuing from a surface fifteen feet above the level of ground water, the flow from fissures here, at Summerville, and to a less extent at Charleston, and the rise of waters in wells in various localities, all point to sudden and considerable contraction, either vertical or horizontal, of the water-bearing sands overlying the marl. "Sinks" are, indeed (rarely), associated with the craterlets; but they appear to have been formed after the subsidence of the extravasated floods.

In the vicinity of Ten Mile Hill, too, the kinking and distortion of railway tracks is most striking. In a number of cases, the rails were so bent as to necessitate removal—the displacement in alignment sometimes reading two feet or more, while that in profile was half as great. It should be mentioned that, in all personally observed and well authenticated cases of compressive distortion of rails, the kinks occurred in the low grounds at the bottoms of inclines, and generally in the vicinity of trestle bridges approached by embankments, and that at least a part (and in one case all) of the contraction relieved by the kinking appears to have been caused by the down hill settling of rails, ballasting, and embankment. Nevertheless, longitudinal fissures in the embankments, and lateral throw of the track, have evidently been produced directly in some cases; and near Ten Mile Hill a locomotive was derailed (with destruction of life) during the second shock; but whether by the tremor, or as a result of antecedent displacement of the track, could not be ascertained.

In general terms, the injury to the few buildings at Ten Mile Hill is similar to that exhibited at Summerville, save that the horizontal displacement has been greater, chimneys have been more generally overthrown, and the plastering of the ceilings is less seriously, and that of the walls more seriously, cracked and dislodged.

It is noteworthy that between Ten Mile Hill and Charleston (perhaps three miles from the latter place) there is a considerable area or zone in which the effects of the earthquake are inconspicuous; chimneys have seldom been overthrown, buildings are not displaced on their foundations, the foundations themselves are not crushed, and plastering is but slightly injured. Even the tall brick chimneys of the fertilizer works within the area appear to have escaped injury.

3. As has already been made known through the daily press, the most conspicuous effect of the seismic disturbance at Charleston was the lateral displacement and overthrow of chimneys, monuments, walls, entire buildings, etc. These records of the great earthquake have been examined and noted with care, with the view of applying Mallet's method of determining the origin and paths of the seismic tremors to the region affected thereby. The observations on injured buildings may be briefly generalized as follows:

1. The throwing outward of walls, gables, cornices, copings, etc., is most common in walls facing north, next in those facing south, third in those facing east, and least in those facing west. 2. By far the greater number of overthrown chimneys have fallen either to the north or south, and more to the north than the south. 3. The most seriously cracked walls are those facing east; those facing west are nearly as seriously injured; those facing south follow, but are much less injured than the two former; and those facing north are least injured, but only slightly less than the southerly walls. 4. When corners of buildings are thrown out, they have gone most frequently to the northeast, next to the southwest, third to the northwest, and least frequently to the southeast. So many isolated observations are inconsistent with these generalizations, however, that little value can be attached to them. Similar inconsistencies are observed in the behavior of the marble and granite shafts in marble yards and cemeteries. Of those which have been overturned, the larger number have been thrown either to the north or south, but some have gone in various other directions; many have suffered torsional displacement, but of these some have turned with others against the sun; while others are displaced laterally without overthrow, and in as many directions as there are compass points. Chimneys, too, have been twisted both with and against the sun, and during their oscillations have "walked" in various directions. A Charleston chimney was twisted with the sun, and slightly displaced southward; and a neighboring monumental shaft was turned in the opposite direction, and displaced northeastward. Perhaps the discrepancies among these observations may eventually be eliminated, and the apparent confusion reduced to order; but for the present, inferences as to the azimuth of the wave paths in Charleston and immediate vicinity are premature.

It is remarkable that the intensity of the seismic action has varied greatly within the limits of the city of Charleston. Thus in certain quarters the buildings have escaped with trifling injury, while similar and similarly oriented buildings in other quarters have been completely destroyed; and all possible intermediate phases of injury are found in different parts of the city. The numerous observations on the variable intensity of the disturbance in Charleston and elsewhere in South Carolina have not yet been collated and digested; but it would appear that there are large areas within which the intensity of the disturbance culminated (and Charleston is one of these), and, moreover, that within these areas themselves there are foci or nodes of maximum vibration circumscribed and separated by annuli in which the disturbance was less severe.

A few fissures, such as those abounding at Summerville, occur in Charleston and vicinity, and some small craterlets have also been observed in the neighborhood.

A number of slight tremors were experienced in Charleston. They differed from those felt at Summerville, 1, in less intensity and greater duration; 2, in direction, which was manifestly more nearly lateral than vertical, though the azimuth was not accurately determined; and, 3, in the absence of detonations or other sounds than such as might be attributed to movements in furniture, in neighboring buildings, etc.

Briefly, it appears that within a radius of a dozen miles somewhere near the center of the district affected, and within an area of remarkably uniform topographic configuration and geologic structure, the effects of the recent earthquake are quite diverse, viz., that at Summerville the principal effects are crushing of structures in the vertical direction, and the formation of fissures, with the outflow of a considerable volume of water; that at Ten Mile Hill, half way between that point and Charleston, the principal effects are local deformation of the surface and the extravasation of a great volume of sand-laden water, with combined crushing and lateral displacement of structures; and that in Charleston the predominant effects are lateral displacement in various directions (without vertical crushing) and overthrow of structures, torsional displacement and over-

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turning in different directions of monuments, together with some fissuring of the surface and the extravasation of small quantities of water.—*Science.*

PEPSIN.

PEPSIN is described in the United States Pharmacopœia as "the digestive principle of the gastric juice obtained from the stomach of the hog, mixed with powdered sugar of milk."

It is required to dissolve at least fifty times its own weight of albumen.

The requirements of the British and German pharmacopœias are very low, considering that from their titles and wording they are not saccharated pepsins, but the ferment itself in its purest obtainable state.

The British Pharmacopœia alone of the three pharmacopœias gives a method of preparation, that of scraping the previously cleaned mucous membrane with a blunt knife or other suitable instrument, and drying the pulp thus obtained on glass plates, at a temperature not exceeding 100° F. The requirement of its digestive strength is very low indeed, considering that it contains no added substances—one grain being required to digest but fifty of coagulated albumen, while the United States Pharmacopœia article will dissolve the same amount, though it may contain many times the weight of the contained pepsin in sugar of milk.

The German Pharmacopœia, like the British, names the article simply pepsin, and recognizes no admixture with sugar of milk.

It is, however, required to possess a greater digestive strength, one part digesting 100 parts of albumen. It also prescribes the degree of fineness to which the albumen should be reduced, as does also the British Pharmacopœia.

After referring to these requirements of the different pharmacopœias, a writer in the *American Druggist* gives the following very practical method of assaying pepsin:

For the assay of saccharated pepsin, five two-ounce wide-mouthed vials are provided, and into each of them is weighed just one grain of the pepsin to be assayed. A quantity of water and hydrochloric acid, in the proportion recommended by the Pharmacopœia, having been provided, 507½ grains are weighed into each bottle, or a measure, graduated so as to hold 507½ grain measures, used for measuring it into them.

The albumen from an egg which has been boiled fifteen minutes and then cooled is carefully separated from the yolk, and by means of a small spatula forced through a piece of brass gauze of 80 meshes to the linear inch.

The albumen is then quickly weighed in portions, placing 20 grains in one vial containing the pepsin solution, 30 in another, 40 in another, 50 in another, and 60 in the last. The vials are then corked, and the number of grains of contained albumen marked on the cork of each bottle, when they are placed in a water-bath and kept at 100° to 104° F. for four to six hours. They should be placed in a part of the bath removed from the source of heat if a direct flame is used, as the bottom of the vials, being in contact with the metal where the flame strikes it, would be much warmer than the water contained in the bath. It is preferable, where a steam water-bath cannot be used, to place the vials in a second vessel immersed in the bath proper.

It is necessary to shake the vials frequently, and to also remove the corks occasionally.

When the proper time has expired, the vials are removed, allowed to deposit all undissolved albumen, and the eye can readily read the result.

In some cases it may be found that all the albumen in each vial is entirely dissolved, and in others that they all contain undissolved portions in varying amounts, the one in which was placed the least containing but perhaps a trace, and from this to the greatest containing progressively greater amounts undissolved. Of course, this depends upon the activity of the pepsin.

In case of desire to assay an undiluted or "concentrated" pepsin, $\frac{1}{10}$ of a grain is weighed into each bottle, or 10 grains are carefully and well triturated with 90 grains of sugar of milk and 1 grain used, proceeding then as above. In case of small amounts of albumen remaining in the bottle containing the least amount, the eye soon learns to judge of the amount far more accurately than could be determined by weighing.

Pepsin contained in gastric juice in the proportion of three one-thousandths was first discovered and made in 1839 by Th. Schwann. Its elementary composition is unknown, and despite the hard word bestowed upon it for a name, has never been obtained in a state of chemical purity. It is looked upon as a nitrogenous substance, coagulates at 212° F. when in the wet state, but dry preserves its activity and virtue at 230° F. When dissolved in water it undergoes at 104° F. a transformation into isopepsin, and upon increasing the temperature to 210° F. all its virtues are then lost. Alcohol dissolves it; anhydrous alcohol precipitates it from the solution in white flakes, as do also all the metallic acetates, chlorides, and sulphates. Pepsin forms in the gastric juice and in the cells of the outer coating of the stomach; it is associated, but not chemically combined, with an acid, and it is only when acid and mixed in water that its virtues are manifested as a digestive. When placed in contact with albuminoids, it induces fermentation and transforms the latter into what are known as peptones.

Some writers believe that pepsin is one of those ferments depending upon or perhaps consisting of a low form of immature animal life, but the microscope has so far not enabled us to prove this.

PREPARATION OF MEDICINAL PURE PEPSIN.

Directly after slaughtering, the rennet bag is taken from the stomach and divested of every trace of food or foreign body. The bag is then thoroughly washed and the mucous membrane scraped with a blunt knife. The result is a pulpy substance weighing about two ounces to each stomach; this is macerated in three times its weight of water for two hours with frequent shaking and filtered through linen; to the liquid is added three drachms of solution of neutral acetate of lead; an abundant precipitate forms, which is washed several times with water; it is then charged with sulphureted hydrogen gas, in large excess, filtered, and evaporated to dryness to about 112° F. Thus prepared, it should dissolve seventy times its weight of wet fibrine in twelve hours. Other processes are to steep the whole of the stomach in hydrochloric acid and precipitate the pepsin by a saturated solution of common salt.

Having thus stated what pepsin is, and how it can be tested, we will add that, as already indicated, the United States Pharmacopœia recognizes saccharated pepsin only—that is, pepsin containing 90 per cent. of sugar of milk to every 10 per cent. of actual pepsin. In France, starch is employed in place of sugar of milk. It will therefore be readily seen that if a pure pepsin, that is, an undiluted or concentrated pepsin, could be manufactured, it would be more than ten times as strong as either the saccharated or amyl pepsin. Such has been made, and is known variously as concentrated, crystalized, and scale pepsin. It would, of course, be stronger than the diluted pepsin, not only in consequence of not being diluted, but also from the fact that the material used to dilute it tends to weaken the actual pepsin by its peptonizing action thereon. Again, a well-made scale pepsin, being hard and dry, is not liable to be attacked by infusoria and bacilli.

Physicians when prescribing any remedy naturally desire to use that which is most reliable, even in strength, and always to be depended upon; and when they have once decided which preparation they will use in their prescriptions, want to be certain that that particular preparation is the one used by the apothecary, and therefore they should be careful to add the name of the manufacturer whose goods they wish, and not trust to the simple word "pepsin," or any of the adjectives applied to it by different manufacturers, for the reason that many apothecaries will take advantage of these open doors to use the cheapest pepsin they can buy, and the result to the patient will be different from what the physician had a right to expect, to his great disappointment and injury to his reputation. There is no doubt that, like all good things, the best pepsin made has been imitated; and where nothing else would serve, unscrupulous manufacturers have substituted adjectives in the appellation of their manufactures which, by the change of one letter, perhaps, or similarity of sound, were intended to convey the idea to the purchaser that it was the best and purest.

The Patent Office reports show that in October, 1883, letters patent were granted to Carl Jensen, of Philadelphia, No 286,138, for a process of subjecting animal stomachs to the action of heat, and whereby a gastric digestion takes place, and peptone containing the digestive or gastric ferments is produced, separating the impurities from said peptone, and then evaporating it to dryness.

This pepsin in the form of hard scales or crystals, is transparent, odorless, tasteless, capable of being permanently preserved, freely soluble in water without the use of acids, free from inert additions, and having a digestive power of one to seven hundred. The other patent, No. 327,567, for a "peptone pepsin," was granted to Morris B. Manwaring, Bayonne, N. J., October 6, 1885, the method of producing peptone pepsin by the action of a solution of pepsin on an acidulated mixture of coagulated egg albumen with water, whereby a peptone pepsin is produced which is thereafter reduced to scale form by evaporation, this improved peptone pepsin consisting of a composition in scale form of pepsin with peptonized egg albumen.

It will thus be seen from these claims that while the former of these patents is for a pepsin free from all inert additions, the latter is for a mixture of pepsin and albumen. Further light was thrown upon this when, at a hearing of one of the patent suits, the owners of the latter patent, the New York and Chicago Chemical Company, under oath, admitted that they used sixty pounds of egg albumen to every two hundred stomachs. As it is well known that this number of stomachs yields only about three pounds of pepsin, it proves that every sixty-three pounds of the "peptone pepsin" made under the latter process cannot possibly contain more than three pounds of pepsin, or a strength of one part pepsin to twenty-one parts of inert addition, or, what is worse than inert additions, that uses up a portion of the peptonizing power of the small proportion of pepsin it really contained before the admixture was made.

Much has been said as to the originality and priority of these inventions. That is a matter which we as journalists or our readers do not care anything about, all we have to do with being the question as to which is the best and cheapest to use. No one will deny that a pepsin of full strength is cheaper at even three times the price than one of only the strength of one in twenty-one.

The largest wholesale drug house in the world, that of Gehe & Co., in Dresden, Germany, have placed the weight of their influence on the side of Jensen's by buying his product to the exclusion of every other.

The courts thus far have decided in the same direction, but a practical test will still further decide the matter. The same writer we have quoted before has made a partial test by the methods he has indicated. We quote his results without giving names before giving the results of the tests made in our laboratory:

"It may be interesting in this connection to give a few of the results obtained by this process with some of the pepsins of the market.

"A so-called 'Turkey pepsin' leads the list. That is, it was found to be absolutely inert. Several samples of commercial pure pepsin were found, one grain of which would dissolve 500 to 700 grains of albumen, and one sample was found to digest 1,150 grains. This is the highest result I have ever obtained from numerous careful tests.

"One of the 'scale pepsins' of the market was found to dissolve 157 grains of albumen, while another sample from the same firm dissolved 350. In fact, there are just as many degrees of strength of 'concentrated' pepsin as there are lots made, since the same conditions cannot always be met with in different membranes used.

"As regards all pepsins, I am inclined to think the manufactures of the United States are far ahead of those of Europe as regards digestive strength.

"These tests were all made in the laboratory of Eli Lilly & Co., Indianapolis."

The tests made by the *American Analyst* consisted of twelve samples of pepsin manufactured by six different firms. All of these were obtained at drug stores, and, after being emptied into clean glass bottles, were numbered from 1 to 12, and handed to two different chemists without any knowledge on their part as to the maker of any of the samples submitted. Their reports are as follows:

Number of grains of egg albumen in finely pulverized form dissolved by two grains of pepsin in six hours at a temperature of 100–103° F.:

Sample No. 1	18 grains.
" " 2	19·7 "
" " 3	inert.
" " 4	"
" " 5	508 grains.
" " 6	·506 "
" " 7	2018 "
" " 8	2007 "
" " 9	174 "
" " 10	336 "

It is fair to add that specimens Nos. 7 and 8 were Carl Jensen's crystal pepsin.

With these statements we leave the matter to be judged by the reader.—*American Analyst.*

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