SCIENTIFIC AMERICAN SUPPLEMENT No. 614

Scientific American Supplement, Vol. XXIV., No. 614.
Scientific American, established 1845.

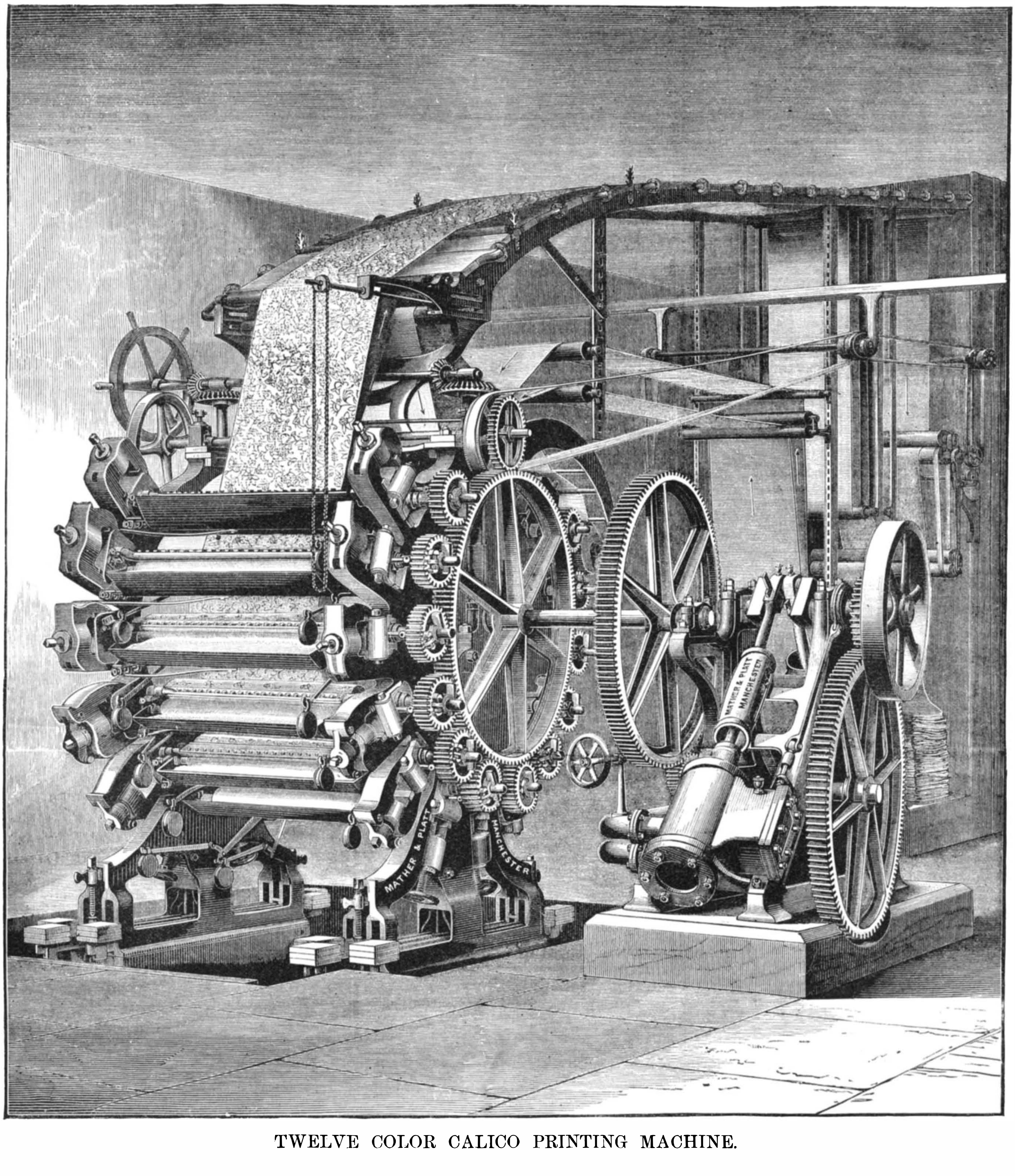
NEW YORK, OCTOBER 8, 1887.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

TWELVE COLOR CALICO PRINTING MACHINE.

ALTHOUGH considerable attention has been given to the transmission of power by electricity and its application to the driving of tram cars, and the utilization of water power at a distance, the distribution of power by this means in workshops, factories, and similar places has received comparatively little attention. There can be, however, no doubt that in this direction there is a wide field for the use of electrical motors. This is especially so in those works where, for various reasons, the principal machines and tools are not driven from one common system of shafting, but have each an independent engine. Such is the case in calico printing works, where each printing machine is driven by its own engine; also in paper mills, in rolling mills, and in many ship building yards and other large engineering shops, where the heavier tools are necessarily distributed over a large area, and where it is important to have complete control over each individual tool. In order to show the applicability of electrical driving in these cases and its advantages, Messrs. Mather & Platt, of Salford Iron Works, Manchester, designed, fitted up, and are running a very interesting exhibit at the Manchester Exhibition. As a typical case, and one in which the conditions to be met are most stringent, they selected one of their ten color calico printing machines, for printing calico with ten colors simultaneously. If electrical driving can be proved to be advantageous and economical for complex machines of this class, where a slow speed under the most perfect control, and at the same time high efficiency, are essential, there is no doubt about its applicability in other cases where the conditions are less exacting.

A large printing machine, similar to the one exhibited, is now illustrated. This, however, is a twelve color machine; but either this or a ten color machine would, under ordinary circumstances, be driven by a double cylinder diagonal engine, as shown in our engraving. This engine has 10 inch cylinders and a 12 inch stroke,



TWELVE COLOR CALICO PRINTING MACHINE.

and runs at about 140 revolutions per minute. The star wheel of the printing machine, when printing at full speed, runs at twelve or thirteen revolutions only; it is, therefore, necessary to reduce the speed by gearing. But where a dynamo motor is used in place of the steam engine, the speed of the motor must be much higher, in order to obtain good efficiency without unduly increasing the size and cost of the motor. The motor employed at the exhibition runs at 700 revolutions. Hence the speed must be reduced in the ratio of 56:1. This is accomplished by a combination of belt and spur gearing. The dynamo shaft is fitted with a pulley, 16½ inches diameter, driving by means of a short belt on to a pulley 54 inches diameter. In order to increase the grip of the small driving pulley on the belt, Messrs. Mather & Platt's system of a loose jockey pulley is employed.

The jockey pulley runs loose on a stud, fixed on an arm projecting from the dynamo bed, and bears against the slack side of the belt. By an arrangement of worm and wheel, the arm can be raised or lowered, moving the loose pulleys with it, and consequently increasing or diminishing the angle at which the belt is bent over it. By this means the surface of contact between the belt and the driving pulley can be increased, and the slack of the belt taken up; thus at the same time giving considerably greater adhesion than can be obtained with a long belt, and providing means for taking up the slack as the belt stretches. The speed is further diminished by a train of two internal spur wheels and pinions. This combination, which we examined at the exhibition, gives a most effective drive, perfectly noiseless, occupying no more space than the gear for reducing the speed of a steam engine, and under perfect control.

The printing machine is of Messrs. Mather & Platt's latest design for printing cloth up to 34 inches wide, with from one to ten colors simultaneously, at a speed of 30 yards per minute. The machine is fitted with traverse motion, driven by friction, for the doctors, a drag roller, and steam chest and cylinder drying. To work it at full speed from 15 to 20 horse power is required. In order to set the pattern, it is essential that the speed of the machine should be so under control that it can be made to creep round, and can be stopped in a fraction of a revolution, so as to enable the printer to see that the rollers, each printing one color, are properly adjusted relatively to one another. With a steam engine, this is effected by a stop valve on the steam inlet, the valve spindle being fixed conveniently accessible to the printer. But a steam engine must have a flywheel, and the valve cannot be instantaneously closed, so that the machine cannot be stopped as quickly as might be desired. A dynamo motor, on the other hand, having no dead points, requires no flywheel, and the current can be instantaneously shut off, and consequently the machine brought to a stand more rapidly than is possible with steam engine driving. The speed is regulated by a switch board placed at one side of the machine, at the printer's right hand, arranged to insert resistance in the circuit, and so lowering the speed of the motor to any desired extent. The whole floor space occupied by the motor, driving gear, and resistance is somewhat less than that which a steam engine would take—a point of much importance in print works.

The current is conveyed to the motor from a generating dynamo by an insulated copper cable, carried under the floor of the exhibition building. The generating dynamo is fixed in the dynamo house, immediately adjacent to Messrs. Mather & Platt's pair of vertical engines and dynamos for lighting the fine art section. The distance from generator to motor is 115 yards, but this might be greatly increased with very slight increase in the proportion of power lost in transmission. The generating dynamo is also of the "Manchester" type, and is a similar machine to the motor, capable of generating 25 to 30 electrical horse power at a speed of 950 revolutions per minute. It is driven by a double cylinder diagonal engine, with cylinders 8 inches diameter, 10 inch stroke, and running at 180 revolutions per minute, with short belt driving, on the same principle as that used with the motor. Although a separate engine and generating dynamo are provided, this is not necessary, and the current could be obtained from any dynamo of sufficient power used for lighting or for working other motors. Arrangements have been made for connecting the motor cables to any of the four dynamos working the incandescent lamps in the art galleries.

The whole loss in conversion from mechanical to electrical power, in transmitting the electrical power, and reconverting into mechanical power, does not exceed 25 per cent. This is far more than compensated for by the fact that the engine driving the generating dynamo can be worked under the most economical conditions, which is impossible with an engine driving direct. No better illustration of this could be afforded than that actually a smaller engine is employed for driving the generating dynamo than would have been employed had the printing machine been driven direct. In a large print works, where there are a considerable number of independent machines, the advantage will be still more conspicuous; for, in place of a separate small engine to each machine, working necessarily with low steam pressure, often with considerable back pressure, and generally under conditions where high efficiency is impossible, a single high class engine can be used, working under the most favorable conditions, with high pressure steam, high expansion, proper automatic cut off valves, giving the highest efficiency. This engine would be employed to drive one or more generating dynamos, which might also be employed for lighting purposes, and from these cables would be taken to each independent machine worked by its own motor. Such a system has, moreover, the advantage of avoiding the necessity of steam and exhaust pipes, or long ranges of shafting, running throughout the building—a point of considerable importance when the operations carried on require great cleanliness. It also obviates the danger of fire from hot bearings or of breakdowns in gear from one line of shafting to another. The advantages of the system of electrical motors for the distribution of power may be briefly summarized as follows: Greater economy in consumption of fuel; more perfect control over each individual machine; greater cleanliness; the availability of the plant used for the distribution of power, for electric lighting and other purposes, and less risk of fire and breakdowns.—*Iron.*

A NEW DEPARTURE IN THE FLAX INDUSTRY.

The present position of the flax industry in Great Britain and Ireland is far from satisfactory. Not only is the quantity of home grown flax insignificant, as compared with the imports of foreign flax, but there has, during the last few years, even been a tendency toward further reduction of the acreage under flax, and simultaneously a falling off in the quantity of flax, both home grown and foreign, which is treated in our mills. In plain language, the flax industry appears to be leaving this country, and unless those interested in it will take some steps to revive it and keep it here, a serious national loss will be the result.

A syndicate of London business men has been formed to carry on the flax industry at Whittlesea on an extensive scale by means of new machinery, and another syndicate, the Flax Growers' Association, with headquarters at 57 Charing Cross, London, is conducting similar experiments at Long Melford, in Suffolk, where from eighty to ninety acres of flax are now being harvested. In this case the object is not so much to test what can be done by improved machinery as to give a practical demonstration of the possibility of developing a profitable business on a small scale.

The tendency of nearly all modern industrial movements is to concentrate operations in a few large works, with which a small manufacturer cannot possibly compete; but Mr. Henly maintains that the cultivation of flax and the preparation of the fiber ready for the spinner are industries which may be exempt from the general rule, inasmuch as they will prove profitable even if conducted on the small scale of a domestic industry. It would obviously be of great importance to the country if the agricultural laborer could find employment during the winter time by preparing the flax for the spinner. This would lessen agricultural distress, while at the same time it would not do away with the advantages of using improved machinery in the subsequent processes of spinning and weaving. This is, broadly stated, the object of the work undertaken by Mr. Henly and the other members of the Flax Growers' Association. They do not propose to supersede the work done in the large flax mills, but to introduce such improvements in the cultivation of the plant, and in the first stages of the preparation of the fiber, as will largely increase the quantity of home grown flax, and at the same time afford profitable employment to a large number of agricultural laborers and their families, many of whom, in the present state of affairs, are almost destitute during the winter months. In this manner the association hope not only to relieve the agricultural laborer, but also to put money into the pockets of the farmers, and retain the trade of flax spinning and weaving in this country.

To make our description complete, it will, however, be necessary to briefly refer to the old methods at present in use in the initial stages of the preparation of flax fiber. After the plant is cut by a reaper, or preferably pulled up with the roots, the seeds are stripped off and the straw undergoes a process of retting, the object of which is to destroy by fermentation the gummy substance which unites the fiber with the wood. Various systems of retting are in use, the most primitive being that known as "dew retting," under which the straw is simply spread upon a meadow in a thin layer and left there under the alternate influence of dew, rain, and sunshine, from two to four weeks. Great care is required to determine the exact period during which the straw is left out. If too short a time, the separation of the wood from the fiber cannot be perfectly carried out, and if too long a time the fiber itself becomes rotten and of diminished strength. In Ireland retting is carried on in pits, which are filled either with soft water, or where that is not obtainable with hard water which has been left standing in the sun for some time to make it softer. The straw is put in and weighted down with hurdles and stones, and left from two to four weeks, according to its quality and the weather. Some thirty years ago retting in steam heated water under Schenk's patent came into fashion, and a plant on that system was until lately in use at the Long Melford mill. The system has the advantage of economizing time, but some spinners object to it on the ground that the fiber is not so strong as with the older and more primitive system. The apparatus itself is, however, simple enough. It consisted of four large wooden tanks, provided with a horizontal perforated steam pipe laid along the bottom, and connected by a system of piping and cocks with two 20 horse power boilers, either of which is alone capable of doing the work. After the flax has been put into the tanks steam is admitted, and the supply is regulated so as to keep the temperature between 80° F. and 90° F., the operation lasting from four to six days, according to the quality of the straw. There are various objections to this system. In the first place it requires great care to maintain the temperature at the right point. If it should be allowed to drop to about 70°, the fermentation is checked, and cannot be restarted by an increase of temperature. In such a case it is necessary to take the straw out, dry it, and repeat the whole process. Another objection is the uneven manner in which the water is heated. Near the pipe it is almost at boiling point, while other portions of the tank are left too cool. There is in fact a want of circulation. The necessity of keeping the steam boiler under supervision night and day also mitigates against the advantage of doing the work in a shorter time. To overcome these objections, Mr. Henly has devised a plan of steeping which appears to be both economical and safe. His vats are 20 ft. square, and are filled with water to a depth of about 5 ft. The straw is put in with the roots downward, and is submerged so that the top end is about 6 in. below the surface. In the middle of one side of the tank, which is constructed of 3 in. oak planking, there are two holes, one close to the bottom and the other about 15 in. above it, and both are joined outside by a wrought iron pipe 3 in. to 4 in. diameter, forming two horizontal branches with a bend. The pipe is in fact of the shape of a very long U, and the bend as well as a considerable portion of the straight parts is heated by a furnace which is built round the pipe. The furnace is provided with a filling hole at the top, and is of the slow combustion pattern. From this description it will be seen that the plant is exceedingly simple and inexpensive. As soon as the fire is lighted the water in the bend becomes heated and ascends, being discharged through the upper hole, while the water from the bottom flows into the pipe to become in turn heated, and thus a continuous circulation is kept up. The water discharged at the upper orifice rises to the top and diffuses all over the surface of the tank and gradually sinks to the bottom, passing through the straw. Experience has shown that the top end of the plant requires a slightly higher temperature in steeping than the root end, and this condition is naturally fulfilled by the way in which the water circulates. It is obvious that the temperature to which the great body of water in the tank becomes heated simply depends upon the relative size of the tank and the pipe, and by adopting the proportion above given, the right temperature of from 80° to 90° is easily maintained without any special care in firing. The furnace may in fact be left to itself for several hours, since the mass of brickwork forms a sufficient store of heat, and this is a great advantage in an operation which must go on night and day for about four to six days, according to the quality of the straw.

The manager at the Long Melford mill informed us that last autumn, when these tanks were first tried, there were steeped in each tank at one operation about 2½ tons of straw, the furnace requiring 1¼ cwt. of coal in the twenty-four hours. In the slightly larger tanks of the Schenk system about three tons were steeped, the quantity of coal required for the steam boiler being, however, above one ton in the twenty-four hours for four tanks, so that according to these figures Henly's system, besides the advantage of not requiring any careful supervision, effects a very considerable economy in fuel, as compared with the old plan of steeping in the steam heated water. A further advantage of Henly's steeping tank is the comparative absence of offensive exhalations. The water in passing through the pipe in the furnace is subjected to so high a temperature that the germs of organic matter are killed, and the offensive smell which generally accompanies the old methods of retting is much diminished. At present the straw after steeping is dried on a meadow, and for this reason the operation can only be conducted during the summer and early autumn; but Mr. Henly is engaged in making a drying chamber, by means of which the work will be rendered independent of the season. Taking, however, the process as it is now carried out, we may estimate that the time during which the straw can be steeped would be about twenty weeks, and as each tank will take 2½ tons of straw per week, this would represent a total capacity of 50 tons for one season. The yield of straw per acre naturally varies according to the quality of the land and the season, but we may take it that 35 cwt. would be a fair average. At this rate there would be a steeping tank required for every thirty acres of land under flax. Artificial steeping must under all circumstances be slightly more expensive than the steeping by the old Irish plan, but the additional expense which is due to labor in firing and to the cost of fuel is not a serious item.

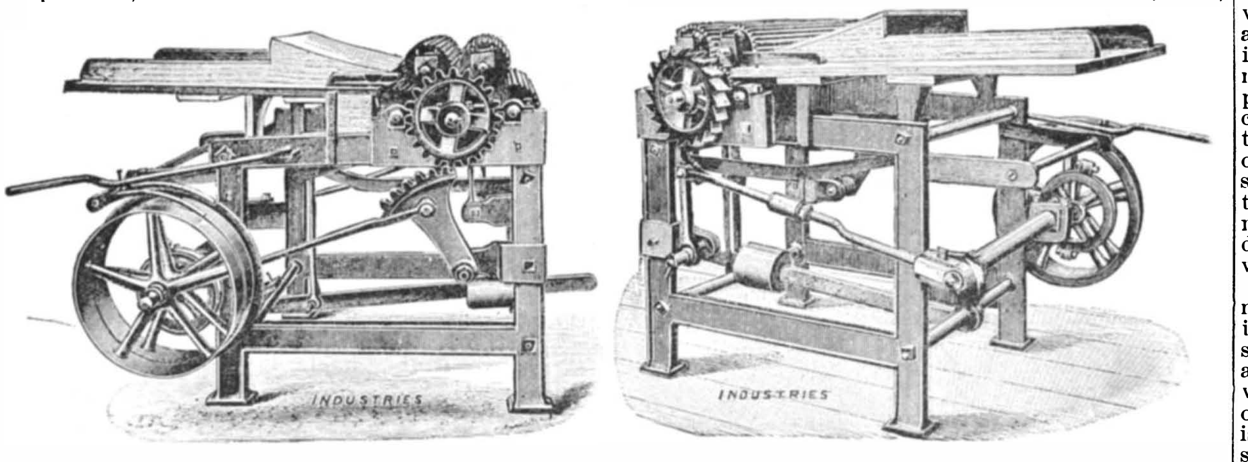
From the figures above quoted it will be seen that with coal at 18s. a ton the cost of fuel per ton of straw is only about 2s. 9d., and this item can be saved if the wood as it comes from the breaker is used for fuel. The cost of labor for firing is also small, since the furnaces require attention only at long intervals.

When the straw has been steeped a sufficient time to allow of the easy separation by hand of the wood and the fiber, it is taken out of the vat, and is either subjected to a process known as wet rolling or is immediately dried and stacked ready for the breaker. Wet rolling is a preparatory treatment before breaking, the straw being passed through plain cast iron rolls while a jet of water plays on it. In this manner the round stems are crushed into a more or less flat shape, and a preliminary separation of the fiber takes place. This treatment, however, is not necessary, well steeped straw being quite fit to go straight to the breaker.

The machine hitherto used for breaking consists of a series of fluted rollers, generally five pairs, the straw being fed into them end on. The flutings are coarser where the straw enters and finer where it leaves the rollers, in order to render the process of breaking gradual. This type of machine is, however, only applicable for fairly large farms. It requires considerable power, and can only be profitably used where a large quantity of straw has to be broken. For small farmers, who have only a few acres of flax, the machine is too expensive and otherwise unsuitable. To meet such cases, Messrs. Thompson & Co., of Fordingbridge, Hants, have constructed a small breaker, which is in use at the Long Melford mill, and which we illustrate in the accompanying engravings, showing the machine from two sides. As in the older type, the straw is broken by being passed through fluted rollers; but instead of ten rollers, there are only five in this machine, and instead of the movement of the rollers being continuous in one direction, as in the old type, in the Thompson machine it is reciprocating, that is to say, the rollers turn alternately forward and backward, the forward motion being, however, slightly greater, so that the straw is gradually carried through the machine. The object of giving the rollers a reciprocating motion is to break the wood more thoroughly and afford facility for the broken pieces to fall out. The machine requires less than ½ horse power, and can break from 5 cwt. to 6 cwt. of steeped straw per day. As the straw loses about twenty-five per cent. of its weight in steeping, this corresponds to about 7 cwt. of unsteeped straw, or, roughly, the produce of from one fifth to one sixth of an acre, so that this little machine can deal with the produce of an acre per week. The construction is very simple, and will be understood from our engravings.

Power is applied by means of a belt, and on the shaft of the pulley is an eccentric imparting by means of a connecting rod reciprocating motion to a toothed sector, into which gears a spur wheel keyed to the spindle of the center roller. On the other end of the shaft is a crank set with a slight angular retardation as compared with the eccentric. This crank works a pawl which engages with a ratchet wheel keyed to the other end of the roller spindle above mentioned. The sector is slightly shorter than its travel, so that once in every revolution it leaves the spur wheel. At that moment the pawl comes in contact with the lowest tooth of the ratchet wheel and advances the roller, and with it the spur wheel, by the angular distance of one tooth. Immediately after, the sector commences the return stroke and again engages with the spur wheel, not, however, with the tooth at which it left it, but with the next one. In

this manner the forward motion of the middle roller exceeds by one tooth its backward motion, and thus all the five rollers, while dragging the straw to and fro, gradually advance and pass it through the machine. The fiber thus produced is more or less entangled, and largely mixed with short pieces of broken wood. In the usual process as hitherto carried on, large quantities of these pieces of wood are knocked out of the fiber by "scutching," performed either by hand or on scutching stocks by power. We presume the operation is generally known, and therefore a few words of description will suffice. In hand scutching, which has almost entirely been superseded by power scutching, the strand of fiber is placed within a nick cut in a vertical board, and is beaten with a wooden knife. The mechanical scutcher, commonly known under the name of the Irish scutching stock, performs exactly the same operation, but with less care. The strand is held over



IMPROVED FLAX BREAKER.

the horizontal edge of a vertical iron plate, and close to it pass wooden knives fastened to a large wheel driven by power. The fiber receives a succession of smart blows, and a good deal of the wood is thus knocked out of it; but at the same time a good deal of tow is produced, and this is more or less balled into lumps mixed with the wood. This mixture of tow and wood is collected from behind the wheel, and is placed in what is called a willy, a concave wooden frame with iron teeth, within which there revolves a kind of thrashing drum, also with iron teeth. This shakes up the tow, and allows a portion of the wood to fall out. The objection to the scutching stocks is that a good many fibers are by the violent treatment they receive either torn off or matted together, thus forming tow; and that the tow which comes off the machine is hard and in lumps, instead of being free and open. After scutching, the fiber is ready for the spinner, but it still contains a considerable quantity of wood, and at the spinning mill this is taken out by the process of heckling, the strands being drawn through combs with steel teeth. Several combs are used, the operation beginning with coarse and ending with finer combs, according to the purpose for which the flax is required. For very fine threads, such as are used in the manufacture of lace, a heckling comb may contain as many as sixty-four steel teeth to the square inch.

Mr. Henly proposes to entirely do away with the operation of scutching, and to heckle the flax immediately it comes away from the breaker. During our visit he had both operations performed, one strand being taken to the scutching stock and treated by an experienced scutcher, while the other was immediately heckled by a boy of thirteen. As regards the speed of manipulation, the process of scutching showed certainly a considerable advantage; but, on the other hand, the finish of the sample heckled direct from the breaker was enormously better than that delivered from the scutcher, and thus, where speed of manufacture is not of primary importance, there seems a decided advantage in substituting the heckling process for the present system of scutching. How far the production of fiber on Mr. Henly's plan will prove an economical success we are unable to say at present. The association, who are about to begin operations at Long Melford, intend to keep careful accounts to elucidate this point. Meanwhile we may reproduce here some figures which were given us by Mr. Henly, being the result of a trial made by him to ascertain the comparative cost of the two methods, viz., the old plan of preparing the fiber by mechanical scutching and delivering it to the spinner in a dirty condition, *i. e.*, full of wood, and his plan of preparing the fiber by hand heckling and delivering it to the spinner almost entirely free from wood. Two 8 cwt. lots of steeped straw were treated with the following results:

SCUTCHING PROCESS.

	£	s.	d.
8 cwt. of steeped straw gave 1 cwt. of fiber, value	1	19	0
40 lb. of tow, value	0	2	6
	£2	1	6

Cost of stricking (arranging the strands ready for the scutcher), scutching, and sorting, 9s. 4d.; leaving £1 12s. 2d. as the net value of the produce.

HECKLING PROCESS.

	£	s.	d.
8 cwt. of steeped straw yielded ½ cwt. of clean fiber, value	1	1	0
¾ cwt. of fine tow, value	0	15	0
1½ cwt. of coarse tow, which reheckled yielded 6 lb. of fine fiber, value	0	1	9
18 lb. of fine tow, value	0	3	0
1¼ cwt. of coarse tow, value	0	10	0
	£2	10	9

The cost of labor, everything included, was 15s., leaving £1 15s. 9d. as the net value of the produce.

The flax with which the experiments were carried out was of rather a poor quality, otherwise 8 cwt. of steeped straw would have yielded more than 1 cwt. of scutched fiber. If we may adopt Mr Henly's estimate as practically correct—and the operations of the next few months will definitely settle this point—he appears to have made out a very good case for intelligent hand labor *versus* the work done by the old fashioned scutching stock, in all cases where only moderate quantities of flax have to be treated. He does not claim that improved scutching machines or improved heckling machines can be dispensed with where the manufacture is carried out on a large scale, his object being rather to show that small farmers are able with a very slight expense for power and machinery to work up their own crops during the winter, giving employment to their laborers.

As regards the economic side of the question, a very simple calculation based on the above figures shows that with an average crop of 35 cwt. of straw per acre, the net market value of the fiber and tow obtained per acre is about £8. Add to this £6 for the seed, chaff, and refuse, and it will be seen that even with a liberal allowance for cost of labor and fuel and depreciation of plant, there should remain a good profit.—*Industries.*

AMUSING PHOTOGRAPHY.

IN photographic studios, canvas or paper backgrounds of various shades are used, and from these the operator, if skillful, can obtain very happy effects from an artistic point of view.

The amateur, who is naturally not so well equipped, can nevertheless obtain a series of very interesting results with two backgrounds only—a white and a black one. With the first, on making use of a vignetter during the printing of the positives, he will obtain shaded portraits of a peculiar character on a white background, especially if he uses the platinum process. With the second, he will be able to form what is called the Russian background. This mode of printing is very valuable where it is a question of portraits of persons in light costume. The process may be easily performed in the following way: A piece of cardboard is cut out in the form of a vignetter (Fig. 1), and is placed in the camera, where it is held by the folds of the bellows. The rays coming from the object can pass only through the aperture in the little screen, and will illuminate but one spot on the ground glass, all the rest being in darkness. The objective is moved in one direction and the other in such a way that the image shall be well centered with respect to the illuminated portion, and the latter is made to vary by moving the screen backward and forward. On account of the distance from the screen to the ground glass, the contours are shaded off with the greatest perfection directly upon the negative.

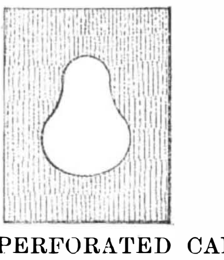


FIG. 1.—PERFORATED CARD.

To take up another line of thought, we know that a perfectly black background has no action upon the sensitive surface, that the latter remains intact in every part that the light has not struck, and that it is capable of receiving a new impression. It is by taking this fact as a basis that Mr. Marey has been enabled to register a series of successive images upon the same sensitized plate. The sole difficulty met with in this sort of work is due to the background, which should have absolutely no action upon the plate. Mr. Marey has had to employ the process pointed out by Mr. Chevreul, and operate before quite a deep cavity lined throughout with black velvet. Under such circumstances, it is possible to obtain a series of images on the same plate without the background having the least action upon the sensitized coating. The amateur, by the use of the black background thus conceived, will be able to obtain subjects varied at his pleasure, which will not fail to puzzle those who do not know how they were produced. It will suffice for him to operate upon a sufficiently dark background or opposite an aperture in some dimly lighted inclosure. A window or the mouth of a cave will give him very good results. Upon placing his model in various positions, and in taking care, by means of reference points taken for each operation, to see that none of the images encroaches upon the other, he will be able to obtain a negative in which the same person will be found represented two or more times. It is useless to say that at every position of the model he will have to make an exposure of the desired duration in order to obtain a good negative. In this way, the various portraits will have the same value.

The subjects that can be made in this way are very numerous. The same person can be represented pouring out a drink for himself, offering himself a fire in smoking, making up a card party, etc. On intentionally giving too short an exposure in one of the cases, we shall have a light, shadowy image that will permit of giving the effect of specters, apparitions, etc. This is the very process that has been used with so much success for obtaining spirit photographs, and by means of which so many dupes have been made.

The amateur may vary his subjects as he pleases, but he must take care to place his model in such a way that the new image shall not be confused with the first. If it be desired to obtain the same effects upon a background other than a uniformly black one, the mode of operating will be different.

The following very ingenious method is pointed out by Mr. H. Duc, of Grenoble. It consists in making use of a special frame, which, instead of having a sliding shutter, is provided with two shutters that operate like

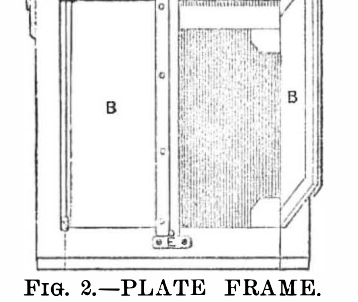


FIG. 2.—PLATE FRAME.

the leaves of a door. These shutters, B B (Fig. 2), pivot upon two vertical axes, A A, whose upper extremities project from the frame so that they can be maneuvered from the exterior. As the shutters must join very accurately, Mr. Duc affixes asbestos paper to their edges. A sliding steel plate, E D, permits of keeping the two shutters closed before and after exposure. This is removed when the frame is in the camera.

The ground glass is divided into two parts by a pencil line that exactly tallies with the junction line of the shutters. The subject is focused on one of the halves of the glass, and then the corresponding side of the frame is unmasked. After exposure the model changes place, and then the other side of the frame is opened.

The photograph reproduced in Fig. 3 was taken in this manner. It contains three representations of the same person. The easel, stool, and artist having been arranged, an image is taken on the left side of the plate, then the painter moves his position to the right and a second exposure is made. The portrait on the

FIG. 3.—COPY OF A PHOTOGRAPH SHOWING THE SAME PERSON THRICE REPEATED.

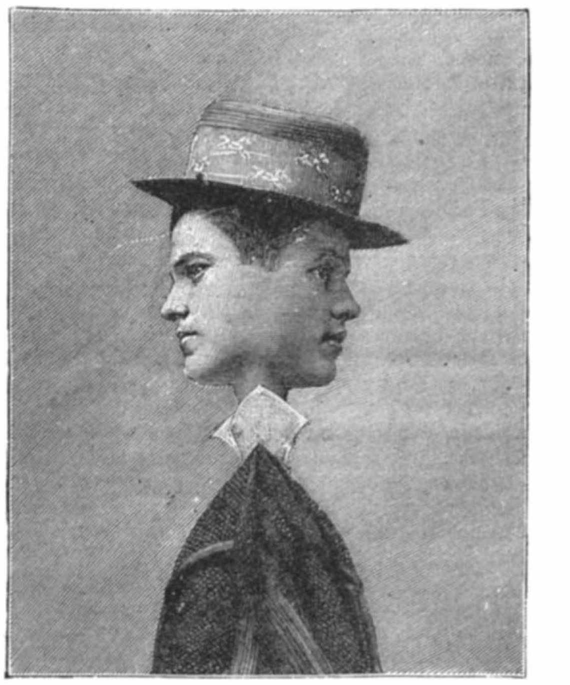
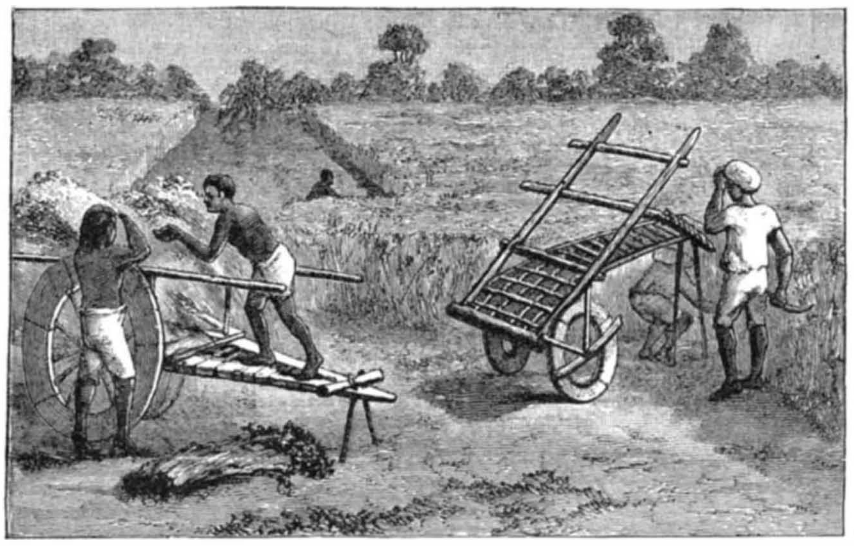


FIG. 4.—COPY OF A PHOTOGRAPH GIVING TWO PROFILES OF THE SAME PERSON.

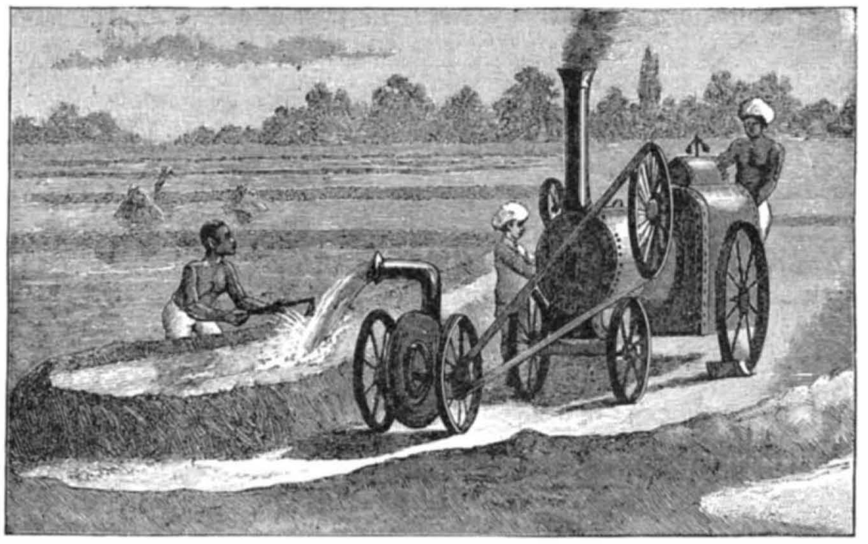
easel is that of the same person, but was taken afterward on the positive by means of the negative and a vignetter. The other photograph (Fig. 4) is likewise very curious, and was taken with the same apparatus. A hat was fixed firmly to a head rest, and the same person then glided under it and presented his two profiles.—*La Nature.*

INDIGO CULTURE.

These sketches show the various stages of culture and preparation for the market of indigo. The lands are first carefully hoed or dug, and then plowed with the primitive native wooden plow. When moisture is scarce, recourse is had to irrigation, the native mode of raising water by the "cureen" and "dhow" being superseded of late by machinery. The seed is generally sown about the beginning of March from drills, and the soil beaten down after by means of the "hengaht," a log dragged along by bullocks. The plant is ready to cut about June, when it is carted into the factory, and steeped in ranges of vats from about twelve to fourteen

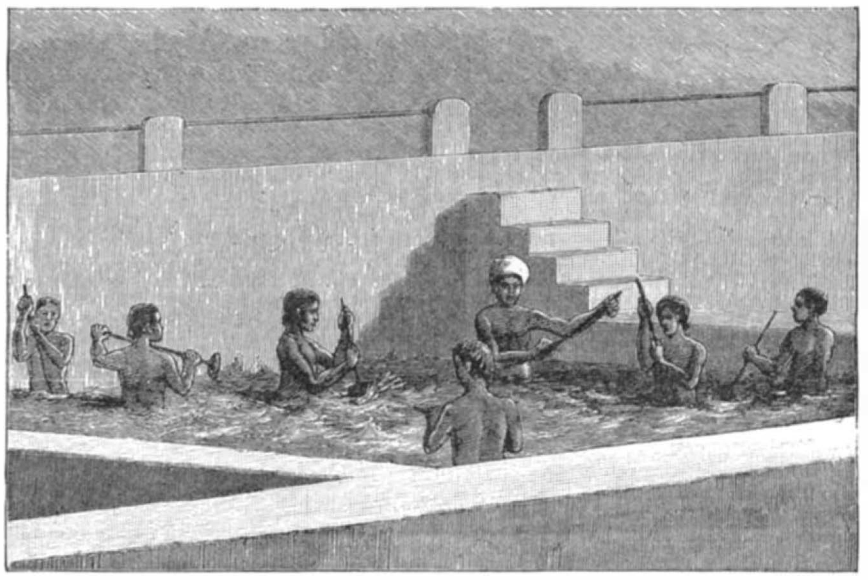


CUTTING THE PLANT

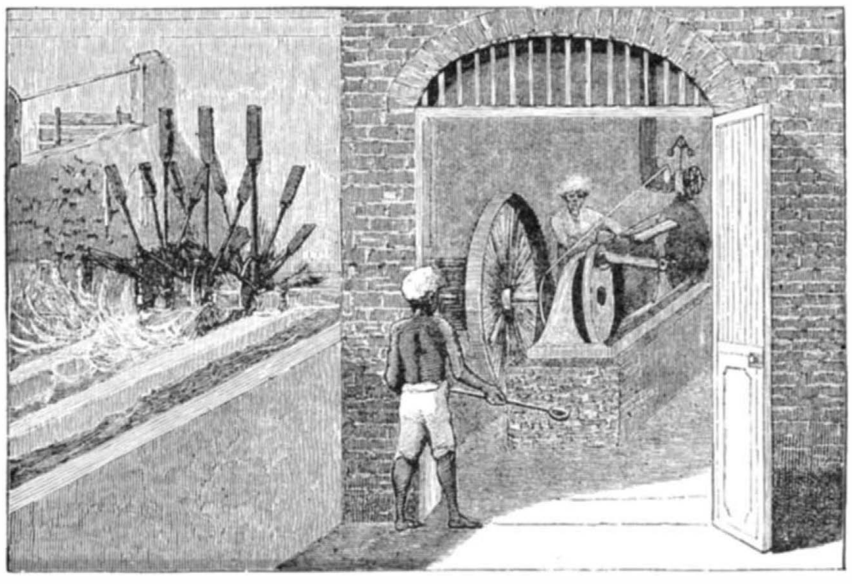


IRRIGATING

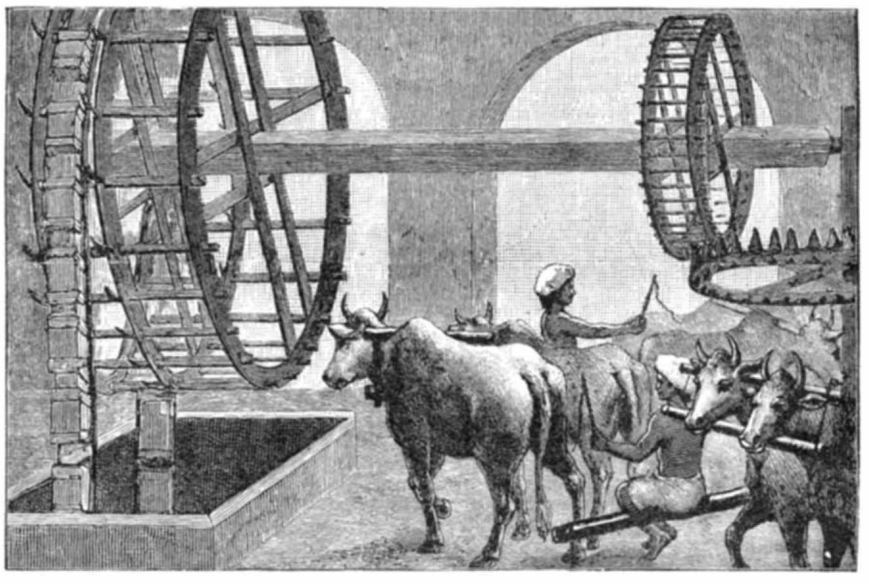
LOADING THE VATS



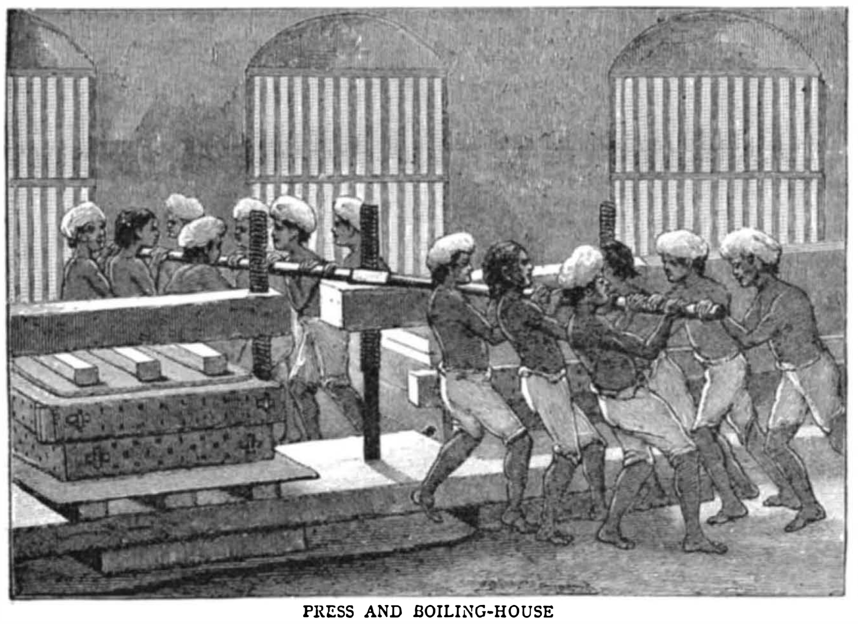
HAND BEATING



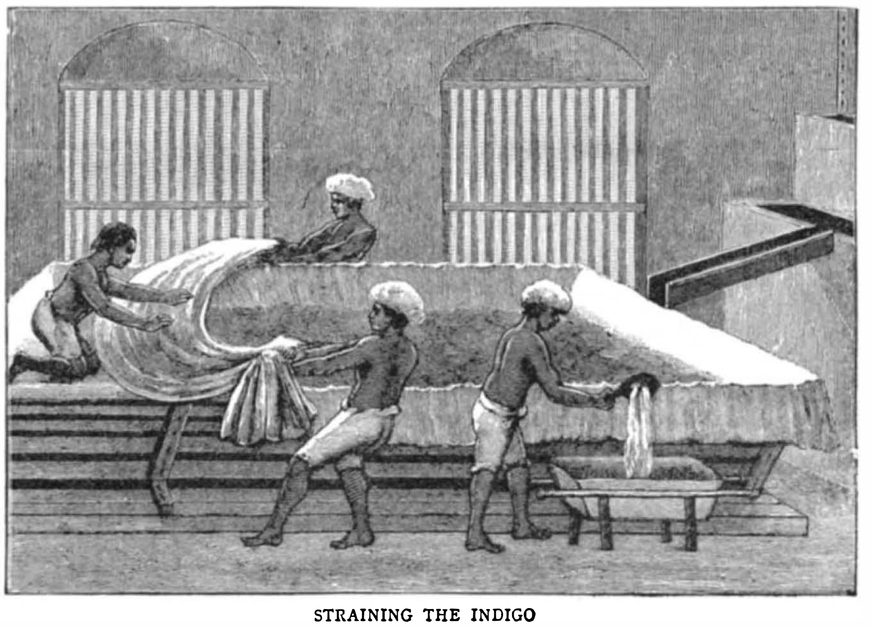
BEATING BY MACHINERY



"RAHUT," OR PERSIAN WHEEL



PRESS AND BOILING-HOUSE



STRAINING THE INDIGO

INDIGO MANUFACTURE IN INDIA.

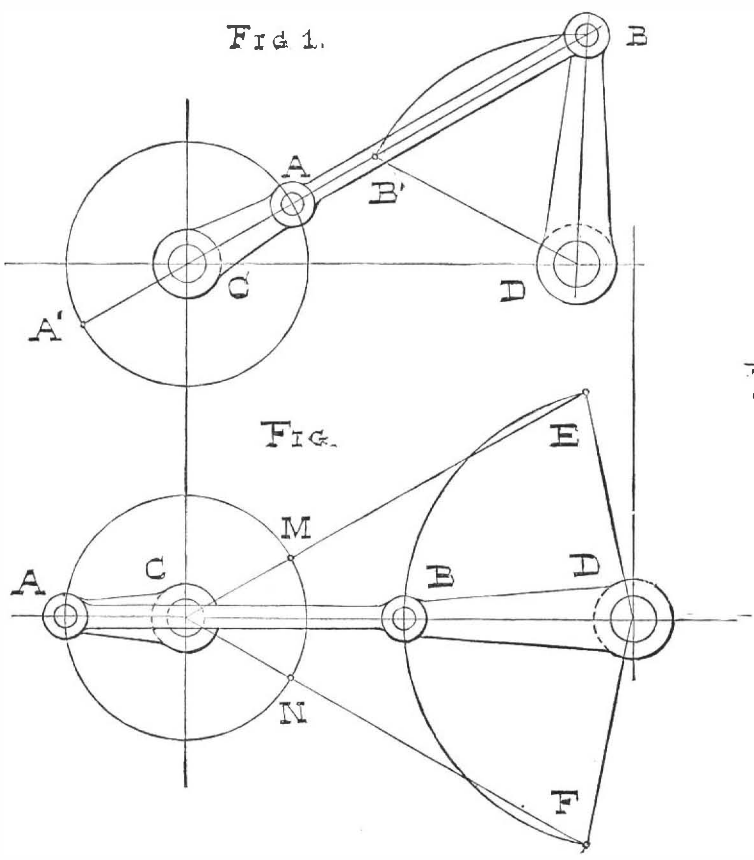
hours. The water is then drained off into a lower range of vats, where it is beaten either by coolies or machinery, and turns from a pale pea green to a dark blue, in which particles of indigo are visible. The surplus water is drained off, and the sediment, known as "mall," is pumped up into large boilers, and boiled for several hours, after which it is run on to a "table," covered with a large sheet, through which the remaining water strains. It is then put in presses, and pressed for twelve hours, and lastly cut up into cakes of three-inch cubes, and shelved to dry, and then packed and dispatched to the Calcutta market as the indigo of commerce.—Our sketches are by Mr. E. D. Campbell Bara, Tirhoot State Railway, India.—*London Graphic.*

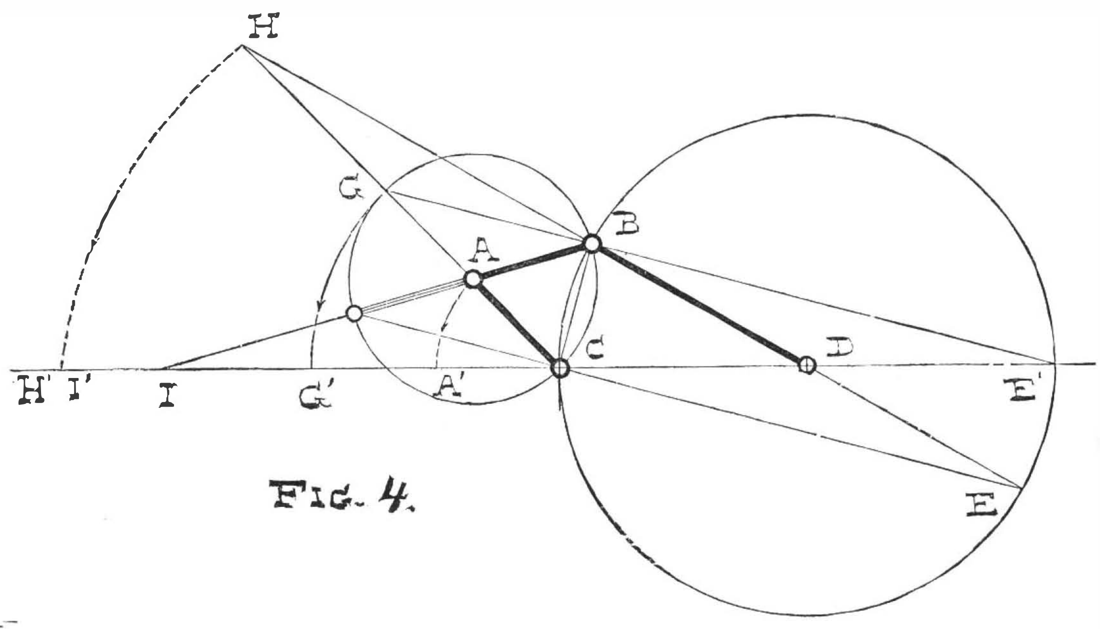
SIMULTANEOUS DEAD POINTS.

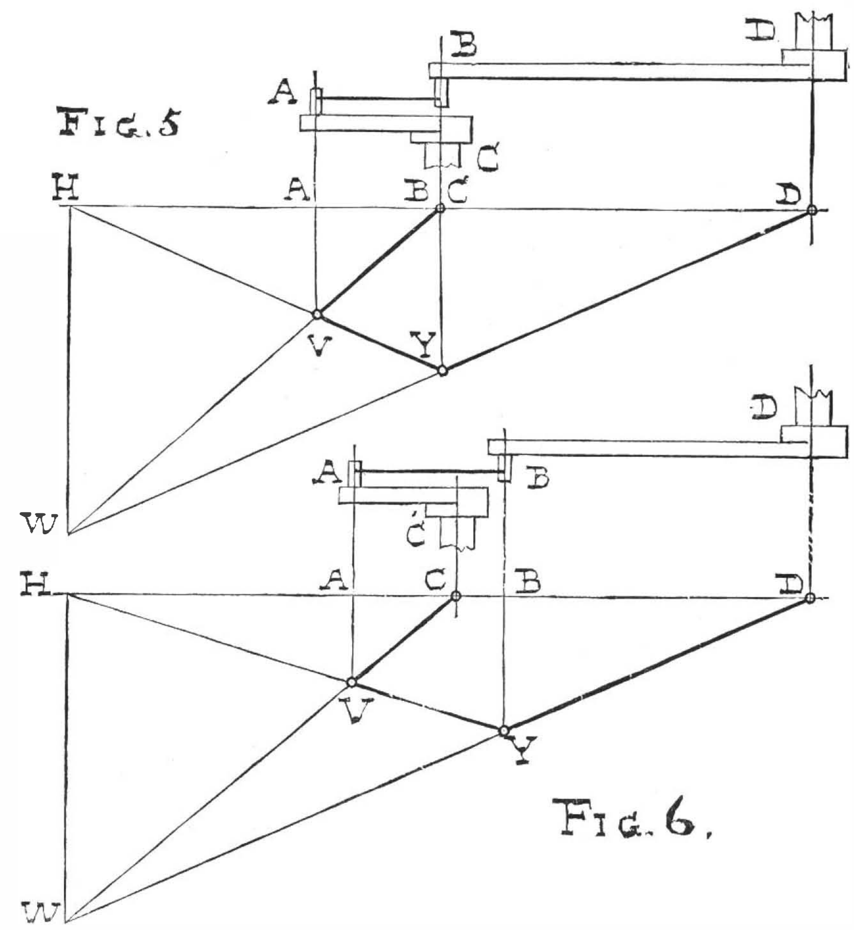
By Prof. C. W. MACCORD, Sc.D.

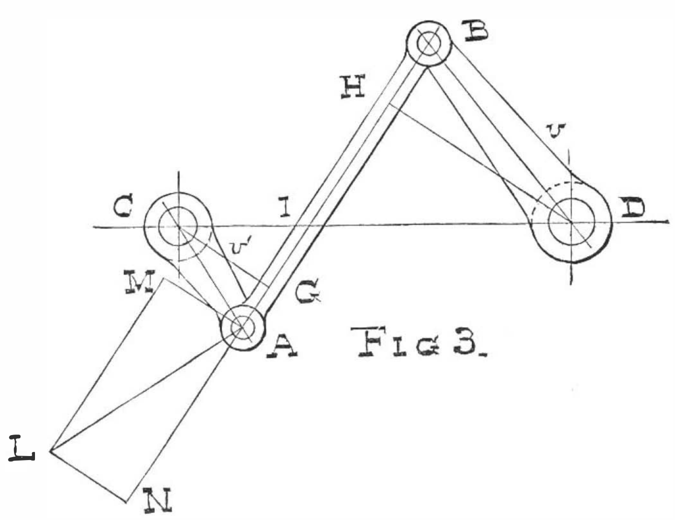
I.

THE nature and the effects of a single dead point, such as occurs twice in each revolution of the common steam engine, are familiar to every reader, and have been fully discussed by every writer on elementary mechanism.









This cannot be said, however, of cases where two dead points occur simultaneously, as, for example, in the motion of the coupled drivers of a locomotive. These seem to have received very little notice, and in what follows we propose to consider the action of link work as affected by such double dead points.

In Fig. 1, the revolution of the crank, A C, causes the lever, B D, to swing through the angle, B D B′, there being a single dead point when the crank pin is at A and another when it is at A′. A very slight increase in the distance, C D, between the fixed centers, as shown in Fig. 2, will permit the rocking lever to traverse a much greater angle, E D F. There will be two single dead points as before at M and N, and, in addition, a double dead point when both A C and B D are horizontal, as represented.

It will readily be seen that there are various other proportions and relative positions of the three elements of this simple combination in which simultaneous dead points may thus occur. Prof. Willis, in his "Principles of Mechanism," has illustrated quite a number of these. He, however, goes no farther than to point out the mere fact, and says nothing in reference to the motions of the parts at the instant of coincidence.

Prof. Rankine gives no illustrations in immediate connection with this topic, but he makes an explicit statement in regard to dead points, which we quote from "Machinery and Millwork" (p. 193):

"If at any instant the plane traversing one of the crank arms and its axis of rotation coincides with the line of connection, the common perpendicular of the line of connection and the axis of that crank arm vanishes, and the directional relation of the motions becomes indeterminate. The position of the connected point of the crank arm in question at such an instant is called a *dead point.* The velocity of the other connected point at that instant is null, unless it also reaches a dead point at the same instant, so that the line of connection is in the plane of the two axes of rotation, in which case the velocity ratio is indeterminate."

The truth of the first paragraph above quoted is obvious from a glance at Fig. 1. B having reached the end of its excursion to the right, must now return toward B′, no matter in which direction A moves, and also B must for the instant be stationary, for the simple reason that it cannot move both ways at once.

But to the last clause of the quotation we cannot assent, and we now propose to show that when the two ends of a link reach their dead points simultaneously, as in Fig. 2, while the directional relation may be indeterminate, the velocity ratio is not and never can be.

Before proceeding, however, it may be worth while to point out that the conclusion given by Prof. Rankine would seem to be reached in this way. One well-known value of the velocity ratio in such a combination is that it is the inverse ratio of the perpendiculars let fall from the centers of motion upon the line of the link. Thus, in Fig. 3, let

v = ang. vel. about D
v' = " " " C

then

$$\frac{v}{v'} = \frac{C\,G}{D\,H}$$

And since D H and C G both vanish upon reaching the position shown in Fig. 2, we then have

$$\frac{v}{v'} = \frac{0}{0}$$

However this may be, it is curious to observe that Prof. Rankine had previously introduced, in illustration of other matters, two arrangements whose action is contradictory to this conclusion. One of these is the parallel rod of the locomotive above mentioned. In this case the two levers are equal, and turn in the same direction, under which circumstances the velocity ratio is unity, and cannot be anything else. The other is the use of a link connecting the free foci of a pair of elliptical wheels. Both levers are of the same length here also, but they turn in contrary directions, and the velocity ratio is at every instant the same as that of the rolling ellipses, which certainly is never indeterminate. It might be objected that this is not absolutely conclusive, since, if it be indeterminate, any value will satisfy the conditions, and the action of the elliptical wheels merely fixes one of many possible values at the critical instant. The presumption, however, is against so remarkable an exception to the law of variation in the velocity ratio in one of two combinations whose actions are otherwise identical, and it will be shown farther on that if the levers are made to turn in opposite directions by any means whatever, the velocity ratio will be determined by that fact, and will be the same whether the ellipses be present or absent.

In Fig. 2, the motions of both A and B must be perpendicular to the line joining those points, and the motion of the link must, therefore, at the instant be one of rotation about some point on A B or its prolongation. Our first step is to find this point, the general method of doing which can be best explained by first considering a special case, illustrated in Fig. 4.

In this arrangement the lever, A C, or r, is equal in length to the link, A B, and the lever, B D, or R, is equal to C D, the line of centers. In the position shown, the instantaneous axis of the link is at H, the intersection of C A and D B prolonged.

Now describe about A a circle through C, cutting C H in G; also about D a circle through B, prolonging H D to cut its circumference in E, and draw G B, B C, C E. Then G B, C E being perpendicular to the common chord, B C, are parallel, and the triangles, H G B, H C E, are similar, whence

$$H\,G : G\,C :: G\,B : C\,E - G\,B.$$

Let the system move as shown by the arrows, then B will ultimately coincide with C, and since A and G describe circles about C, they will at that time be respectively at A′ and G′, also E will be at E′, and we shall then have

$$G\,B = G\,C = 2\,r,$$

and

$$C\,E = B\,E = 2\,R.$$

Meantime, the instantaneous axis, H, being always at the intersection of the levers prolonged, will move in a path whose form is not material, and at the instant of collapse will fall at some point, H′, on the line of centers, such that

$$H'\,G' : 2\,r :: 2\,r : 2\,R - 2\,r$$

whence

$$H'\,G' = \frac{2\,r^2}{R - r}$$

thus locating the instantaneous axis at the instant in question.

Now let

u, u' = linear velocities of B and A } at this instant.
v, v' = angular " " R " r }

Then, because the linear velocities are proportional to the distances from the instantaneous axis, we have

$$\frac{u}{u'} = \frac{H'C}{H'A'} = \frac{\frac{2r^2}{R-r}+2r}{\frac{2r^2}{R-r}+r} = \frac{2R}{R+r}$$

And also, because angular velocity $= \frac{\text{linear velocity}}{\text{radius}}$

we shall have $\left.\begin{array}{l} v = \frac{u}{R} \\ v' = \frac{u'}{r} \end{array}\right\} \therefore \frac{v}{v'} = \frac{u}{u'} \times \frac{r}{R}$, whence, substituting for $\frac{u}{u'}$ the value just found, we obtain as the value of the velocity ratio at the critical instant,

$$\frac{v}{v'} = \frac{2r}{R+r}$$

The system, with these proportions, presents a rather curious feature. When B coincides with C, its elements are in what may be called an ambiguous condition if A C is the driver, for it is then possible that B D may remain stationary while A C revolves at any speed and for any time, although if the follower be helped over the dead point, the velocity ratio at the instant will have the value just ascertained. But mere inspection of the figure will show that if the longer lever drive, it will compel the other one to move, and the action will be continuous while passing the double dead point, neither the velocity ratio nor the directional relation becoming indeterminate.

We may remark in passing that if the link in Fig. 4 be prolonged to P, making A P = A B, a pencil at P will trace the curve well known to mathematicians as the semniscate. Were the velocity ratio then to become indeterminate, the radius of curvature of the semniscate at its vertex would likewise become so, which it certainly is not. What its exact value is may be graphically determined by a process of what may be called kinematic analysis, described by the writer in other numbers of this journal. That operation requires not only the location of the instantaneous axis as above explained, but also that its velocity should be ascertained, which latter will now be necessary for our present purpose, since upon it depends another mode of procedure which is applicable when the proportions of the elements are different from those given in Fig. 4, in which case the geometrical solution above given is impracticable.

Now, in Fig. 5, and other like movement diagrams which follow, it is to be understood that C V and D Y do not represent *positions* of the levers; but A V, B Y, and H W represent the *motions* of A, B, and the instantaneous axis, H, at the instant of collapse.

The actual magnitudes of these lines are immaterial, but the relative velocities must be such, and H must be so situated, in all cases, as to satisfy the following conditions, viz.:

1. Because the link, A B, is at the instant turning about H as a center, the line, Y V, prolonged if necessary, must pass through H.

2. Because H is the virtual intersection of the center lines of the levers, A C, B D, the magnitude of H W must be such that the prolongations of C V and D Y shall pass through W.

From the similar triangles thus formed, the velocity ratio may then be deduced algebraically, whatever the relative lengths of the levers and the link.

The proportions of these in Fig. 5 are the same as in Fig. 4, and we have:

(Triangles HWD, BYD).. $\frac{HW}{BY} = \frac{HD}{BD}$

(Triangles HWC, AVC).. $\frac{AV}{HW} = \frac{AC}{HC}$ } $\therefore \frac{AV}{BY} = \frac{HD}{HC} \times \frac{AC}{BD}$

(Triangles HAV, HBY).. $\frac{AV}{BY} = \frac{HA}{HC} \therefore \frac{HA}{HC} = \frac{HD}{HC} \times \frac{AC}{BD}$..(1)

Now let A C = A B = r, B D = R, H A = x;
then H B = H C = $x + r$, and H D = $x + r$ + R, and Eq. (1) becomes

$$\frac{x}{x+r} = \frac{x+r+R}{x+r} \times \frac{r}{R}$$

which gives

$$x = \frac{r(R+r)}{R-r} \;\ldots\ldots\ldots (2)$$

Now H W is the linear velocity of H, a point common to both levers, whose angular velocities will therefore be inversely proportional to the distances of H from their centers of motion; then if we again let

v = ang. vel. about D
v' = ang. vel. about C

we have $\frac{v}{v'} = \frac{HC}{HD} = \frac{x+r}{x+r+R}$.........(3)

and combining (2) and (3), we find as before,

$$\frac{v}{v'} = \frac{2r}{R+r}$$

But again, another familiar value of the velocity ratio in general is expressed by saying that it is the inverse ratio of the segments into which the line of the link divides the line of centers.

Thus in Fig. 3, the link crosses the line of centers at a point, I, between C and D; in Fig 4, B A produced cuts the prolongation of D C, and thus divides the latter distance externally into the segments, C I, D I; and in either case we have

$$\frac{\text{Ang. vel. about D}}{\text{Ang. vel. about C}} = \frac{CI}{DI}$$

If now in Fig. 4 we draw P C, B E', these two lines will be perpendicular to B C, and therefore parallel, making the triangles, I P C, I B E', similar; whence

I P : P B :: P C : B E' − P C.

As the rotation progresses in the direction of the arrows, I will move to the left along D C, and at the instant of collapse, when B coincides with C, making B E' = C E' = 2 R, P will fall at G', making P C = P B = 2 r; and I will have reached a position, I', such that I' G' : 2 r :: 2 r : 2 R − 2 r

whence $I'G' = \frac{2r^2}{R-r}$

Then $I'C = \frac{2r^2}{R-r} + 2r = \frac{2Rr}{R-r}$

and $I'D = \frac{2Rr}{R-r} + R = \frac{R(R+r)}{R-r}$

But $\frac{I'C}{I'D} = \frac{v}{v'}$

whence $\frac{v}{v'} = \frac{2Rr}{R(R+r)} = \frac{2r}{R+r}$

Assurance then is made trebly sure, by the agreement of the result thus reached with those previously deduced; and we may now proceed to consider the effects of variations in the relative lengths of the levers and link.

Fig. 6 differs from Fig. 5 only in the length of A B, which is now made longer than A C, the shorter lever (just as it was in Fig. 2), so that B does not coincide with C. But, taking first the case in which the rotations are in the same direction, we have the same series of similar triangles, similarly arranged, and the diagrams being lettered to correspond, we at once deduce the same equation,

$$\frac{HA}{HC} = \frac{HD}{HC} \times \frac{AC}{BD} \ldots\ldots\ldots\ldots (1)$$

Now let
A C = r, A B = l, B D = R, H A = x;
then
H C = $x + r$, H B = $x + l$, H D = $x + l$ + R.

Substituting these values in (1), it becomes

$$\frac{x}{x+l} = \frac{x+l+R}{x+r} \times \frac{r}{R}$$

whence $x^2 - \frac{2rl}{R-r}x = \frac{rlR + rl^2}{R-r}$

Completing the square and extracting root, this gives

$$x - \frac{rl}{R-r} = \frac{\sqrt{Rlr(R+l-r)}}{R-r}$$

or $x = \frac{rl + \sqrt{Rlr(R+l-r)}}{R-r}$..........(2)

Next, we have

$\left.\begin{array}{l} v = \frac{BY}{R} \\ v' = \frac{AV}{r} \end{array}\right\} \therefore \frac{v}{v'} = \frac{BY}{AV} \times \frac{r}{R}$

or, since $\frac{BY}{AV} = \frac{HB}{HA} \cdots \frac{v}{v'} = \frac{HB}{HA} \times \frac{r}{R}$;

But
H B = $x + l$, and H A = $x \therefore \frac{v}{v'} = \frac{x+l}{x} \times \frac{r}{R}$....(3)

Combining (2) with (3), and reducing, we find ultimately the value

$$\frac{v}{v'} = \frac{Rlr + r\sqrt{Rlr(R+l-r)}}{Rlr + R\sqrt{Rlr(R+l-r)}} \ldots\ldots (A)$$

Or we may take the expression

$$\frac{v}{v'} = \frac{HC}{HD}$$

which, since H C = $x + r$, and H D = $x + l$ + R, gives

$$\frac{v}{v'} = \frac{x+r}{x+l+R}$$

and substitute in this the value of x from Eq. (2); whence by reducing we find

$$\frac{v}{v'} = \frac{r(R+l-r) + \sqrt{Rlr(R+l-r)}}{R(R+l-r) + \sqrt{Rlr(R+l-r)}} \ldots (B)$$

It must be confessed that the identity of the expressions (A) and (B) is not obvious on inspection; but if one be inverted and multiplied by the other, it will be found, on performing the operations indicated, that the result reduces to unity; moreover, if in either we make $l = r$, it will reduce, as it ought, to the form

$$\frac{v}{v'} = \frac{2r}{R+r};$$

showing that all this complexity in the expression for the velocity ratio is due to the fact that B and C do not coincide at the instant of collapse.

In order to construct the diagrams, Figs. 5 and 6, for any given values of R, l, and r, it is necessary to determine the position of the instantaneous axis, by substituting these given numerical values in the formulæ (2), and reducing; but for the purposes at present in view it is not essential that the diagrams should be accurately drawn, since a mere sketch will suffice in making the computations.

As before remarked, the directional relation in Fig. 6 is indeterminate, the case being identical with that in Fig. 2, by referring to which it will be clear that in moving from the position there shown, the levers may turn either in the same or in opposite directions.

The discussion of the velocity ratio in the latter event is reserved for a subsequent article, but we would here call attention to a special feature of the action of the arrangement shown in Figs. 4 and 5, which has not yet been mentioned.

It is usually considered, we believe, that only the component in the line of the link is effective in transmitting motion from one lever to another. Thus, if in Fig. 3 the shorter lever drive, let A L, perpendicular to A C, be the motion of the point, A; resolve A L into the components, A M and A N, respectively, perpendicular to and coincident with A B; then A N is that which imparts motion to B D. So that if, as in this case, the link acts by *pulling*, a very thin, inextensible, but perfectly flexible wire might be substituted for it without affecting the result in the transmission of either motion or force.

Now, so long as there *is* any component in the direction of the link, there is no occasion, and, it may be said, no ground, for questioning the argument; nor yet in the case of a single dead center, as seen in Fig. 3, where the link rotating about the instantaneous axis, B, which is stationary at the instant, no motion is transmitted from A to B D.

But in Fig. 4, we may imagine B D to drive with a perfectly uniform motion, in which case the velocity of A C will be variable, of course, but it does not vanish at the instant of collapse, when, as above shown, the ratio of the angular velocities is $\frac{2r}{R+r}$, and that of the linear velocities of A and B is $\frac{2R}{R+r}$. Under these circumstances, then, this combination seems to present a remarkable exception to the general proposition referred to, whether it be regarded kinematically or dynamically.

It may be said that, owing to the elasticity of materials, to the impossibility of securing perfect freedom from play or "lost motion," and in short, to all that prevents the realization of abstract desiderata, there will practically be a small rotation about A at that time, and that an infinitesimal action of that kind will introduce a longitudinal component of motion or of force.

But we conceive ourselves at liberty to imagine what we may not be able to realize, and to confine our attention to what is going on at the exact instant in question. We have shown that neither the directional relation nor the velocity ratio is indeterminate; we have the right to assume the motion of B to be continuous, in which case that of A must also be uninterrupted; and supposing absolute perfection of materials and workmanship attainable, the question remains, How is the force transmitted in the one view, or the motion in the other—not an instant before or an instant after crossing the line of centers, but at the precise instant of collapse? Our explanation is this: That the link then acts as a lever, whose invisible, intangible fulcrum is the instantaneous axis. Supposing for the moment the levers to be removed, it is easy to see that if by any other means we impart to A and B motions satisfying the conditions of direction and velocity above deduced, the result will be identical with a rotation about that axis. Now, restoring the levers and imparting the same motion to B, it will be perceived that the action of A B is so constrained by its connection with A C that its point, A, *must* move with a velocity having a definite ratio to that of B. As before, then, the result will be a rotation about the instantaneous axis, and the link is for the instant a lever, and both the dynamic and the kinematic transmission depend upon its absolute rigidity.

Supposing it to be rigid, then, we perceive that a continuous motion of B D will carry the system past the double dead point position, and that if it be stopped in that position, a motion of B D will start it. But the operation is different if the shorter lever be made the driver. In that case, it is true that the velocity ratio will be maintained as before, up to the instant of collapse, but it does not follow that B D will be carried past the dead point, for there, as before mentioned, the condition is ambiguous, as B coincides with C, so that A C may go on revolving, carrying A B with it, and imparting no motion to B D, which certainly would occur were the system stopped in the critical position.

In this one contingency, therefore, the velocity ratio becomes infinite in the sense that A C may have any velocity whatever. This, however, is equally true for the instant in the case of a single dead point, where the driven lever is also stationary, but it is not indeterminate in the full meaning of that term, which would require it to be possible for both levers to move with any velocities assigned at pleasure.

Practically, then, the shorter lever fails to drive past the double dead point, not because the velocity of the longer one becomes indeterminate, but because it is in that position possible for the combination to become in fact a different system, if it may be so called, in which B D is to all intents and purposes a part of the frame, while A B and A C constitute in effect a single lever revolving about a fixed center, C. The resistance being obviously much less in this case, the probabilities are that unless the momentum of B D were considerable, that lever would stop abruptly on reaching the horizontal position, and the simple rotation just mentioned would be established.

On the other hand, if B D be the driver, a reciprocating motion of that lever can maintain a continuous rotation of A C only by the aid of the momentum of the latter in carrying it past the two *single* dead points.

One other circumstance may be noted in regard to this interesting arrangement. If A C and A B together do revolve about C while B D is at rest in the horizontal position, through never so small an angle, then B D will be locked in that position, and can neither move nor be moved until a double dead point again occurs. That will happen when A C has made a half revolution from the position shown in Fig. 2, the two levers then pointing in opposite directions. But they will also rotate in opposite directions, and the investigation of the velocity ratio in that case will be given at another time.

TEXTILE MACHINERY AT THE MANCHESTER ROYAL JUBILEE EXHIBITION.

The display of textile machinery at the above exhibition is the finest which has ever been made. It is, of course, mainly an illustration of the machines used in the manufacture of cotton; but there is a very notable collection of machines for the treatment of wool, and a few intended for the manipulation of silk. As the various machines exhibited are from the latest patterns designed by the makers, and comprise the whole of their most recent improvements, no better education is possible to a student of textile mechanics than a careful inspection of the exhibits in this section. It is our object in these articles to describe and illustrate, as far as possible, the various devices and appliances used by different machinists in each class of machines. To do this effectually within a reasonable space and avoid repetition, we propose to treat each

machine separately, and describe the variations in the mechanism adopted in the various exhibits. The establishment, however, of any comparisons would necessarily lead to the introduction of many other considerations which are at present beyond the scope of these articles.

The process of cotton spinning consists of three main stages. There is first the opening and cleaning treatment, which is necessary to eliminate dirt, leaf, and other extraneous matter, always to be found attached to the fiber when received in the bale. The second process consists in the straightening and drawing of the fiber preparatory to twisting, and this is effected by the carding and drawing machines. Twisting the sliver which is thus obtained constitutes the third stage, and is effected by a series of machines which will be duly considered. After the yarn is formed it can be manufactured into thread for lace or sewing purposes, or it may be woven into cloth. Before it reaches the loom, however, the yarn passes through a series of preparatory processes, and after being woven the cloth may be bleached, calendered, or printed, as desired. The

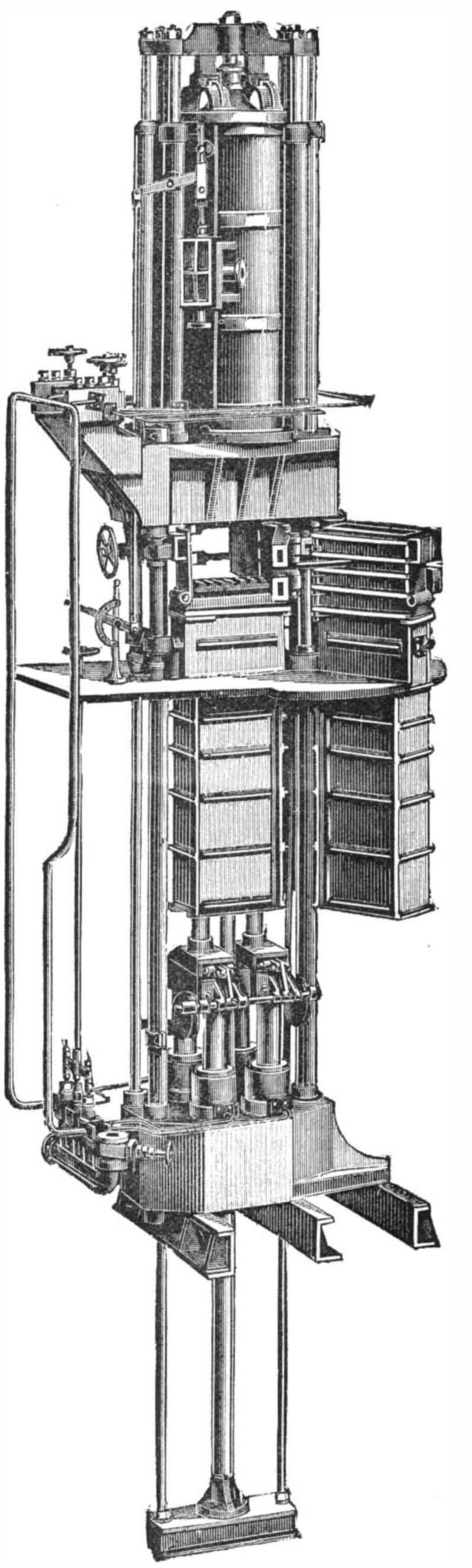


FIG. 1.—IMPROVED COTTON PRESS.

whole of these stages in manufacture and the machines used in them are represented in the exhibition. In addition to this, the machinery used in preparing the fiber for importation into this country receives illustration by means of the cotton gin of Messrs. Platt Brothers & Co. and the presses of Mr. William Turner and Messrs. Nasmyth, Wilson & Co.

Dealing with the machines in the order in which they successively treat the fiber, the first to be noted is the cotton gin made by Messrs. Platt Brothers & Co., Limited, of Oldham. This machine is on the Macarthy principle, but is constructed so that beyond the necessary labor entailed in feeding it no attention is required. At the bottom of the hopper into which the cotton is flung are two rollers covered with walrus leather, to which, by reason of its rough surface, the fiber adheres and is drawn against a knife blade which rests upon the surface of the roller. By means of a weighted lever a steady pressure is kept upon the knife, the position of the blade being practically a rigid one. As the cotton is being drawn forward as described, a second knife blade, which is oscillated within the hopper and which comes in close proximity to the fixed blade, separates the seed from the fiber. The latter is then carried forward underneath the fixed blade, and is delivered at the under part of the machine free from seed. In case of any obstruction arising from the presence of large pieces of cotton, strings, bands, etc., the rollers are arranged to recede and allow of the passage of the obstructing element. The gin will treat various lengths of fibers, and can be altered to suit these by simply making a change in the length of the traverse of the oscillating knife. The machine rollers are 40 in. wide and 6 in. diam., and the production varies from 60 lb. to 120 lb. per hour, according to the class of material treated. After being treated by the gin the cotton is then ready for making into bales, and although no press actually constructed for the treatment of this material is shown, models are exhibited by Mr. William Turner, of Salford, and Messrs. Nasmyth, Wilson & Co , Limited, of Patricroft. The press of which Mr. Turner shows a model is constructed in a novel manner, and is illustrated in Fig. 1. It presents a combination of the steam and hydraulic press, and has three boxes, which revolve so that two of them are always out of the way of the ram and in position for filling while the bale is being pressed in the third. Assuming that the full box is in the position shown in the engraving, the steam cylinder which is at the top is put in operation and its piston lifted by the steam pressure. To the end of the piston rod is attached a cross head, which is connected with a similar cross head below the box by rods. As the cross heads are raised the follower or bottom of the box is also raised, thus partially pressing the cotton. This first stroke is 10 ft. or 11 ft. in length, and is made in two seconds. As soon as the steam stroke is finished, two props attached to the follower are locked underneath by two strong shutters, which automatically slide into position over the heads of the rams of the four hydraulic cylinders shown in the engraving. As it ascends, the piston draws up eight rams, which fit in cylinders placed immediately adjoining the steam cylinder. In this way the water is siphoned into the cylinders named, which practically act as pumps. As soon as the steam has done its work the siphon valves are closed, and the pressure valves between the pumps and hydraulic cylinders opened. The steam exhaust valve is then opened, and the weight of the various parts forces the water out of the pumps into the cylinders below and completes the pressing of the bale. The doors are opened, and the bale is roped or banded. The central prop attached to the follower is a ram fitting in an air cylinder. As soon as the bale is packed, the shutters holding up the props are released, and the follower and props fall to the starting position in about two seconds. The bale is then removed, the door shut, and the boxes are revolved until the next one is under the cylinder, when the cycle of operations is again gone through.

While the bale is pressed in the manner described, the two boxes not in use are being filled, and this can be done in the time occupied by the formation of a bale. As actually made, the apparatus combines a pumping engine and press, and is very strongly constructed, the hydraulic cylinders being all of steel and the baling boxes of wrought iron. The attendants required to work this press are four in number, one man to work the relief valves, one the steam cylinder valves, and two to revolve the boxes, these being, of course, in addition to those required to fill the boxes. An output is reached per hour of sixty bales of Egyptian cotton, each weighing 700 lb. The advantages derived from this arrangement include specially the speed attained in conjunction with pressing power, the dead weight which is lifted by the upward stroke of the steam cylinder being all utilized during the down stroke to provide the hydraulic pressure which is necessary to finish with.

The cotton being now in bale form is imported and arrives at the mill, where it is freed from the bands or ropes, and is then, in some cases, placed in layers upon the feeder of the bale breaker or cotton puller, illustrated in Fig. 2. Of this machine there are two examples shown, one by Messrs. Platt Brothers & Co., Limited, and the other by Messrs. Taylor, Lang & Co., of Stalybridge. In construction the two machines are very much alike, being made with three pairs of rollers, which revolve at different speeds, so that the cotton is

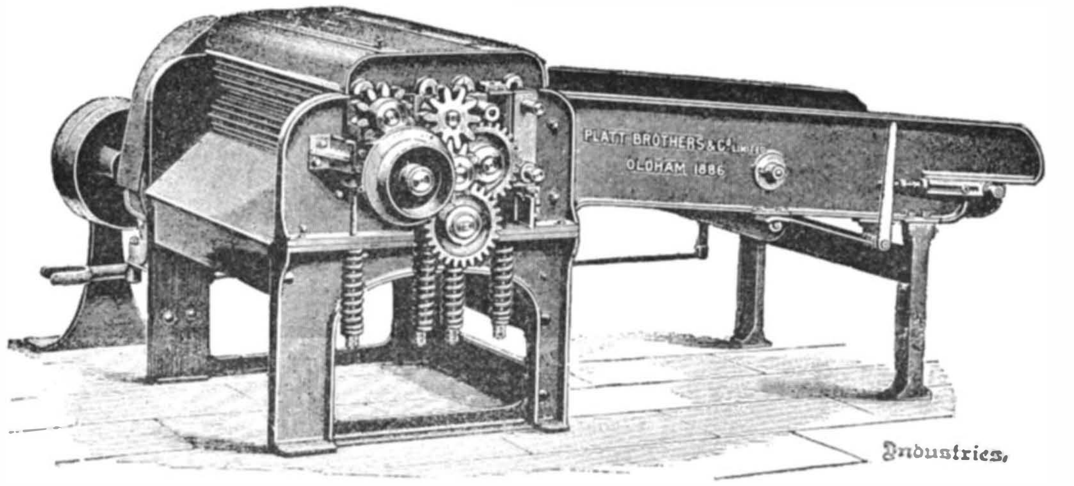


FIG. 2.—THE COTTON PULLER.

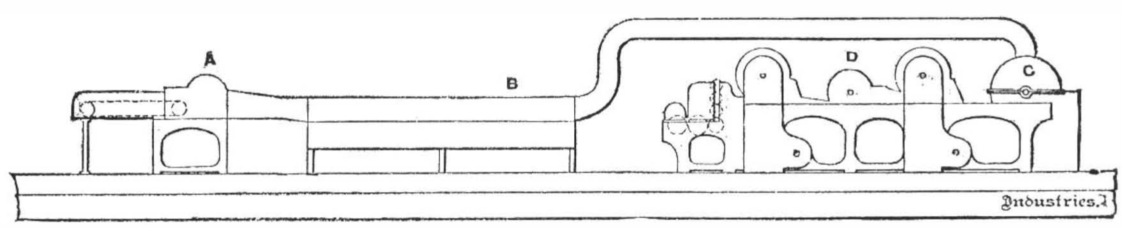


FIG. 3.—THE COTTON OPENER.

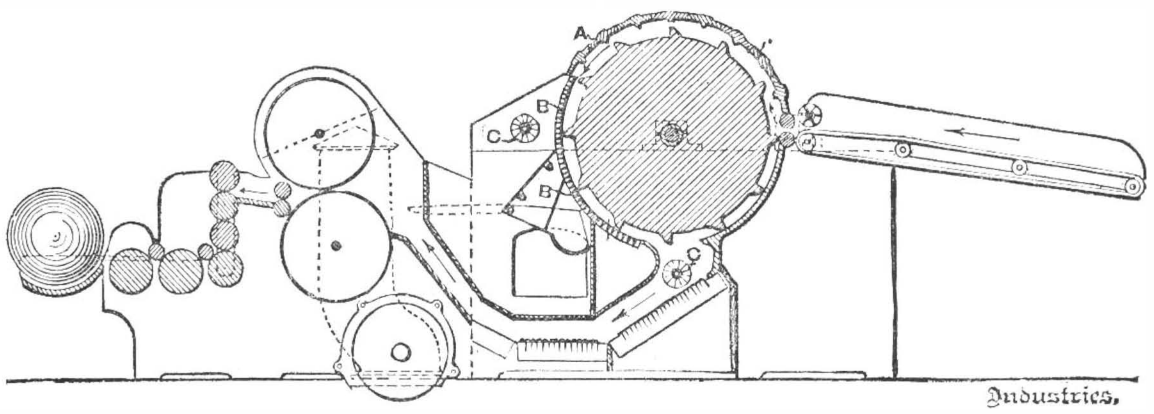


FIG. 4.—OPENER AND LAP MACHINE.

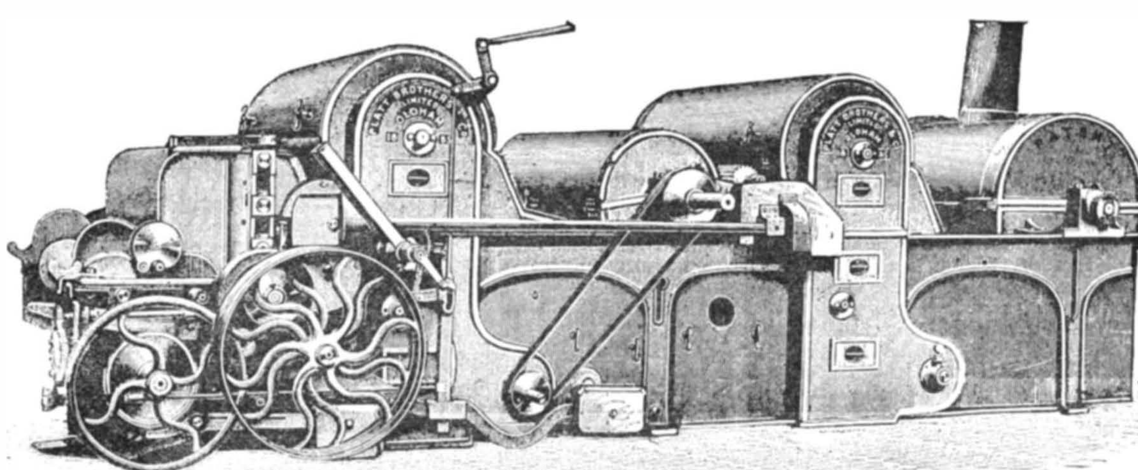


FIG. 5.—OPENER AND LAP MACHINE.

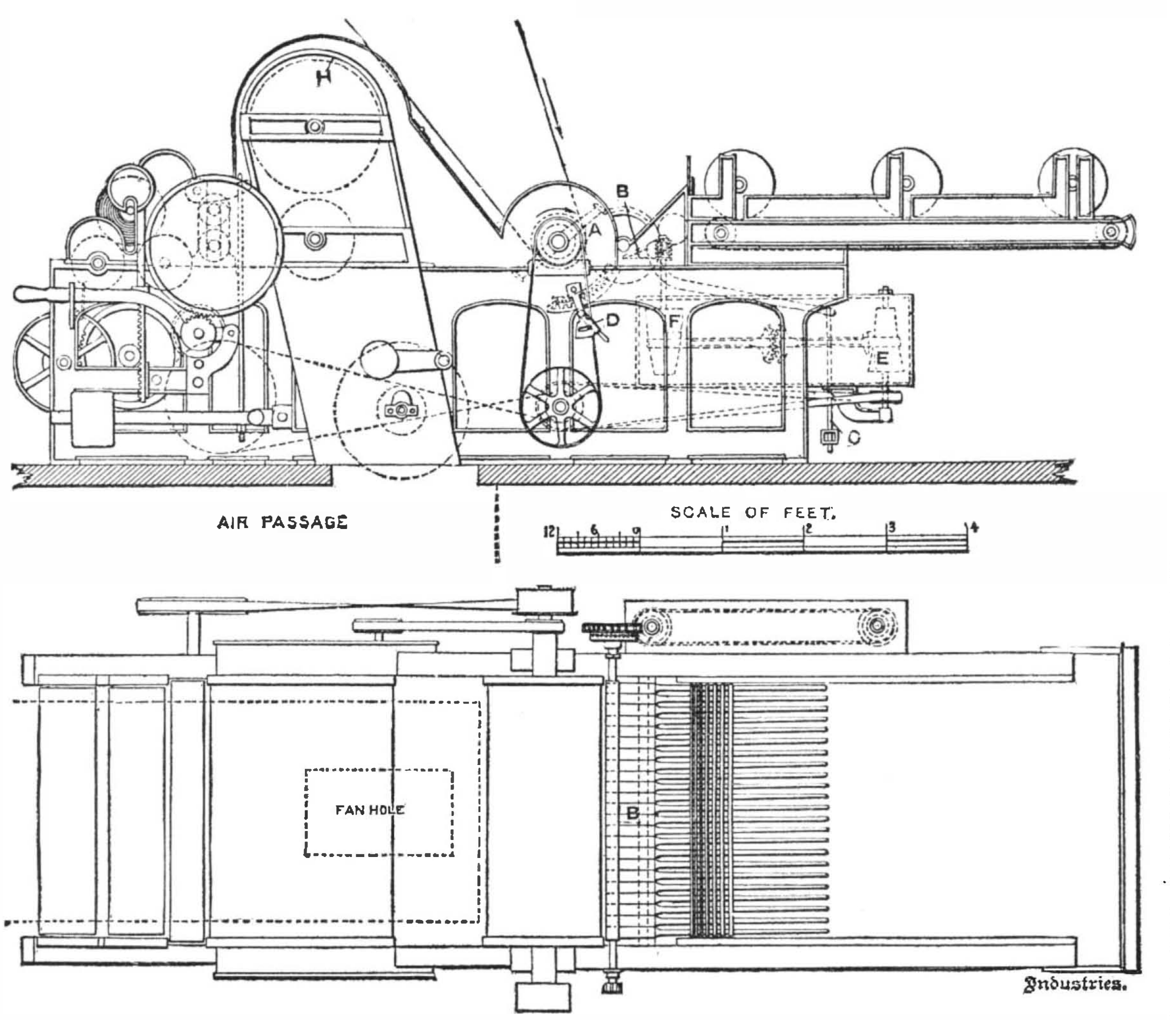
pulled as it passes through the machine. The first two pairs of rollers are formed with blunt spikes, and the third pair are fluted. In Messrs. Platt's arrangement the spikes in each roller are formed on flat disks, this allowing of any one of the disks or segments being broken off the shaft in case the teeth should break, the remaining disks being pushed up, and the replacement being made at the end. The teeth of each segment or disk are set at half pitch of the adjoining disks, so that the feeding action is a gradual one, and no choking takes place.

The details of the machine are well worked out, the intention being to "pull" the cotton in such a way as to open it thoroughly and take out all the lumps. After passing through the rollers the cotton is delivered on to a creep lattice, and is carried forward to the place where the mixing takes place. By a simple arrangement the delivery of the pulled cotton may be made in two or three places in the mixing room, and the combination so attained can be made to pull and lay down 90,000 lb. of cotton per week, for which output only two men are required.

The cotton having been pulled and mixed is then taken to the opener. The machine for this purpose which has for some years found most favor with spinners is that which bears the name of its inventor, Mr. Crighton. The object of the process of opening is (as the name implies) to put the cotton fiber into a loose or open condition, and at the same time to allow the sand, leaf, or other adherent impurities to fall into receptacles formed to receive them. The only Crighton opener shown is the double one made by Messrs. Curtis, Sons & Co., which has two beaters. These are conical in shape, and consist of a number of disks placed horizontally on a vertical shaft, and decreasing in diameter from top to bottom. Steel blades are placed on the rim of the disks, which beat or throw the cotton against a vertical grid, which is also conical, thus loosening the fiber, and driving the dust or other impurities through the bars of the grid, whence it falls to a cavity at the bottom of the beater box. An exhaust fan is so placed that the cotton is drawn upward through the beaters and over revolving dust cages, from which it is taken by means of rollers and delivered upon a lattice feed. In the machine made by Messrs. Curtis the adjustment of the draught is such that either single or double opening can be given. In order to obviate handling of the material, it is now becoming a general practice to connect the opener with the next machine of the series, viz., the scutching machine. As the cotton is drawn from the one machine to the other by means of pneumatic suction, the feeder and the opening machines may be at any distance apart, either in the same room or any other. Fig. 3 shows the connection between the two machines, B representing the flue or duct, and C the fan which draws the cotton into the combined opener and scutcher, D.

Before treating of the scutching machine with its lap attachment, it will be convenient to describe a combined opener and lap machine, made by Messrs. Taylor, Lang & Co., and which we illustrate in Fig. 4. The machine consists of a lattice feed, which travels in the direction of the cylinder as indicated by the arrow, and upon which the cotton is fed. A feed roller takes the cotton from the lattice and passes it forward into the beater chamber, which is horizontal. On the inner side of the cover are a number of nogs, A, against which the material is thrown by the action of the revolving cylinder (shown in section), which has also on its circumference a number of similar projections. The fibers are thus loosened and partially straightened, and the heavy impurities are freed. As the cotton is passed round the cylinder, the impurities which have been loosened as described are thrown against and through the grate bars, B, falling into a deep cavity made to receive them. Immediately after passing the first series of bars the cotton is stripped from the cylinder, and travels over the additional bars shown in the lower passage (which are made with much finer apertures than the first set), moving in the direction indicated by the arrow.

The leaf and sand are thus freed from the cotton, which passes up the air trunk shown, and is formed into a fleece on the two circular cages, being afterward stripped by rollers, and formed into a lap or roll at the end of the machine. The suction is supplied by a fan which is fixed immediately below the ascending air trunk, to which it is connected, as also the cages, by the pipe indicated by the dotted lines. The draught is regulated by means of louvers marked C. The advantage claimed for this arrangement is that a very large area of cleaning surface is given, thus allowing of the formation of a lap which only needs to pass the finisher scutching machine before carding.



FIGS. 6 AND 7.—SCUTCHING MACHINE.

Messrs. Platt Bros. & Co. show a combined opener and lap machine, illustrated in Fig. 5. The cotton is delivered by means of a special feeder, which may or may not be in the same room. This machine is fitted with a porcupine feed roller, and the cotton is carried forward by means of the draught created by the opener fan through dust trunks, as shown in Fig. 3, and thence into the cylinder of the opener shown at the right hand side of Fig. 5. At each end of the cylinder is a wing disk fan, which throws the cotton about the cylinder upon the first cage in a very evenly distributed fleece. This is stripped from the cage and submitted to the action of a three-wing beater, which is made with elliptical arms, these presenting less resistance to the air, and being equally strong. The cotton is then formed into a lap in the usual way.

Figs. 6 and 7 show in section and plan respectively the scutching machine made by Messrs. Howard & Bullough. Assuming that the material has been formed into a lap or roll, three or four of these are placed in brackets over a feed lattice, whence the combined laps are drawn forward over the feed regulator.

It is somewhat to be regretted that Messrs. Lord Bros., of Todmorden, who were the original inventors of the ingenious piano feed regulating motion, are not represented in this exhibition by one of their machines, but there are several examples showing modifications of this method. The feed, as shown in Figs. 6 and 7, consists of a series of levers extending the full width of the feed lattice, and having a flat nose or pedal, B, over which the fleece passes. This lever is pivoted at the back of the pedal. Thus if a thick place in the lap passes, the pedal is depressed, inasmuch as the revolving feed roller placed above the pedal nose has no vertical movement. To the other end of the pedal lever is attached a pendant rod, C, which is broadened as its lower end. An oblong box surrounds the lower end of the pendants, and carries a number of bowls, which are placed between each pair of rods, the bowls being held so that they have a free revolving movement, and are arranged to traverse laterally, but not vertically. Ordinarily one bowl only is placed between one pair of pendants, and the effect is that when the two pendants are lifted at the same time, the bowl is operated in two directions. This results in the stoppage of the motion of the bowl, and a great amount of friction is set up. To obviate this, Messrs. Howard & Bullough construct one side of the pendant at its lower end with a central rib, and instead of having one bowl only, three are used. The two outer bowls are of larger diameter, and press against the plain side of the pendant, while the central one, being smaller, is operated only by the rib on the adjoining pendant. In this way, as all three are free to revolve separately, the lift of two adjoining pendants is accomplished without the friction just spoken of. As the pendants are lifted, the bowls are of course revolved, and the pressure of the wider ends of the former sets up a horizontal movement, which is communicated, by means of levers suitably placed, to the strap guides operating the strap on the cone drums, E F, the strap guide levers being connected by sector wheels as shown. The cone, F, is directly geared by a worm and worm wheel to the feed roller.

It will be seen that, when the strap is moved, a quicker or slower motion will be given to the roller, and the feed increased or diminished to compensate for thin or thick places. As soon as the cotton passes the pedal, it is struck by the blades of a two-armed beater, A, revolving at 1,500 revolutions per minute, and is thus flung about and opened. At the point, D, on the under side of the beater case are dirt grids, below which are air bars, which can be adjusted as desired to admit a greater or less quantity of air. Between the two sets of bars are plates, which effectually prevent any return of the dirt or leaf into the beater box. The object of the air grates is to allow of the air being drawn in only in the necessary quantity, since the dirt and leaf will not otherwise fall easily and freely. This very desirable object is further attained by the use of a hollow beater shaft, which has slotted openings in it inside the beater box, air being thus drawn in and a partial equilibrium or slack place in the current of air set up. From the beater the cotton passes on to a pair of dust cages formed of perforated metal sheet, upon which it is deposited in the form of a fleece, being thence stripped by the usual means and formed into a lap. The draught required in the machine is obtained by means of the air passage shown and a fan placed in a suitable position. With the exception of the arrangement of the pendant bowls, the construction of the beater with a hollow shaft, and the adjustable air bars, the description thus given fairly embraces the general construction of the various scutchers shown, there being, however, differences in points of detail which will duly be noted.

The finisher scutcher shown by Messrs. Platt has the pedals placed upon a knife edge bearing, giving great sensitiveness. Some of the bars under the beater are cut so as to offer a sharp edge to the cotton, and the dust box is very long, with a number of loose bars. The feed rollers of this machine are three in number, one above the nose of the pedal and the other two immediately behind the pedal nose, this being an improvement on the usual mode of construction. The old and new arrangements are shown in Figs. 8 and 9, and the advantage gained is that the cotton is struck by the beater bars at a less acute angle than when struck directly from the pedal nose, and as a consequence sustains less damage. This arrangement is also adopted by Messrs. Taylor, Lang & Co. in the scutchers shown by them. The lever in the cone box is actuated by a chain instead of by a series of levers, and a more direct action with fewer joints is thereby obtained.

The scutching machine which is exhibited by Messrs. Asa Lees & Co., limited, of Oldham, varies in its feed arrangement from all other machines in the exhibition. The method pursued is shown in Figs. 10 and 11, which give respectively an end and side view of the mechanism. The pedals, E, are threaded on a rod, and their loose ends rest upon vertical rods or pendants.

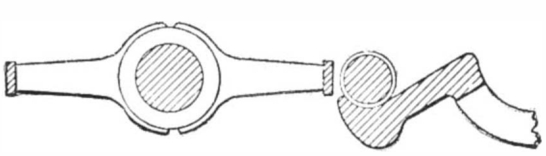


FIG. 8.

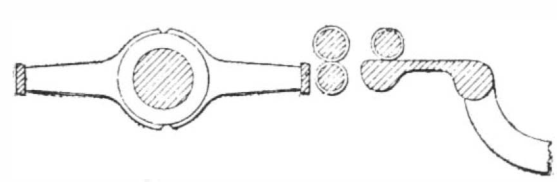
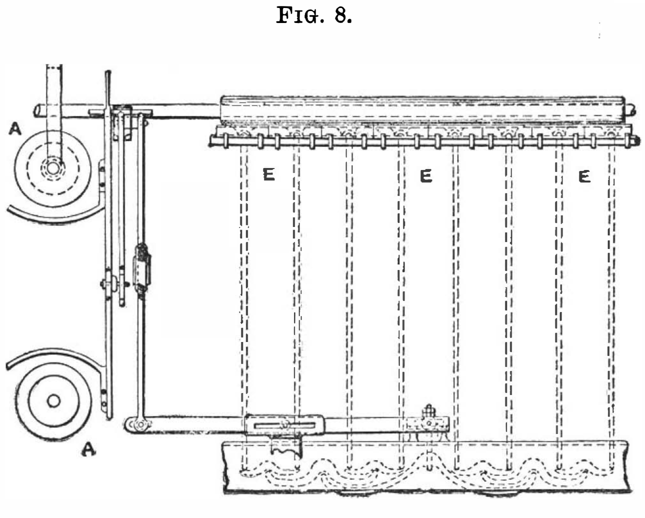
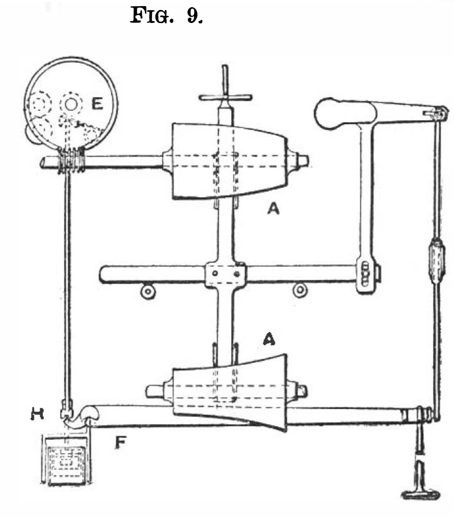


FIG. 9.





SCUTCHING MACHINE. FIG. 11.

The lower ends of the pendants rest upon balanced plates, two of which in turn rest upon a second plate, the weight of the whole of these being sustained by a longer plate of the same shape. The large plate is hung by a rod or hook upon the end of the lever, F, fulcrumed on a knife edge, as shown at H in Fig. 11, the motion given being communicated to the strap guides by the series of levers seen in Figs. 10 and 11.

The oscillation of the plates set up by the depression of any of the series of pedals results in an altered position of the strap, and by means of worm gear of the speed of the feed roller. One important feature of this motion is that the cone pulleys, A, are horizontal instead of vertical, so that the strap is adjusted with less exertion. A second improvement consists in the method of driving, which is illustrated in Figs. 12 and 13. The usual plan is to drive the feed cones and the lap attachment by separate belts. The defect of this process is that if the lap strap comes off or breaks, the feed attachment will continue to work, and the beater box become full of cotton, resulting in a stoppage or smash. The method employed by Messrs. Lees, and shown in side elevation in Fig. 12 and in end elevation in Fig. 13, is to drive both attachments by means of an endless rope passing over a groove in the loose half of a friction clutch, C, on the beater shaft, B, and thence traveling as shown by the arrows so as to drive the lap roll, D, and the cones, A. The result of this arrangement is that both the feed and lap motions are stopped at the same time, and immunity from breakdowns is secured.

The machines just described complete the series which clean and open the cotton. The primary object of them all is to form a lap which shall be even in substance, and cleaned from the greater part of its impurities ready for treatment by the carding engine. It is now recognized universally that an even yarn depends greatly upon the proper performance of the scutching operation; and although it is true that inequalities in the laps can be treated effectually afterward, it is much cheaper to get regularity in weight at the earliest stage. It will be seen, by considering the mechanism described, that evenly weighted laps are formed at a very early period, and makers will guarantee the production of laps with no greater variation in weight than 1½ per cent. Messrs. Platt Bros., who show the whole series of machines, state that they can pass cotton through the series without any weighing after the receipt of the bale, and produce laps of such regularity that the variation shall not exceed 4 ounces either way. Messrs. Taylor, Lang & Co. make the same claim.

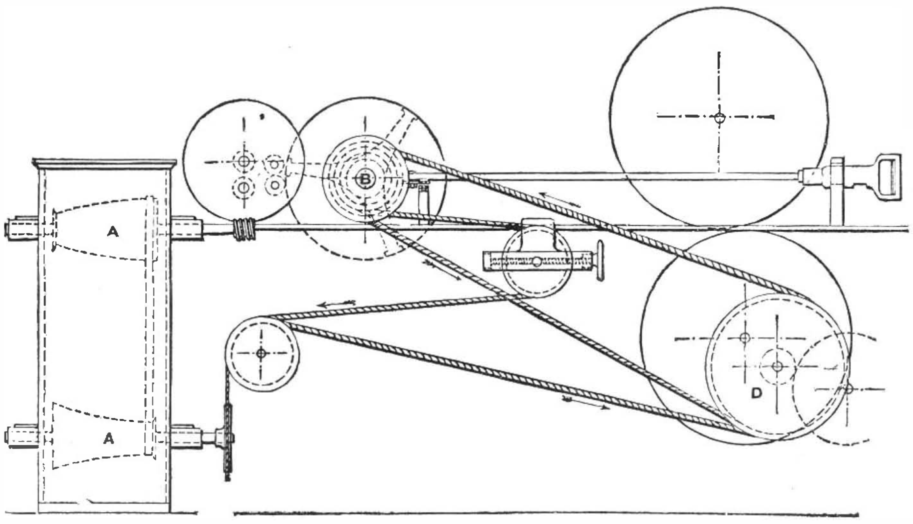


FIG. 12.

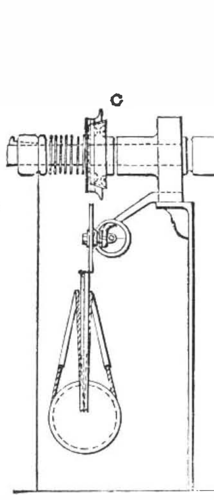


FIG. 13.

CONCRETE FOUNDATIONS.

FOUNDATIONS for government buildings are almost invariably made of concrete. The materials are generally purchased under advertisement and the mixing and laying performed by days' labor under the direction of the superintendent of construction. The concrete is composed of cement, sand, and broken stone.

The bids for each kind of material are to be made at a rate per unit of quantity, and are considered separately. The quantities given in the specification are estimated; the right to purchase more or less of the materials at the quoted rates is reserved.

Cement.—The cement is to be delivered in barrels of three hundred pounds each, to be American cement freshly ground and equal in quality to the United States government brand, manufactured by the Standard Cement Co., of Hartford, Conn. The above standard has not been long established, and is not rigidly used in all cases, as several other cements are cheaper and good enough for the purposes required. The following cements, with the given average tensile strength per square inch after immersion six days in water, have been used in the past year:

AVERAGE TENSILE STRENGTH PER SQUARE INCH.

Milwaukee cement, 45 pounds.
Newark cement, 40 pounds.
Buffalo and Akron, O., cement, 54 pounds.
Star and Black Diamond, Louisville, 116 pounds.
Rosendale cement, 53 pounds.
James River, Va., cement, 75 pounds.
U. S. G. brand, Hartford, 8 days' immersion, 230 pounds; 1 day's immersion, 105 pounds.

The more finely ground cements, when mixed with sand, will stand a higher test than the coarsely ground, but the coarser cements stand the higher tests when pure and without sand.

Sand.—The sand to be sharp, clean, and free from all clay, earthy, vegetable, or other foreign substance.

Broken Stone.—The stones to be hard, durable, clean, and broken to a size that will pass through a two inch diameter ring, and be in quality, shape, and size suitable for concrete. Pebbles or smooth stones are seldom used, as the cement more strongly adheres to the rough or broken stones.

Mixing.—The concrete to be composed of five (5) parts of broken stone, one and one half (1½) parts of sand, and one (1) part of cement measured dry. Only the requisite quantity of water to be used (about twenty-three gallons to the cubic yard of concrete), and the whole to be thoroughly incorporated when prepared for the trenches.

Only so much mortar should be worked up at a time as can be put in the trenches and rammed solid in position, complete before the setting has taken place. The cement and sand must be well and thoroughly mixed dry, then water added and worked in until the whole is reduced to mortar of a uniform consistency. The broken stone, well drenched and drained, is then to be thrown into the boxes containing the freshly made mortar, and worked into it till each stone is thoroughly coated with mortar, care to be taken that no more mortar is used than is necessary to fill the interstices between the stones.

Laying.—The concrete foundation is to be of the dimensions shown and noted on the drawing, of the various widths and depths figured and shown by sections, and must be carefully laid to the lines shown on the plan.

The concrete is to be mixed in small batches, and, immediately after mixing, to be put into the trenches in layers about nine inches thick, commencing and working both ways, and thoroughly but gently ramming until the water forms on the surface; this packing is to bed the broken stones firmly in contact with one another. Care should be taken that all joining of the concrete be made in the most judicious manner, the layers breaking joint. The first layer, after setting, is to be brushed and wet before the upper layer is put in, and the surface of the top layer to be finished with a skim coat of mortar without stone, made level and even, ready to receive the masonry.

The concrete must not be thrown into the trenches from a height, as is commonly recommended, for this has a tendency to disarrange the mixing, making the stones and heavy pieces go to the bottom, but must be deposited in the trenches as carefully as practicable, so that the entire mass after deposit is thoroughly and uniformly mixed. The entire concrete foundations when completed must be a thoroughly consolidated mass, without crack or flaw.

The opening for the passage of the drain pipes under the walls of the building is to be formed while the concrete is being laid. For this purpose a glazed earthenware pipe, amply large for the passage of pipes, is put down, extending through the entire width of concrete, which is to be thoroughly packed around and over the top of the pipe.

Furnishing and Laying Concrete.—Where bids are received for furnishing materials and laying the concrete foundations complete, the rate per cubic yard must be stated in the proposal, at which rate payment will be made for any additional concrete that may be required. If necessary, the contractor must furnish the necessary materials, and form the trenches with plank sheeting, and after the concrete is set, must fill in with earth, and pack solid to line of top of concrete.

Measurement.—Concrete foundations are estimated by the cubic yard. The actual net cubic contents to be measured, but no deduction is made for passage of pipes; each different width and depth to be measured separately, and not in the aggregate by taking an average depth. The constants used for estimating the quantities of materials and the cost per cubic yard of concrete are:

Broken stone, 5 parts=1 cubic yard.
Sand, 1½ parts=0·33 cubic yard.
Cement, 1 part=1·4 barrels.
Water=23 gallons.
Labor=0·375×mason's wages per day.

By actual experiment, it is found that two inch broken stones gently rammed contain forty per cent. of voids. This can be tested by filling a water tight box with stones, first drenched and drained, then pouring in water, and afterward measuring the water. This forty per cent. of voids must be filled with sand and cement, and some excess must be allowed for the absorption of cement by the stone, which will be more or less, according to the porosity of the stone, and on this account a porous stone may be better for some purposes (as the cement will take a better hold of it) than a harder one, provided it has the necessary crushing strength. The constants given were adopted after careful experiments and calculations, and are believed to be the best for almost all purposes.

To estimate the cost of a cubic yard of concrete by the above constants, add to the cost of one cubic yard of broken stone the cost of thirty-three per cent. (0·33) of a cube yard of sand, one and four tenths (1·4) barrels of cement, and thirty-seven and one-half per cent. (0·375) of mason's wages per day; water is usually considered free, and need not be considered unless it costs the contractor something to furnish it.

Cost.—The cost of cement can usually be obtained from the quoted market rates, which, of course, vary in different localities. The cheapest cement ever used by the government was the Syracuse cement at forty nine and one-half cents per barrel; the average cost of the other cements was from one dollar to one dollar and a quarter, except the Louisville and United States government cements, which cost from one dollar and ninety-five cents to two dollars and ten cents per barrel. The cost of sand varies a good deal. The prices paid for it per cubic yard in the last few years were, at—

Des Moines, Ia.	$0.40
Pensacola, Fla	.80
Pittsburg, Pa.	1.00
Galveston, Tex.	1.60
Richmond, Va	.95
New Albany, Ind.	1.20
Terre Haute, Ind.	.55
Syracuse, N. Y.	.98
Columbus, O.	1.49
Quincy, Ill.	.80
Aberdeen, Miss.	1.00

The cost of broken stone per cube yard varies greatly, as follows:

Frankfort, Ky.	$0.94
Detroit, Mich	2.85
Pensacola, Fla	5.00
Galveston, Tex.	3.50
Minneapolis, Minn	1.95
Syracuse, N. Y.	1.68
New Albany, Ind.	1.82½
Aberdeen, Miss.	5.00

The cost per cubic yard for concrete materials furnished and laid complete was as follows:

Minneapolis, Minn.	$6.00
Brooklyn, N. Y.	6.50
Pittsburg, Pa.	4.95
Louisville, Ky.	3.50
Leavenworth, Kan.	2.75
Hannibal, Mo	3.50
Fort Wayne, Ind.	6.50
St. Joseph, Mo.	4.00
Erie, Pa.	6 54
Rochester, N. Y.	4.00

—*Jas. E. Blackwell, in American Architect.*

THE PANAMA CANAL.

REVIEW OF THE FRENCH COMPANY, THE WORK ACCOMPLISHED, AND FUTURE PROSPECTS OF THIS GIGANTIC UNDERTAKING, BY A WELL KNOWN ENGINEER.

WE have obtained from Frederick G. Corning, the distinguished engineer of this city, who has just returned from the isthmus, the following discussion of the canal subject. This topic is one of great interest, especially after the late conclusions regarding the Nicaragua route by the scientific congress lately in session here.

The names of De Lesseps, Suez, and Panama, whatever may prove to be the issue of the latter venture, will always remain great among the chapters in the progress of civilization. To review the career of F. De Lesseps and fully appreciate the vastness of his projects is to become forcibly impressed with the man's extraordinary genius as the projector of startling undertakings and his unsurpassed ability as a successful promoter. A broad view of his achievements inspires a degree of admiration for this magnetic character only comparable with the intense interest felt throughout civilized countries regarding the success of his globe-remodeling projects and their important bearing on the interests of commerce and navigation. More minutely scrutinized, however—passing, as it were, from the poetic to the prosaic side of this talented Frenchman's schemes—we meet with some disappointment regarding the execution in detail and probable fate of his last great engineering and speculative undertaking at Panama. This concern for the future of the canal and for the prestige so long enjoyed by De Lesseps grows out of an impartial attitude toward the undertaking, in which the present condition of things on the Isthmus is contrasted with the original promises officially advertised by De Lesseps and his company.

In the United States it has become almost fashionable to cry down the Panama enterprise, and ridicule the efforts of the French company. It is hoped, however, that this small contribution to the already voluminous literature on the subject will not be taken as a blind indorsement of the many malicious adverse opinions heretofore rendered. It is only intended to be a compilation of the more important data affecting the success of the canal and a synopsis of the company's policy and management as observed on the isthmus and in Paris.

In spite of the indifference shown by Americans regarding the success of this special company, the interoceanic canal problem has nevertheless long been a subject of deep interest in the United States. For, although we have not as yet, to any great extent, actively participated in the construction of a canal, yet it is still fresh in the minds of the people that our government at one time expended a very considerable sum of money in reconnaissance surveys and preliminary work with a view to determining from an engineering, geographical, and economical point of view the most feasible route from the Atlantic to the Pacific. And when subsequently it appeared, as the result of careful estimates based on these accumulated data, that a sufficient amount of shipping could be relied upon to insure a volume of business for a canal through Central America to even justify an investment of at least double the amount of the cost of the Nicaragua route, the great attractions of a properly constructed canal to connect the two oceans by the most feasible line became manifest. At the same time our carefully and ably conducted investigations pointed strongly to the Nicaragua route as practically in all respects the preferable one. In the face of all this it is not surprising that the French company's choice of the Panama line should have incited a certain degree of adverse criticism and prophecies of disaster on the part of the Americans of the North. And now after quietly and patiently watching for six years the company's progress and prospects on the isthmus, the time is at hand when the nations pecuniarily and otherwise interested in

the operations of the "Compagnie Universelle du Canal Interoceanique" are beginning to realize the correctness of the verdict of the United States scientists on the natural obstacles to the Panama route. At the same time it is becoming apparent that our exploratory engineering work, which showed the impracticability of the Colon-Panama line, was more thoroughly and intelligently executed, and the results more reliably made known to the public, than were the preliminary surveys and estimates of other countries.

At the so-called "International Congress," held in Paris in 1879, nominally for the purpose of discussing and deciding upon the best of the five projected canal routes submitted at that time, the Nicaragua route, after some comparatively superficial comment, was, with other plans, hastily set aside; and thereupon, in conformity with the wishes of Mr. De Lesseps, who substantially controlled the whole convention and framed its resolutions, it was finally decided: "That the cutting of an interoceanic canal at sea level was feasible; and that in order to secure the natural conditions essential to an undertaking of this character, it would be necessary to adopt the route from the Gulf of Limon to the Bay of Panama." More particular reasons for the choice of this line were stated on this occasion to be "the length of 45 miles," that would require but "one day for the passage." Following along in this impulsive, one-man policy, that may eventually culminate in serious reverses and disappointments to the De Lesseps following, as far as the dividend rate on the company's ultimate capital is concerned, came a long series of erratic announcements in the "Bulletin Interoceanique de Panama" the official organ of the company. Thus in the early "circulaires" and "bulletins" issued the management constantly proclaimed its ability to cut and complete the entire canal for 600 millions frs., including expenses of every description and all fixed interest charges. For example, in an address by Mr. F. De Lesseps at the general meeting in January, 1881, we find, in his opinion, "the sum of 600 millions (frs.) will be required to open the Panama Canal to all classes of navigation." And in a February bulletin, 1884, by the same recognized authority, "The original estimate of the cost of the canal, namely, 1 milliard 70 millions (1,070,000,000 frs.), has been reduced to 850 millions; and upon the late arrival of contractors at Panama, the total cost has been still further reduced to 600 millions. The one public at various intervals through bulletins and annual reports, approximately as follows:

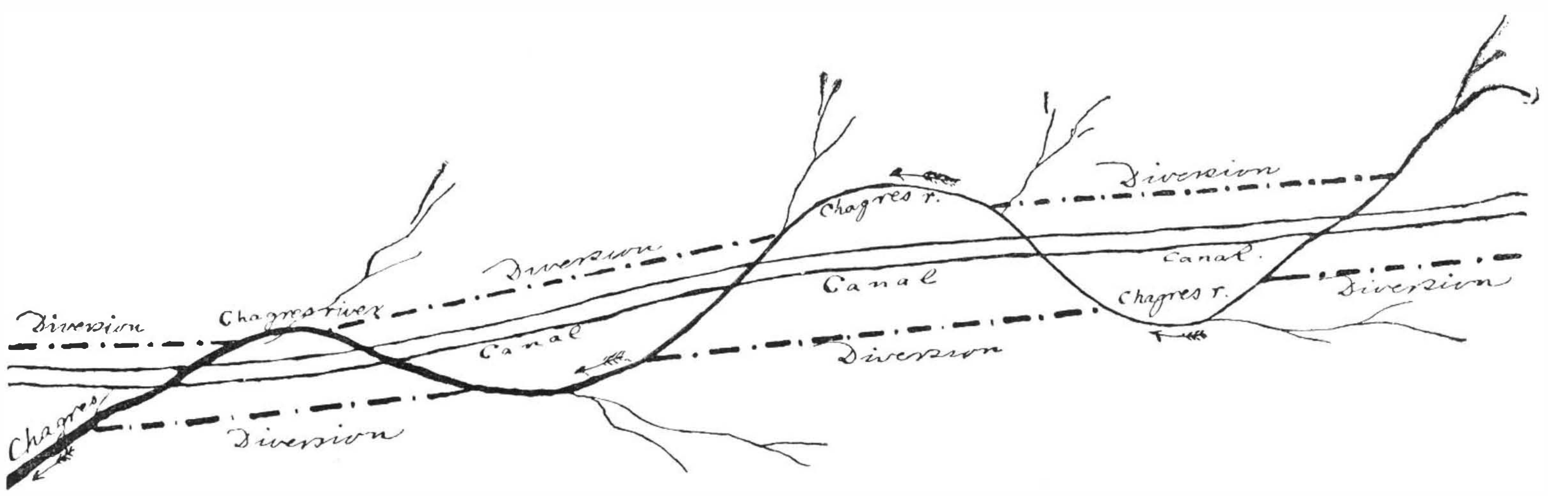
Interest on 250,000 bonds (5%)	6,235,000 frs.
Interest on 477,387 bonds (4%)	9,547,740 frs.
Interest on 600,000 shares of stock (6%)	18,000,000 frs.
Interest on 600,000 bonds (3%)	9,000,000 frs.
Interest on 458,302 bonds (6%)	13,764,000 frs.
Annual cost for services and miscellaneous acts	9,000,000 frs.
Central administration	1,500,000 frs.
Minimum local administration, Panama, (1,100 *salaried* employes in June, 1886)	10,000,000 frs.
For inspectors, engineers, opening new roads, repairs, hospitals, etc.	3,000,000 frs.
General expense account	80,046,740 frs.

After the next loan or two shall have been placed, it is quite probable that the above general expenses will run closely to 100 millions yearly. Added to this account, it must be remembered, are the actual expenses of the machinery and the canal work proper—the excavations now under contract—which latter, together with the general expense account, make up the entire yearly outlay.

The total material to be removed in cutting the canal appeared in July, 1885, to be finally estimated at 128,000,000 cubic meters. By persons more familiar with the topography and surveys of the line than would be possible for one who has only paid four visits to the isthmus, it is claimed that this volume of 128 millions of cubic meters is a very considerable underestimate; and that in this figure, as in most others, a serious increase will eventually be met with. But however this may prove, the sad fact remains that, up to May 1, 1887, there had been excavated only a little over 36,000,000 cubic meters of the grand total. Yet in the face of all these hard facts, which would appear to unavoidably retard the progress of the work, that sooner or later must come to the surface, it would appear that the company's policy has been to foster self-deception regarding the real state of affairs on the isthmus. In this connection we find in a September bulletin, 1886: "The work done per man per day now exceeds 5 cubic meters." Then again, in a January bulletin, 1887: "The army of 12,000 to 15,000 laborers on the isthmus larly adjacent to the line workings; and now it has become so difficult to draw labor from Jamaica even at the advanced prices that it seems almost impossible to secure the adequate force for the rapid advancement of the work. In the rainy season the interruptions are incessant, while night work is hardly entertained. This climatic feature has proved a drawback to the Panama route, as far as the rapidity and cost of construction are concerned, little calculated upon originally; but already it has entered into the account, directly and indirectly, to the extent of many millions of pounds sterling.

This same fatal peculiarity of the narrow isthmus section in Colombia renders it difficult to see wherein lies the immense value of the company's land grant, already amounting to 500,000 hectares, gratuitously secured from the Colombian government in pursuance of a provision in the act of concession. Here again, in a May bulletin of this year, the vice-president, Mr. Charles De Lesseps, refers discreetly to the prospective value of the land, stating: "In addition to the revenue accruing from traffic, there are five hundred thousand hectares of land gratuitously granted by the Colombian government. How much these lands are worth I cannot determine; but what I do know is, that the lands at Port Said and Suez are worth from 100 to 120 frs. per meter." The Suez valuation here hinted at, applied to the Panama land grant, would lend a value to the latter of some 600,000,000,000 (600 milliards frs.). Even were this absurd comparison at all permissible, it would not indicate much of an asset, for it is plainly set forth in the Suez reports that the lands sold at Suez and Port Said in 1885 and 1886 collectively realized only about 670,000 frs. ($134,000).

But the threatening complications of the Panama company do not end with a diminution in the value of its land assets. Of far greater gravity are the old difficulties involved in the complicated *Chagres River diversions*, the *Gamboa regulating dam*, and the *great Culebra mountain cut*. On account of the numerous windings of the erratic Chagres across the path of the canal, as also owing to the heavy double drainage of the country on either side toward the river (the latter following with the canal practically the same synclinal axis), it has become necessary to provide two separate diversions for the respective river bends, together with the corresponding tributaries on either side of the



hundred million cubic meters to be excavated will cost 500 millions, to which 100 millions are added for the *general expense account.*" About the same period a notice of similar import was circulated among the shareholders, by a large firm, to whom had been assigned a considerable portion of the work, stating and indorsing that: "Mr. De Lesseps announces that eight years will be sufficient for the completion of the work, and that the estimate of 512 millions is considerably in excess of the real cost." Following these concise, business-like, official announcements, there appeared, about one year and a half later, in the bulletin of August, 1885, a report of the general meeting held in July, 1885, with the following extraordinary piece of incongruous news: "Contracts having been entered into providing for the completion of the canal to the bottom, we are now enabled to compute the further cost of finishing the same at 480 millions (frs.). This sum, added to the amount already spent, namely, 220 millions, gives 700 millions as the total cost of the canal on the opening day. To this figure must be added the expenses of administration and interest charges, to make up the total estimate of 1 milliard and 70 millions (frs.)."

The continued outpouring of dispatches of this character, proving the company's calculations and official reports to be inexcusably inaccurate, could not but give rise to much unfavorable criticism on the part of the United States, which the French attribute to jealousy. Already about 900 millions (frs.) have been sunk (realized from the marketing of various classes of securities whose aggregate face value is almost doubly as great), and, it may be said, without accomplishing much more than fairly starting the great work, now at the best not over one fourth completed. Up to the end of December, 1885, the so-called *general expense account*, above referred to, amounted to something like 350,000,000 (frs.), and at this date cannot be far from the alarming sum of 500,000,000 (frs.). Furthermore, it is evident that should the company's operations continue for six or eight years longer, which would seem to be the least time required to finish the canal, these general expenses will swell to a sum closely approximating 1 milliard (1,000,000,000 frs); because already they have reached the enormous sum of over 80 millions (frs.) annually and must continue to increase proportionately with the increase in the loan account, the limit of which is not yet in sight.

Some of the round sums of money which contribute *yearly* to swell this "*general expense account*" are interesting in the significance they bear to the ultimate outcome of this system of financiering in the event of either a suspension of operations or a continuance of the actual work of construction beyond a certain limited number of years. They have been given to the has the co-operation of machines representing an effective power equivalent to nearly 600,000 men."

It is surprising, in view of the transparency of these absurdly exaggerated dispatches, that their object of sustaining the company's credit should have been at all attained. The unsuspecting shareholder naturally concludes from such glowing accounts that the canal work is being vigorously pushed forward in accordance with the original assurances of the promoters, and quietly subscribes to new loans as fast as the opportunities are presented. His enthusiasm is too great and his mathematics too limited to reflect that, with "six hundred thousand men" handling "five cubic meters per man per day," the entire canal could be cut in less than two months. Again, the return to Paris of the Messrs. De Lesseps from Panama was the signal for some further authoritative utterances; and about this time we find an extract from one of Mr. De Lesseps' announcements published in the bulletins as follows:

"After having exhaustively studied all technical questions and examined every foot of ground along the line, I consider it within the bounds of truth to say that in 1887 the scale of the work as well as the amount accomplished will be three times as great (that is, more than 3,000,000 cubic meters per month)." As near as can be ascertained, however, this year's records do not show an average of much over 1,000,000 cubic meters per month.

The rapidity of the work, generally speaking, is regulated by the labor supply and the ability of the local management, or the contractors, to gradually increase the working force, or at any rate to keep the same constant when once an adequate number of men has been secured. But their power to do this is in turn almost entirely dependent upon the ups and downs, the periods of relative salubrity and insalubrity, of the climate. The latter, without doubt, if not the greatest, is one of the most serious factors militating against the satisfactory, uniform progress of the work. With reference to this subject, about two years ago Mr. De Lesseps, with a promoter's enthusiasm, was published in the bulletin as stating: "The mortality is lower than in any other excavations, not even excepting Europe." Notwithstanding, however, the opinion of one in a position to be familiar with the local climatic conditions, the incontestable fact remains that the canal happens to follow along one of the most unhealthy zones known on the planet, as proved by all statistics, personal observation, and in fact by the actual experiences of the company. Indeed, it is fully established that one of the first and greatest disappointments in the company's original calculations was the rapid doubling of the price of labor in consequence of the extra risks involved in living on the isthmus, particu- canal. By this means it is expected to prevent the Chagres from running along the canal bed for long distances or from emptying into and repeatedly crossing the same back and forth. Thus in numerous places the work amounts to almost as much as three parallel canals, doubling, if not trebling, the cost of construction; and withal the occasional disturbances incident to the sudden freshets and rises so characteristic of this tropical region will probably not be fully eliminated.

Probably no division of this immense work of altering and regulating the natural drainage system of the isthmus remained longer obscured in uncertainty than the Gamboa dam, its feasibility, cost, and exact requirements. As early as November, 1883, it was announced through the bulletins in Paris that "the dam was very simple, and would cost eight millions." But in 1886, after some three years of pondering over its simplicity, less favorable reports began to appear; and, in a May bulletin of that year, the dam was announced to be "the greatest technical difficulty yet encountered." About this time, according to the company's annals, the estimates of the cost of this piece of work jumped from eight to forty, and then to one hundred millions (frs.). But now the plan is to control the drainage by the more extended system of Chagres diversions in process of excavation, which will materially reduce the enormous scale and cost of the dam as originally designed. Hence this piece of work and the Culebra cut are now looked upon as the most serious and costly divisions of the canal. With reference to the latter, at the general meeting in August, 1885, the Culebra mountain was qualified as "the culminating point and most knotty problem." But it was officially reported that notwithstanding the cut involved the removal of twenty-five millions of cubic meters, the contractors were "under agreement to finish the canal through Culebra mountain and open the same to all navigation by July 1, 1889." The February bulletin of 1887, however, showed plainly that of the twenty-five millions of cubic meters in the Culebra not much over two millions had been removed, leaving, according to the company's own statements, something like twenty-three millions yet to be handled in this job alone.

These and similar exaggerations directly from the management have inspired the frequent accusations of bad faith that have been made against the company. But notwithstanding the ambiguity and unwarranted favorable character of many official reports, it does not necessarily follow that the whole enterprise is a "barefaced swindle," as many have unjustly claimed. These sanguine reports are rather to be construed as an effort on the part of the directors to keep up the shareholders' spirits and sustain the company's credit. Having once embarked in so formidable an undertaking, and subsequently discovered that much larger sums of money

would be required than originally anticipated, it is easily understood how difficult would be the task of protecting the shareholders' interests and floating new loans unaided by the infusion of a sanguine tone into reports from the seat of operations.

The work yet to be done may be roughly classified in the following six subdivisions :

1. The canal excavation proper ; a *minimum* of say 90,000,000 cubic meters (in all probability greater), including something like 20,000,000 cubic meters falling to the Culebra section.
2. The completion of the Chagres diversions.
3. The Gamboa dam (on reduced scale).
4. The deviation of the Panama Railroad.
5. The turning out or passing basins.
6. The Atlantic and Pacific approaches and the canal entrances.
7. Numerous miscellaneous improvements, of secondary moment in point of cost as compared with the foregoing.

The magnitude of the Panama undertaking is so great, and the unforeseen contingencies arising to complicate and retard the work have proven so numerous, with the probability in the future of at least a temporary suspension of the company's operations, owing to the difficulty in placing new loans, that it seems futile to presume to set a date for the inauguration of the canal. With the immense mechanical equipment and permanent improvements already paid for and in operation (valued at over 147,000,000 frs.), it would follow, theoretically, that in the future the work must progress more rapidly than in the first years of preparatory work. But this is the very point that has lately proved so delusive, for reasons already stated, although since the completion and working of the plant in all its branches along the line divisions, the work of excavation has become noticeably accelerated, though far from what had been expected.

With reference to the guesswork of determining the number of years that will still be required to finish the work, one formula is about as good as another under conceive how deep seated and long of duration would be the depression and mistrust in new undertakings that would follow so sad a failure of the present canal company. Should, however, at such a crisis, the French people show the same admirable perseverance and fortitude that have characterized their liberal investments thus far, notwithstanding the increase in the amount of money required, it is quite possible, and sincerely to be hoped, that, after a scaling down of the capital and obligations of the old company, a liberal extension of time may be secured, and the government step in and complete the work of connecting the two oceans on a financial basis that will at least bring a fair return to a portion of the nation's good money.

This consideration suggests the all-important question of the earning power or incoming value of the canal and the equivalent average interest on the invested capital that may be looked for when the work shall have been completed and the highway opened to the world. The point of momentous interest in financial circles is : Will the traffic be sufficiently large at the proposed tariff rate (15 frs. per ton) to yield a revenue that, after deduction of the expenses of maintenance and preservation (presumably unusually heavy, owing to the peculiarities of the climate), will still leave a fair interest on the total nominal capital ? Officials in high standing at Panama speak confidently of an annual traffic of 10,000,000 tons, at 15 frs. per ton. And this appears to be the accepted basis for the argument that even if the capital swells eventually to 4,000,000,000 frs. (4 milliards), the gross income will amount to 150,000,000 frs. or 3¾ per cent. (without allowance for running expenses, to be deducted herefrom). The more exact figures are embodied in one of the recent official reports of Senor Nicolas Tanco Armero, canal commissioner for the Colombian government, as follows : "The committee on statistics of the International Congress calculates the tonnage that will pass the canal in 1889 (!!) at something less then 7,000,000 tons. But in my later calculations, taking into account the growth of commerce, the sum total comes nearer 9,000,000 than 7,000,000 tons, as is evident from the following abstract from the official statistical table published in England :

From Europe to American Pacific ports :	
England	1,426,852
France	573,922
Germany	360,000
From other European countries to American Pacific ports	210,000
Total ..... Tons	2,570,774
European trade with Australia, Oceanica, Philippines, etc., that will pass the Panama Canal	2,696,754
United States trade, excepting from San Francisco, with the same places, and also India, China, and Japan	1,619,440
From the United States, Western coast, with the Eastern section, for Europe and Eastern American States	1,500,000
Actual traffic per R.R. from Colon to Panama and *vice versa*	262,497
Total tonnage ready for canal first year	8,649,465

"Moreover, a few years hence, when the canal shall be opened to commerce, the available annual tonnage will have reached 12,000,000 to 15,000,000 tons." (!!) The bulletin of the company attempts to give more accurate figures regarding certain divisions of the traffic when it states that the trade from Antwerp that would have passed the canal in 1886, had the same been finished, may be taken at :

Peru	46,635 tons.
Bolivia	5,919 tons.
Chili	42,046 tons.
Australia	58,046 tons.
	152,646 tons.

Furthermore, in the same year the trade between Antwerp and the United States rose to 1,029,037 tons, of which 100,000 tons fell to American Pacific ports. Hence 250,000 tons are a more accurate estimate of this particular line of traffic, included in the foregoing large and more general estimate of Mr. N. T. Armero.

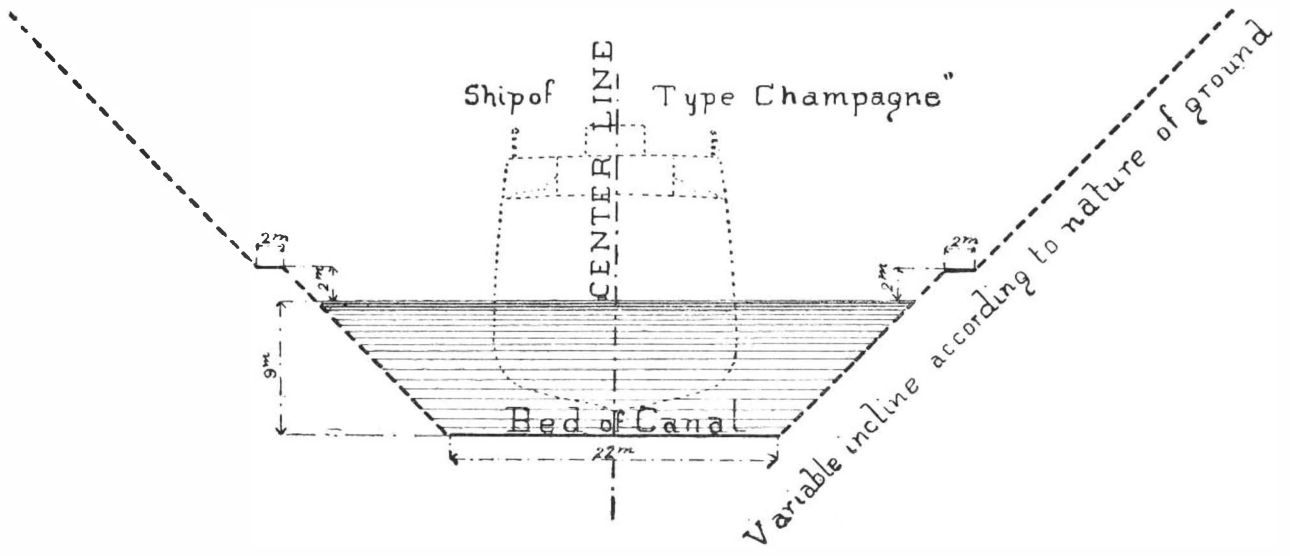
By the very complicated nature of the subtile changes in the relations of navigation and commerce bound to be called into existence by the shorter lines of transportation that will follow the opening of the canal, the element of conjecture must necessarily enter largely into all attempts to solve mathematically this all-important traffic problem. But, to say the least in opposition to the canal company's figures, it is difficult to conceive how so high a rate as 15 frs. per ton can be consistently maintained at Panama, if the canal intends to monopolize the Australian trade, while at Suez the average rate is now about 10 frs. per ton. Then, too, in the matter of tonnage, everything indicates that a considerable reduction in the foregoing figures will, in all probability, be met with ; for it should be remembered that the traffic at Suez after some fifteen years grew only to 5,767,656 tons in 1886, notwithstanding all brilliant predictions of a much larger volume of business. The Suez report for 1886 records 3,100 vessels, 5,767,656 tons, from which the receipts were 54,771,076 frs. Added to this are receipts from passenger traffic amounting to 1,714,115 frs., and revenue from miscellaneous sources of 313,093 frs., making the total gross income 56,798,285 frs. for 1886.

The economy in the principal lines of transportation to be afforded by the canal, expressed in "milles marins" of 1,852 meters, is complied from official sources as follows :

	Via Cape Horn.	Via the Canal.	Economy of Distance.
London to San Francisco	13,795	8,135	5,660
London to Honolulu	13,915	9,556	4,359
Liverpool to San Francisco	13,678	7,897	5,781
Le Havre to San Francisco	13,627	7.949	5,678
Bordeaux to Valparaiso	8,675	7.239	1,436
New York to Valparaiso	8,550	4,574	3,976
New York to Panama	11,057	1,966	9,091
New York to Callao	9.791	2,333	6,488
New York to Guayaquil	10 441	2,808	7,633
New York to San Francisco	13,334	5,257	8,077

A not over-conservative weighing of the available statistics bearing on these points, leaving out of account a probable competition at Nicaragua in the near future, would indicate that in any event the Panama traffic at

PROPOSED PROFILE



the existing circumstances. Perhaps as simple and safe a method as any (assuming the company's credit to hold out) is to reason that if in five years forty million cubic meters have been dug, it will take, on a basis of 90,000,000 cubic meters remaining to be cut,

$$\left(\frac{90,000,000}{40,000,000}\right)\times 5 \text{ years, less 40 per cent.}$$

The latter for the possible acceleration and increased efficiency of the work in the future over the past ratio. This would give about seven years more. A similar reasoning applied to ascertain the probable cost of the work gives something near 2,325,000,000 frs. as the total minimum cash cost and 3,750,000,000 frs. in various forms of securities as the total ultimate capitalization (capital stock plus bonded debt) of the concern. Up to 1887 the securities issued by the company represented a nominal value of 1,500,000,000 frs. (1½ milliard), that were marketed at rates which brought the treasury in cash about 930,000,000 frs.

It may be interesting here to recall the company's old figures, that show how far short were the most liberal calculations as to the amount of capital required.

Canal estimated to cost	1,070,000,000
The Panama Railroad purchase, about	94,000,000
	1,164,000,000
Now practically spent	930,000,000
Balance margin	Frs. 234,000,000

Should in reality at the expiration of five years (1892) the canal not be finished, as indicated by the facts here stated, serious legal, if not political, complications may arise with the Colombian government, involving the forfeiture of the company's grant and property. The act granting the concession provides that "The canal must be finished and thrown open for public service within 12 years from the date of the formation of the company that shall have as object the construction of the canal. But the executive power is authorized to grant an extension of six years in case of exigences beyond human foresight."

As the shares of capital stock were issued in 1880, the work should be finished in or before 1892, or, with the extension, if secured, in or before 1898 at the outside. After either of these dates the Colombian government will have the right to force the law and declare the concession and the canal forfeited without indemnity, however near completion the work may be, to either finish it themselves or dispose of it to another company. In the event of such a fatal issue, the millions lost to France would fall most heavily on the small investors. It is principally this thrifty class of the great French public that has with unparalleled loyalty backed Mr. De Lesseps in his Panama scheme ; and it is difficult to

the start will fall considerably below present anticipations ; while the 15 frs. rate appears too exorbitant to command the anticipated volume of business. Is it not more probable that the traffic will be about 5 million tons at say 10 frs. a ton, making 50,000,000 frs. as the revenue for the first year ; *i. e.*, about 1½ per cent. on the probable cost of the canal ?

Notwithstanding all rumors to the contrary, the work of excavation is being prosecuted at more points and with a larger working force than has generally been acknowledged in the United States. As the work is now almost entirely under contract, it is extremely difficult to ascertain accurately the number of men actually employed. The management claim between 15,000 and 18,000 men, while special contractors do not estimate less than 10,000. Under the efficient management of Mr. Pioch the company is learning at last to conduct its operations with economy ; and the sums of money now spent are accomplishing relatively more than ever before. Setbacks are still caused occasionally by land slips, particularly in the rainy season. But the Culebra mountain is not "traveling into the canal on a bed of quicksand." Nor is the bottom of the canal, through some unheard-of tropical phenomenon, rising up even with the old surface of the ground.

The conclusion is, therefore, that while the canal can be built and operated with sufficient money, as far as overcoming all engineering difficulties is concerned, yet in the hands of the present corporation, and owing mainly to the impracticability of the route, the enterprise has become handicapped in its infancy with an ever-increasing financial load, already of such formidable proportions as to threaten its credit and foreshadow a failure from a business point of view.

Not the least interesting in a detailed criticism of the company's internal affairs would be the unraveling of the contracts, sub-contracts, promoters' and others' commission interests that have swallowed up the large sums of money at Panama and in Paris. But this information is, of course, inaccessible to outsiders. Indeed, much of the complicated network of letting, subletting, checking, and settling of contracts on the line will probably never be generally known, even to the insiders. It is said that according to the original agreements, the promoters are to be allowed 15 per cent. of the net profits of the canal. For the convenience of allotment and transactions among the numerous participants in this promoting commission, the interest was split into 9,000 shares ; and these shares are reported to have once sold as high as 10,000 frs. apiece, and were quoted as late as May, 1887, at 3,000 frs. The latter price values the entire interest at 27,000,000 frs., while at 10,000 frs. a share (the highest price) the valuation was 90,000,000 frs.

May the Panama canal, contrary to all present indications, and the general opinion in the United States, turn out to be a happy disappointment and an unex-

pected bonanza to the French people. May its credit be preserved, may it be finished with less money and in less time, and may the undertaking bring in greater returns to the original investors, than now appears probable, thus once more defeating the skeptical and scoring another victory at Panama for De Lesseps only second to his well-earned triumph at Suez. No ultimate result less auspicious will gratify the well wishes of all who appreciate the vastness of the undertaking.

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Mills Building, New York.

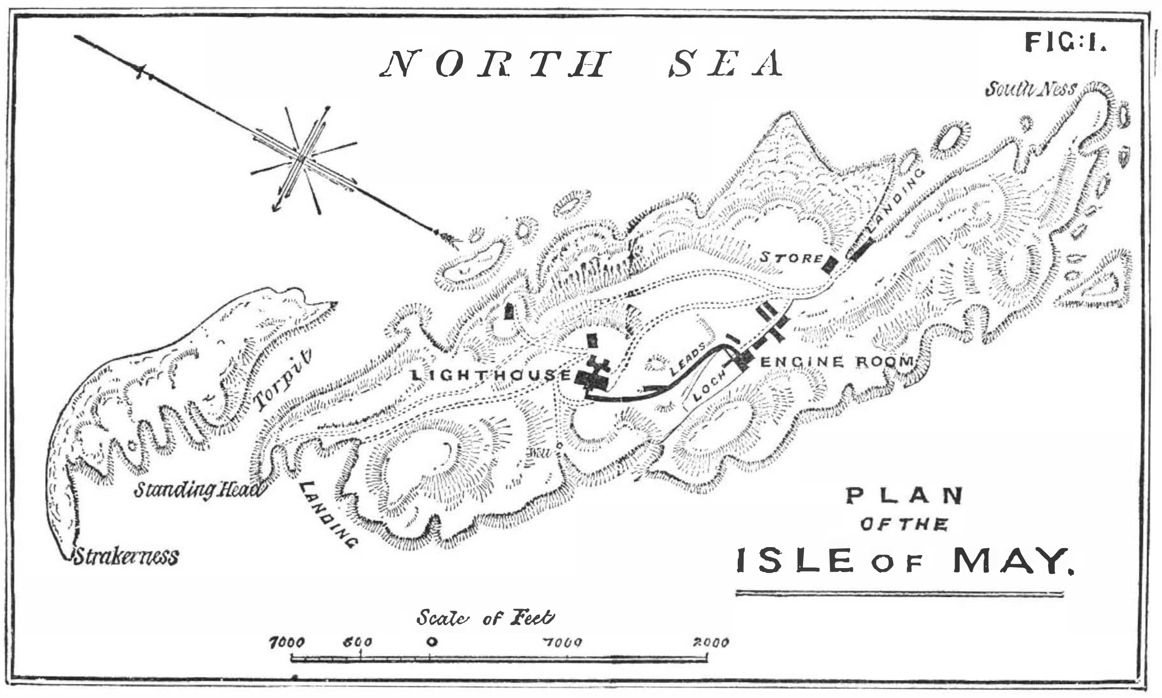
THE ELECTRIC LIGHTHOUSE ON THE ISLE OF MAY.*

By DAVID A. STEVENSON, B.Sc., F.R.S.E., M.Inst.C.E.

THE lighthouse situated on the Isle of May, at the mouth of the Firth of Forth, has recently been lighted with electricity, and as this light, besides being, the author believes, the most powerful in the world, possesses several novel features, he has the pleasure of offering the following notes regarding it, trusting that they will prove of interest in connection with the visit to be made to the lighthouse on the occasion of the present meeting.

Previous Lighting.—The Isle of May was originally lighted in 1636 with an open coal fire. In 1816 the commissioners of northern lighthouses, having previously purchased the island, with the right to levy tolls for the lighthouse, altered the light to Argand lamps with silvered parabolic reflectors. In 1836 it was converted to the dioptric system, with a first order fixed light apparatus and a four-wick burner; on the 1st December, 1886, the electric light was substituted, and shown in connection with a dioptric condensing apparatus. For the last fifteen years, the commissioners of northern lighthouses, acting under the advice of their engineers, Messrs. Stevenson, had been anxious to establish an electric light on the Scottish coast, but it was not till 1883 that the board of trade were able to sanction the expenditure, and suggested its introduction at the Isle of May on the ground that "there was no more important station on the Scottish shores, whether considered as a landfall, as a light for the guidance of the extensive or important trade of the neighboring coast, or as a light to lead into the refuge harbor of the Forth." Notwithstanding the difficult access and isolated position of the Isle of May, distant five miles from the Fife shore, which is the nearest land, it was resolved to accept the view of the board of trade, and to introduce the electric light there. The necessary plans and specifications were accordingly prepared by Messrs. Stevenson, and the works, begun in June, 1885, were completed and the new light installed by 1st December, 1886.

Site.—Fig. 1. The existing establishment consisted of a lighthouse tower with accommodation for three keepers, placed on the summit of the island; and the additional buildings which it was necessary to provide were dwellings for three more keepers with their families, an engine house, boiler house, chimney stalk, workshop, coal store, etc. It was decided to place the whole of the new buildings and machinery near the base of the island, and to lead the current up to the tower by conductors. This decision was arrived at, because it was considered that the fact of being able to place the engines close to the small natural fresh water loch, situated 270 yards from the light and 175 ft. below it, from which fresh water for feed and condensing purposes could be readily obtained, and also the saving which would be effected by not having to convey the fuel to the top of the island or to pump up water, would compensate for the loss of energy due to such a length of conductor; while the saving of the cost of carriage of the materials and machinery to the top of the island, and of piping and pumping machinery, would more than counterbalance the original cost of the conductors. The buildings were constructed in a plain and substantial manner of fire-brick, built in Portland cement, and roofed with concrete and Val-de-Travers, carried on rolled beams and buckle plates. This part of the work was executed in an expeditious and satisfactory manner by the contractors, Messrs. Stratton, Edinburgh, notwithstanding the difficulty of getting materials taken to and landed on the island.



* Paper read at the Institution of Mechanical Engineers, at Edinburgh.

Generators.—It was originally intended by Messrs. Stevenson to use the Brush compound-wound Victoria dynamo, giving a continuous current, and supplying a single automatically-fed arc lamp, with the positive carbon below. This system was selected as being at once cheaper and as giving a stronger light power for the engine power applied than the magneto-electric machines, which had hitherto, with success at least, been exclusively used in lighthouses. The placing of the positive carbon below was adopted in order that the strongest light might be thrown upward, so as to be dealt with by the upper part of the dioptric apparatus, and thus be more effectively utilized. The Brush company at once set to work to produce a lamp of the above description, giving with a current of 100 amperes and 70 volts a light of 30,000 candle power in a horizontal line, steady and suitable for burning in a lighthouse. This unfortunately they were unable to accomplish, even after numerous trials; and at last, as the buildings on the island were nearly completed and it became necessary at once to procure reliable apparatus, recourse was had to the more expensive alternate current machines of De Meritens, which though not so powerful, are admirably steady in working, and had given excellent results in several lighthouses and also at the South Foreland experiments. The generators at the Isle of May are two of De Meritens' alternate current magneto-electric machines of the L type, and are of the largest size hitherto constructed, weighing about 4½ tons each. The induction arrangement of each machine consists of five sets of twelve permanent magnets, sixty in all; and each magnet is made up of eight steel plates. The armature, 2 ft. 6 in. diameter, is composed of five rings with twenty-four bobbins in each, arranged in groups of four in tension and six in quantity. It makes 600 revolutions per minute. With the circuit open, each machine develops an electromotive force of 80 volts, measured at the distributor; and with the circuit closed through an arc, 40 volts. An average current of 220 amperes is developed, thus yielding an electrical energy of 8,800 watts or 11·7 horse power in the external circuit. The five rings are so arranged that one-fifth, two-fifths, three-fifths, four-fifths, or the whole of the current of a machine can at pleasure be sent to the distributor for transmission to the lantern; and further, the two machines can be coupled, and the full current from both be employed.

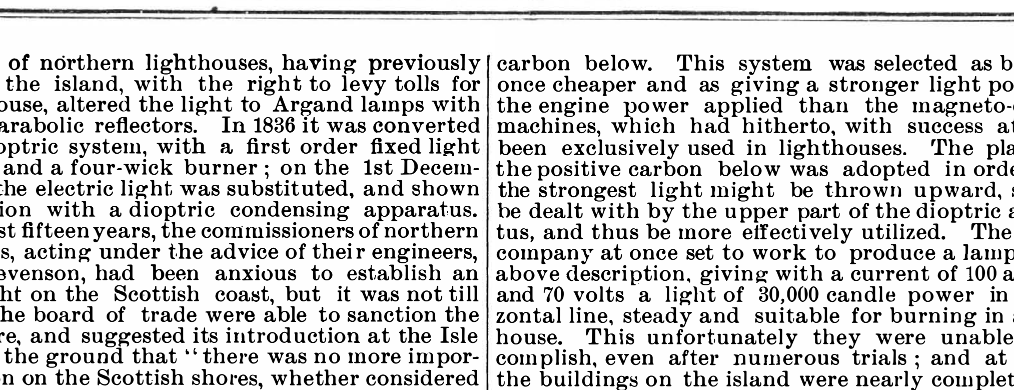


FIG. 2.—SECTION OF ENGINE ROOM.

Engines.—Fig. 2, one-eighth full size. The machines are placed in the engine room, bolted down to concrete foundations, and are driven through a countershaft by belting from the engines. There are a pair of horizontal surface condensing steam engines, each with two cylinders of 9 in. diameter and 18 in. stroke, making 140 revolutions per minute, and each indicating 17·7 horse power with 40 lb. steam pressure above atmosphere and 11 lb. vacuum. To provide against accident or failure of water supply, they have been arranged so as to be capable of being worked either condensing or non-condensing. Either of them is sufficient to drive one machine, the other engine being idle; or the two can be used together for driving both machines in thick weather. The steam to both cylinders is regulated by an equilibrium throttle valve, which is controlled by a high speed governor, adjusted for the engine to run at the normal speed of 140 revolutions per minute. Single in place of compound engines were adopted, because they are less complicated and better suited for the less skilled attendance of ordinary light keepers. Probably also greater regularity in driving has thus been secured, which is, of course, a matter of the greatest importance in electric lighting, especially where, as in this case, there is only a single arc lamp in the circuit forming the resistance. The result has been eminently satisfactory; and the engines, which were built by Messrs. Umpherstone of Leith, are a most excellent piece of work.

Boilers.—There are two steam boilers, of which only one is in use at a time, the other being spare. Each is 20 ft. long and 5 ft. 6 in. diameter, with one furnace flue 3 ft. diameter and 8 ft. long, having six cross Galloway water tubes. The shells are of best ⅜ in. steel plates, with the longitudinal joints double riveted; and they were tested up to 110 lb. per square inch, the working pressure being 40 lb. The feed is principally rain water collected from the roofs and the pavement of the court; but water can, if required, be taken from the small loch, which is also used for condensing purposes. The coal consumption is 1 cwt. per hour of lighting, which includes banking the fires during the day.

Conductors.—The current generated in the engine room is conveyed to the lantern by leads, which consist of copper rods of 25 mm. or 1 in. diameter, covered with a double waterproof wrapper. This is the first time that copper rods have been used for conducting the current for lighthouse illumination. They are constructed in 14 ft. lengths, the joints being formed with a zigzag scarf screwed up tightly by gun metal coupling boxes with four bolts in each. They are carried by timber bearers, placed in a groove made for them in the side of a concrete wall running from the engine room to the tower. The total distance to the lantern is 880 ft. Several bends are introduced to allow for expansion and contraction due to changes of temperature. The loss in the leads was expected not to exceed one-sixth of the total energy generated; but it is considerably more than this, amounting to at least one-fifth. It is hoped, however, that an improvement will yet be made in this particular.

Lamps.—The lamps, of which there are three, one in use and two spare, are of the Serrin-Berjot type, with some modifications, notably the shunt or by-pass, first introduced in the South Foreland experiments on the suggestion of Dr. Hopkinson, whereby a large percentage of the current goes direct to the lower carbon, and only an amount sufficient to regulate the carbons is passed through the lamp. This is a great improvement, and prevents injury to the lamp from heating. The weak point about it, in the lamps sent to the Isle of May, was that the contact between the lower carbon holder and the by-pass, being necessarily a sliding contact, was effected by copper wire brushes, and these were found to wear out rapidly. On the suggestion of Mr. Munro, the engineer in charge of the station, a simple form of mercury contact has been substituted and works quite satisfactorily.

Carbons.—The carbons in use are 40 mm. or 1·6 in. diameter, but if desired 50 mm. or 2 in. carbons can be used when both machines are running. They are Siemens make, and have a soft central core of pure graphite, which has the effect of causing them to burn with greater regularity and steadiness than they otherwise would, and prevents a crater from forming and remaining at one side. The rate of consumption of the 40 mm. carbons is 1¼ in. per hour, or 2 in including waste. The power of the arc is estimated at 12,000 to 16,000 candles, when one machine only is running.

Dioptric Apparatus.—Figs. 3 and 4, half full size. The dioptric apparatus, which was manufactured from Messrs. Stevensons' designs by Messrs. Chance, of Birmingham, is of a novel description, the condensing principle being carried further than in any apparatus previously constructed. The principle consists of darkening certain sectors by diverting the light from them, and throwing it into the adjoining sectors so as to re-enforce their light. Thus the power of the light is increased in proportion as the dark arc is increased. The light gives four flashes in quick succession every half minute; and during the bright periods the effect of this concentration of the rays is that the light radiating naturally from the focus is increased in power fifteen times in azimuth in addition to the vertical condensation, excepting, of course, the loss due to reflection and absorption. The apparatus which effects this result is a second order fixed light apparatus of 1,400 mm. or 55 in. diameter, which operates on the rays in the vertical plane. Outside of this there is a revolving cage of straight vertical prisms, extending the full height of the fixed apparatus, or 5½ ft., and composed of two panels on opposite sides of the center, each operating in the horizontal plane on 180° of the light coming from the fixed apparatus, in such a way as to condense the whole 180° into four flashes of 3° each—that is, 45° into 3°, with the proper intervals of darkness between them. This cage of glasswork is caused to make one complete revolution every minute round the fixed apparatus, thereby producing the characteristic of four flashes every half minute. The fixed light apparatus is not of the ordinary Fresnel

section, but has the refracting portion confined to an angle of 10°, the upper and lower reflecting prisms being carried nearer to the focal plane. This design, although involving the loss of some light, facilitated the adoption of the late Mr. Thomas Stevenson's proposal of dipping lights in fog, so as to be able to direct the strongest part of the light to the horizon in clear weather, and in fog to a point only three to five miles distant. Such a change could be most easily produced by simply raising and lowering the level of the radiant in the apparatus; but there was a difficulty in doing so in an ordinary optical apparatus, inasmuch as, when the position of the radiant was altered, the rays from the reflecting prisms, above and below the refractor, would be sent in an opposite direction to those coming from the refractor. This form of the fixed-light apparatus was also specially necessary at the time the apparatus was designed, because it was then intended, as already mentioned, to use a continuous current machine with the positive carbon below; and consequently the strongest part of the light would have been dealt with by the upper reflecting prisms. By making the apparatus almost entirely of totally reflecting prisms, instead of refracting and reflecting combined, all the prisms act in the same way, so that by lowering the radiant the whole of the light from every part of the apparatus can be dipped simultaneously to any required extent, with the exception of a small piece in the center, which is left a refractor, and which will send light to the horizon when the other part of the apparatus is dipped. In clear weather the three upper prisms send their light from ½° above the horizon to 3° below it; the rest of the upper prisms and all the lower ones send their light to the horizon, and the refracting portion from 3° to 5° below the horizon. The dipping of the light during fog has not yet been used, but as soon as the light keepers, who, with the exception of the engineer, were the ordinary keepers in the service, and knew nothing of electric lighting, have become thoroughly familiar with their duties, it is intended to introduce it, and probably in the same way to employ a less powerful current, and say 25 mm. or 1 in. carbons in very clear weather, while both machines, with 50 mm. or 2 in. carbons, will be used in very thick weather.

Lamp Changing and Revolving Arrangements.—Fig. 3. Standing in the center of the light room is a circular case, 5 ft. 8 in. diameter and 5 ft. 4 in. high, formed of cast iron pilasters filled in between with glazed doors. The top of this case carries the fixed light apparatus, as well as a steel roller path 5 ft. 10 in. diameter, on which the carriage supporting the cage of vertical prisms travels on twelve steel rollers. The top of the case also serves as the service table, on which the electric lamp stands when in focus. Access to the interior of the apparatus and to the lamp is obtained from the inside of the case, through a trap in the top of it. Some difficulty was experienced in devising a suitable system of readily substituting one lamp for another, when it may be desired to change them, or in the event of the one in focus going wrong. The difficulty arose from the necessity of keeping the spare lamp out of the apparatus entirely, so as to prevent its interfering with the light emanating from the lamp in use, as the light shows all round the horizon. The change is accomplished by means of an arrangement of rails, and three turn tables or shunt tables, on which the lamps can be freely run, and which are placed on the service tables. One of these is in the center of the apparatus, and one is on a trap door, working vertically in guides and counterbalanced, in the manner of a hoist, whereby a lamp can be lowered from the level of the top of the case to the floor of the light room. Here the lamp is again received on rails, on which it can be conveniently run out of the case, to be recarboned and adjusted. In this way a lamp can be raised from the floor of the light room into the apparatus, the lamp in focus withdrawn on to one of the turn tables and the fresh lamp run into focus, the original lamp shunted on the hoist and lowered out of the apparatus, all in about eight seconds. A three-wick paraffine oil lamp is kept trimmed and ready for use, in case of a failure of the electric current, and it can be lighted and put in focus in about three minutes. Within the case, and placed at one side of it, is a train of wheelwork, actuated by a weight with a fall of 60 ft. down the center of the tower. This machine drives the revolving cage of vertical prisms by a shaft which passes up through the top of the case, with a pinion working in an internal wheel of 4 ft. 10½ in. diameter secured to the carriage of the cage. This machine is carefully boxed in, to prevent the dust from the incandescent carbons finding its way into the bearings, whereby great trouble has been caused at various lighthouses.

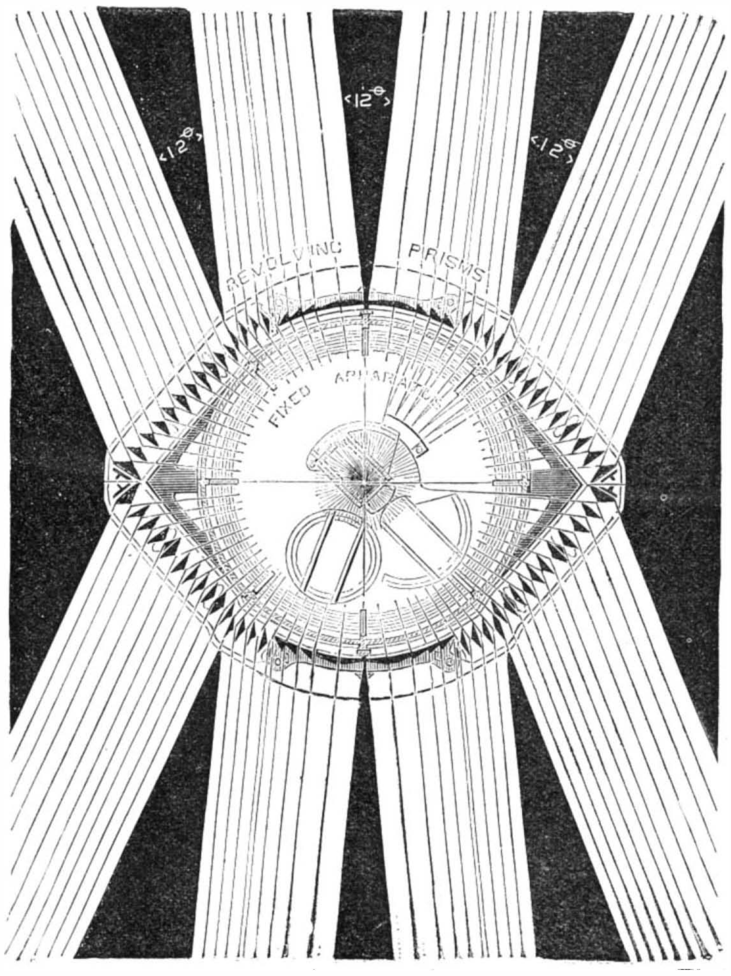
Power of Light.—The resulting beam of light from this apparatus is about 3,000,000 candles when one machine is in use, and with both machines 6,000,000; that is, about 300 and 600 times more powerful than the old fixed oil light. When the three wick oil lamp is put in the focus of this apparatus, the emergent beam is more powerful than the old fixed oil light with a four wick lamp, which was 9,446 candles. The light has been picked up and recognized by sailors at forty and fifty miles off, by the flashes illuminating the clouds overhead, although the geographical range of the light is only twenty-two miles. The engine room is connected by telephone with the light room; and the houses of the keepers are connected by air whistles or electric bells with either the light room or the engine room.

Men Employed.—The establishment consists of an engineer, four keepers, and an occasional or auxiliary keeper. The engineer, who is responsible for the management of the station, does not take a regular watch, but visits the engine room and light room occasionally during the night. Two of the keepers attend to the light room duty and two have charge of the engines and boilers, relieving each other in regular watches. The auxiliary keeper does any odd duties, such as carting fuel, etc.; and in the event of any of the others being ill, takes his place. Since the light was first exhibited, the machinery and electrical appliances have worked without a hitch, and recourse to the oil lamp has been unnecessary. This is the more gratifying when it is remembered that the men in charge, with the exception of the engineer, were new to the work, and that the light was started at a period of the year when the hours of lighting were longest, namely, sixteen hours.

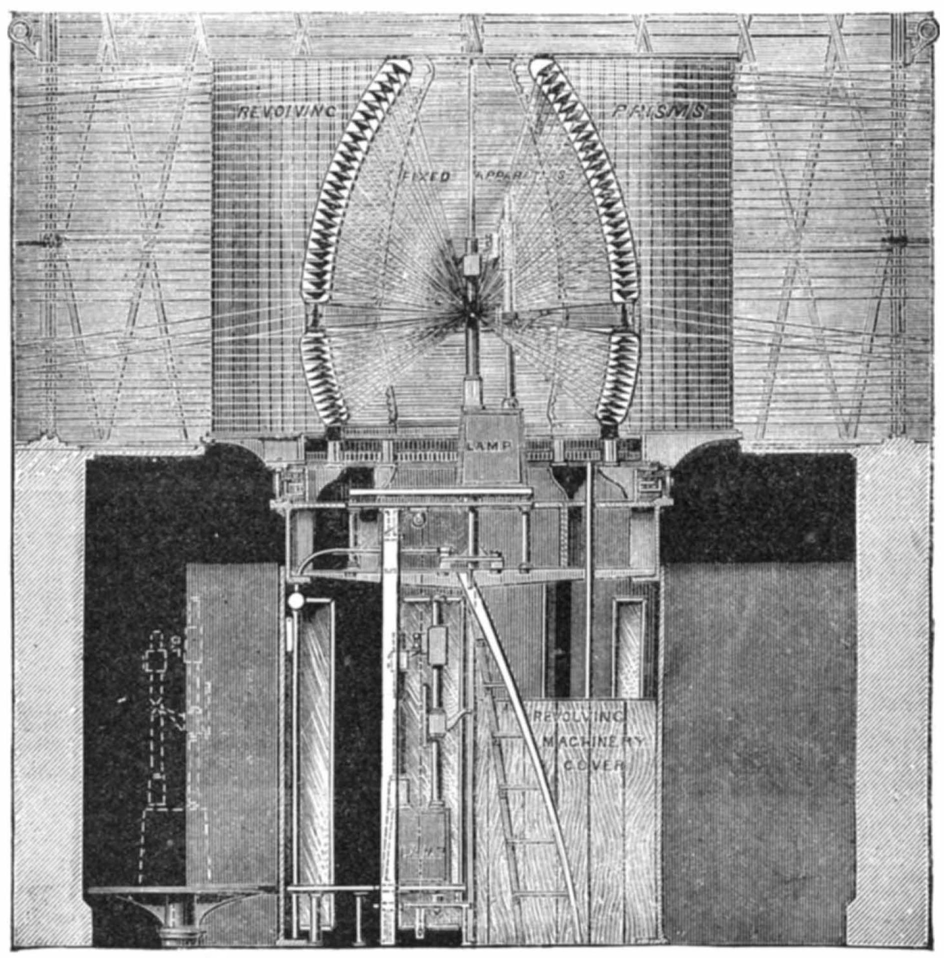
Cost.—The new buildings, engines, electric machines, lamps, etc., have cost £15,835; and the buildings, lanterns, etc., previously on the island, which have been utilized, may be valued at £6,600. Thus the total cost of the installation may be taken at £22,435; and the cost of maintenance will not exceed £1,050 per annum. These figures are very moderate, considering the great power of the light and the isolated position of the lighthouse. To compare the cost of this installation with what it would have been if oil were the illuminant, there must be added to the above £6,600 for buildings, a sum of £2,925 for the cost of the apparatus and machine, etc., making a total of £9,525, while the cost of maintenance would have been £330 per annum. Taking these figures, and adding to the maintenance 3½ per cent. on the original outlay, it is found that while the oil light would cost 3·49s. per hour, and 0·00017d. per candle power per hour, the electric light costs 9·66s. per hour, or two and three quarter times more, and 0·000038d. per candle power, or less than one quarter of what the oil light would cost per candle power. This is taking the electric light power of one machine. Surprise has frequently been expressed by masters of vessels, and by residents on the neighboring shores who live in view of the Isle of May light, that this light, which is so extremely brilliant in clear weather as to cast shadows at a distance of ten and fifteen miles, is so cut down by fog that some even go the length of believing the old oil light was better in fog. All who have experience of the electric light are quite prepared for the first part of this statement, while the last, it need hardly be said, is a mistake, inasmuch as the electric arc has been proved, both by experiment in natural and artificial fog, and also by observations on existing lighthouses lighted by electricity, to be in all circumstances of weather the most penetrating. Every night at 12 o'clock the lightkeepers at St. Abbs Head, 22 miles distant, where there is a first order flashing light and one of the most powerful oil lights in the service, observe the Isle of May light, while the keepers there also observe the St. Abbs Head light. The result of the last five months' observations is that the Isle of May light is seen one-third oftener from St. Abbs Head than the St. Abbs Head light is seen from the Isle of May. It is perfectly true, however, that the superiority which is so apparent in clear and rainy weather is very much reduced in hazy weather, and practically disappears in very dense fog. Looking to this fact, and to the large first cost and annual maintenance, the author feels that the conclusion arrived at by the Trinity House is sound, that electricity should be used only for important landfall lights.

If, however, the most powerful light is desired independently of cost, then the electric arc has no rival. And if the further expense is to be incurred of introducing biform, triform, quadriform, or even double quadriform lights, then the electric light is better adapted than any other illuminant, because, on account of its focal compactness and other properties, it can be so dealt with by suitably designed dioptric apparatus that the whole light evolved is effectually utilized. This is not the case with the large gas or oil flames generally used in the multiform system, in which for this and other reasons a considerable loss of light is incurred. Moreover, the coolness of the electric arc renders multiform lights really practicable with electricity, which can hardly be said to be the case either with gas or oil.

Hyper-radiant Apparatus.—In the author's opinion, however, it is only in very exceptional cases indeed that electricity should be used; and he considers that a single oil or gas burner placed in the focus of a proportionately sized dioptric apparatus is sufficient for the generality of cases; and that any additional outlay which can be permitted should be expended in establishing a powerful sound signal to be used during fog when the light is obscured and when for all practical purposes even the electric light itself would also be obscured. This is specially the case since the introduction, on Messrs. Stevensons' suggestion, of hyper-radiant apparatus suited for use with burners of large diameter. As the result of experiments made in Edinburgh in 1869, they pointed out that the effectiveness of the large Wigham burner was to a great extent lost in revolving apparatus, because much of the light was ex-focal. A year or two ago, when the Commissioners of Northern Lighthouses resolved to increase the size of the burners in some of their lights, an experimental lens of 1.330 mm. or 52⅜ in. focal distance, designed by their engineers, was constructed by Messrs. Barbier and Fenestre, and by the courtesy of the Trinity House was fully experimented upon at the South Foreland, on the termination of the experiments conducted there with electricity, gas, and oil. From experiments made by Sir James Douglass and the author, and from photometric observations by Mr. Harold Dixon, the expectations of Messrs. Stevenson were fully borne out, and the following conclusions seem warranted: That a single burner, shown in a complete panel of a revolving apparatus of the hyper-



HORIZONTAL SECTION THROUGH FOCAL PLANE.



VERTICAL SECTION THROUGH APPARATUS AND LANTERN.

THE ELECTRIC LIGHT ON THE ISLE OF MAY.

radiant kind, would give a more powerful light than burners and ordinary Fresnel lenses, arranged as biform, and would be of equal power to triform; while the consumption of oil or gas would be one-half or one-third respectively. Moreover, all the disadvantages of superposed lenses, including excessive heat in the light room, difficulty in the management of the burners, and obstruction of light by the necessary ventilating tubes, would be avoided. The result of the above experiments has so conclusively established the advantages of the hyper-radiant apparatus that the American Lighthouse Board have since ordered a complete apparatus of this kind; while the Trinity House and the Irish Lighthouse Board have adopted this size of lens recently ordered by them on Mr. Wigham's biform principle.

THE PROGRESS OF GEOGRAPHY.

AT the anniversary meeting of the Royal Geographical Society, held on May 23, 1887, General R. Strachey, the vice-president, delivered an address, from which we take the following extracts:

The attention of geographers during the year, as far as regards Africa, has been chiefly directed to the basin of the Congo, where many explorers, of various nationalities, have been employed in exploring and surveying the numerous streams which combine to make the Congo one of the greatest fluvial systems of the world. Other explorers have been engaged in the same region in examining into its economical and prospective commercial resources, but at present without definite results. An excellent summary of the geographical work done in the Congo region up to the middle of last year was given to the society in this hall, in June last, by Sir Francis De Winton, who had then recently returned from his two years' administration of the country. The most important of the new explorations he described was that of Lieut. Wissmann and his party, who had embarked on the upper waters of the Kassai River, near the part made known to us by Livingstone and Cameron, and navigated it to its junction with the Congo. Since then Dr. Wolff, one of Wissmann's companions, has explored the Sankuru, a large northern tributary of the Kassai, and found it navigable for a long distance. One result of this latter exploration is to show that another navigable river of the far interior, the Lomami, enters the Sankuru from the northeast, and that it is a distinct river from the Lomami of Cameron, recently ascended by Grenfell, which enters the Congo near Stanley Falls.

The direction which the Kassai takes—in a long curve, from southeast to west-northwest—causes it to be the recipient of nearly all the drainage of the southern half of the Congo basin, and near its junction with the main stream it adds to its volume the waters of another great tributary, the Quango, besides the Mfini, from a chain of great lakes further north. The united waters are poured into the Congo through the Kwa, which, according to Mr. Grenfell's measurement, is contracted in its passage through a range of low hills, and at its mouth is only 700 yards wide (a little higher up only 450 yards); the depth of the swiftly flowing stream Mr. Grenfell was unable to ascertain, as no bottom was touched with a line 120 feet long.

The prospective value to the Congo State of the Kassai, with its immense mileage of navigable waters flowing through fertile plains, is acknowledged on all hands. Already stations have been founded on its banks, and Portuguese traders are choosing the newly discovered river route in preference to their old inland road into the interior from Loanda. It has been during the past few months repeatedly reascended by river steamers; once by Sir Francis De Winton himself.

Equal in importance and extent have been the explorations and surveys along the main river and many of its tributaries carried out by Mr. Grenfell. The chief of these explorations were noticed by the Marquis of Lorne in the address of last year; and a brief general account of his surveys was given, together with a reduction of his admirable series of river charts, in the October number of our proceedings. Since then Mr. Grenfell has added to his achievements the ascent of the unknown portion of the Quango between its junction with the Kassai (or Kwa) and the Falls of Kikunji, which latter was the farthest point, coming down river, reached by a former traveler, Von Mechow.

Other considerable additions have been made to our knowledge of the Congo region by Lieuts. Kund and Tappenbeck, members of a scientific expedition sent out in 1884 by the German African Association. These courageous travelers, instead of following the courses of the rivers like others, and gleaning information only of the country and people along the banks, struck across the country, first from Stanley Pool to the south, and thence toward the east, crossing in succession all the southern tributaries, from the Quango inclusive to the Lukenye, beyond the Kassai; a toilsome and dangerous march of about 600 miles. Another member of the same expedition, Dr. Buttner, made also a land journey, of less extent, but not less interest. Starting from San Salvador, the old capital of the Congo, he traveled eastward and crossed the Quango, reaching the capital of a negro potentate named Kasongo, whence he struck northward to the main Congo above Stanley Pool. Much valuable information regarding the configuration of the country and the ethnology and products of the interior was obtained on these two journeys. We learn, for example, that the whole western section, to a distance of some 400 miles inland, is a hilly country cut up by deep valleys, to which succeeds, further inland, a wide stretch of undulating plains, wooded only along the courses of streams, and that it is only when the eastern side of the Kassai is reached that continuous tropical forest is met with.

North of the Congo the French have been active both in completing the pioneer exploration of their new possessions and in laying down with scientific precision large tracts of country imperfectly known. The most important work of the latter kind is that of Capt. Rouvier, the representative of France on the joint commission for laying down the boundary between the Congo State and the French possessions. This accomplished surveyor fixed numerous positions by a long series of observations both for longitude and latitude, and his report, which will be accompanied by an atlas of thirty-eight maps on various scales, will form a solid contribution to our geographical knowledge of the region. An important pioneer exploration, about the same time, was made by M. Jacques De Brazza, brother of the eminent traveler, to the north and east of the French stations on the river Ogowe, undertaken soon after Mr. Grenfell's discovery of the magnitude of the Mobangi, and apparently with the object of ascertaining whether that great river flowed within the French boundary as fixed at the Berlin conference. After a journey of a month's duration through dense forests, M. De Brazza emerged on an open plain, through which flowed, not the Mobangi, but the Sekoli, an independent tributary of the Congo lying far to the westward. After a fruitless attempt had been made to penetrate beyond this river, his party built canoes and descended the Sekoli to its mouth.

It has been recently announced that by arbitration the French boundary has been extended a little farther to the east than fixed by the Berlin conference, so as to include the right bank of the Mobangi. A complete and very useful *resumé* of all the geographical work accomplished by recent French explorers in the Ogowe-Congo region, by Major De Lannoy De Bissy, was contributed to our proceedings for December last, illustrated by a map reduced from the French surveys.

Public interest has recently been directed toward the region north of the Congo, and the practicable routes it may offer to the Niam-Niam countries and the Egyptian Soudan, in consequence of the dispatch of the expedition under Mr. Stanley, for the relief and rescue of Emin Bey, which has adopted the Congo route to the Upper Nile in preference to the more direct and shorter route inland from Zanzibar. A paper giving a *resumé* of all published information regarding this region was recently read in this hall by our accomplished young colleague, Mr. J. T. Wills. Since then, you have had before you the greatest of all travelers in this little known region, Dr. Junker, and heard his own account of his six years' explorations. The wide open plain country lying between the Congo and the Nile, which Dr. Junker described to us, is watered by numerous streams, the chief of which, the Welle-Makua, flows westerly in the direction of the Upper Mobangi, and judging from Dr. Junker's maps, it is difficult to dispute his conclusion, in which Mr. Wills agrees, that the two rivers are the same.

Other geographers believe that the Welle-Makua belongs to the Shari system and flows into Lake Chad. The alternative offers one of those problems in which speculative geographers seem to delight; but in this case it will not be long before a solution is arrived at in the only satisfactory way—namely, by actual exploration. Meantime we learn, by the latest news from the Congo, that Mr. Stanley has chosen to adopt a somewhat more direct route to Emin Pasha than that first proposed—namely, from the Congo near Stanley Falls by land to the shores of the Albert Nyanza.

Two more journeys across the continent have been brought to a successful conclusion during the past year. One by M. Gleerup, a Swedish officer, formerly in the service of the Congo State, who crossed from Stanley Falls to Zanzibar, and the other by the experienced traveler and geologist, Dr. Oscar Lenz, who undertook, in 1885, an expedition for the purpose of reaching Dr. Junker and Emin Pasha *via* the Congo. Reaching Stanley Falls in February, 1886, Dr. Lenz was unable to obtain men from the Arab traders there to accompany him on the march through the unknown country between that point and the Upper Nile, and proceeded to Ujiji in the hope of meeting with better success there, and advancing northward along the eastern side of Lake Tanganyika. The disturbed state of the country and the excitement in Uganda made this impossible, and he took the Tanganyika and Nyassa route to the Indian Ocean, emerging at the Portuguese settlement of Quillimane.

Further south, Dr. Hans Schinz, a learned botanist and ethnologist, has been exploring with fruitful results the region between the Kunene and Lake Ngami.

On the eastern side of the continent our society is especially interested in the expedition of Mr. J. T. Last, who was commissioned by us in the summer of 1885 to proceed to the region between the Rovuma and the Zambesi, and follow up the work of Mr. O'Neill by exploring the Namuli Hills and the Lukugu Valley. We hear by recent telegram of his safe arrival at Zanzibar, and may shortly expect him home to give us in person an account of his journey. The letters which we have received from him from time to time have informed us that he has carried out his programme, though he found the summit of the Namuli Hills inaccessible, and, in addition, traversed the whole region a second time, striking into the interior from Quillimane, and emerging at Ibo on the Mozambique coast.

Count Pfeil, one of the most active of the pioneers in the newly acquired German Protectorate of Eastern Tropical Africa, published last year an account of his two journeys in Khutu and in the neighboring region, a country previously known to us only through Thomson's expedition to the Central African Lakes. Some additions to our knowledge of the geography of this part of the African interior have resulted from Count Pfeil's labors, the most interesting of which is the discovery of the main stream of the Ulanga, or upper course of the Rufigi, a river which this explorer claims to be of some importance, and which he navigated in a boat for upward of 150 miles.

The unsuccessful attempt of the experienced African traveler Dr. Fischer to carry succor to Dr. Junker in 1885–86, a mission with which he was charged by that traveler's family, would have excited great interest in the earlier days—not long past—of Central African travel. The route he took led for several hundred miles through a totally unexplored country, namely, from the Pangani westward across the region which still remains a great blank on our maps to the caravan route between Unyanyembe and Victoria Nyanza. He reached the southern shores of the Victoria in January, 1886, but found it impossible to obtain leave to pass through the territory of the fanatical king of Uganda. Turning backward, he made a valiant attempt to reach the Upper Nile by the eastern side of the great lake, but his supplies failed him by the time he arrived at Lake Bahringo, and he returned with a sorrowful heart to the coast. He did not long survive the fatigues of this arduous journey, but died soon after his return to Europe, in November last.

In the continent of Asia the most important addition to our accurate geographical knowledge of the interior is no doubt that gained by the joint Russian and British commission, which has been engaged on the survey of the northern frontier of Afghanistan from the borders of Persia to the Upper Oxus, but pending the diplomatic settlement of disputed points this information has not been made public, though it will doubtless soon become available.

A brief note of a portion of this work, describing surveys made by Capts. Maitland and Talbot, between the Hari-rud and Bamian, connecting Herat with the last named place, and also with points north of the Oxus, and the neighborhood of Kunduz, has appeared in our proceedings. The total area surveyed amounts to about 120,000 square miles, mapped on the scale of one-quarter inch to the mile, in sixty sheets. These brilliant results are believed to be unique in the annals of surveying. The chief of the British topographical staff, by whom these surveys were undertaken, was Colonel Holditch, to whom one of the gold medals has now been awarded, in recognition of the valuable services to geography rendered by him in this and other similar expeditions.

Much valuable geographical work has also been accomplished by Mr. Ney Elias, the gold medalist in 1873, who was dispatched from Ladakh on a mission to Chinese Turkistan, and diverging westward at Yengi-Hissar, traversed the Pamir Plateau for a distance of 360 miles, to the Khanat of Shignan. The details of this journey have not yet been made known by the Indian authorities, but Sir Henry Rawlinson has communicated to our proceedings a note in which he points out that his former suggestion that this route, first brought to notice by Major Trotter, was probably that by which caravans of Rome passed from Bactria, and had been used as a military road in comparatively modern times, is confirmed by the additional light now thrown on the subject, and he identifies the lake *Rang-Kul*, visited and described by Mr. Elias, as the famous Dragon Lake of Buddhist cosmogony, and as answering very closely to the description given by the Chinese traveler Hwang-tsang in the seventh century.

Mr. A. D. Carey, a gentleman in the Indian Civil Service, has in a most enterprising manner devoted a period of leave of absence to a very remarkable journey in Eastern Turkistan and Tibet, and has traversed a large part of those central regions which have lately been made known by General Prejevalsky, and of which a brief *resumé* was given in the last presidential address. Accompanied by Mr. Dalgleish, an enterprising trader, who had previously visited Eastern Turkistan, he started from Ladakh in the summer of 1885, taking a route which had never before been trodden by a European, from Leh eastward across the high Tibetan plateau, and descending to Kiria by an extremely difficult and rugged defile *via* Polu. After a short stay here, he traversed the desert northward, along the course of the Khotan River, and arriving at the Tarim, crossed that river to Shah-yar and Kuchar.

At the end of the year he tracked the Tarim to Lake Lob, and proceeded thence in a southward direction to the foot of the great escarpment which in this meridian forms the northern limit of the Tibetan highlands, where he wintered, and made a fresh start across the Altyn Tagh in the spring of 1886. No news having been received of him for many months, his friends had begun to fear for his safety, but all anxiety has been set at rest by recent telegrams from India announcing his safe arrival at Ladakh at the end of the winter. Considering that Mr. Carey traveled without escort and unarmed, and that his journey has been performed on slender means through vast unknown tracts peopled by tribes supposed to be of hostile and fanatical temper, his exploit is one of the most remarkable in the recent annals of adventurous travel.

Northward of Khatmandu, the capital of Nepal, about 400 miles of entirely new traverse in Nepal and Tibet has been contributed by a native explorer, surnamed M—H., besides a confirmation of the details of a hundred miles of ground previously traveled over. It is regretted that the explorer brought back no determinations of heights, which would have been most interesting, for he crossed the main ridge of the Himalayas by one of the highest passes (the Pangu-la), and approached within fifteen miles of Mount Everest. Another native surveyor, R—N., who accompanied Colonel Tanner in his explorations on the Tibetan border in the autumn of 1884, was dispatched across Bhutan and the mountains to the east to reach Gyala Sindong, the lowest point yet reached on the Sanpo, and, starting from the left bank of the river, to find his way back to India by *any* practicable route, without recrossing the river.

The object was to set at rest the vexed question of the connection between the Brahmaputra and the Sanpo on the one hand and the Irawadi on the other. The explorer met with bad luck at the outset, from the fact of there being hostility between Tibet and Bhutan, a state of things which had closed all the passes into Tibet. He therefore had to find his way back to India down the Hachhu and Wongchu Rivers to Baxa, having been detained and kept under surveillance for ten days by the *jongpon* of Chukhajong. His next attempt was made from Dewangiri, whence he proceeded by a pretty direct route to the Monlakachung Pass, and thence to the vicinity of Seh, a very large monastery on the Lhobra River, the position of which had been previously obtained from the north by Lama U—G.'s traverse of 1883.

Here, in consequence of the rumors regarding the advance of the Tibet Mission from the south, and of a party of Russians from the north, the officials absolutely stopped his further progress, and kept him in custody for nine days, and then conveyed his party under escort to Seh. From here he escaped with his party by night, and keeping away from the beaten tracks, found his way to Menchuna (lat. 28° N., long. 92° E.), and thence, *via* Tawang, to Odalguri, along the route formerly traversed by Pundit Nain Singh. His work furnishes about 280 miles of new route survey, and throws light on the general geography of Bhutan, besides forming a connection with the work of Pemberton (1838) from the south and of the Pundit and the Lama from the north.

Another journey carried out by three English gentlemen through the heart of Manchuria, from south to north from the shores of the Yellow Sea, and from west to east to the Russian settlement of Vladivostock on the Pacific coast, also calls for notice. The party consisted of Mr. H. E. M. James, of the Indian Civil Service; Mr. F. E. Younghusband, of the King's Dragoon Guards; and Mr. H. Fulford, of the Chinese Consular Service. We have received at present brief accounts

only of this meritorious achievement, but they are sufficient to show that the travelers made excellent use of their opportunities of gaining accurate information regarding the country, its inhabitants and products.

One of their objects was to ascend the Pei-shan or White Mountain, the highest mountain in the country, which they accomplished, and fixed its altitude by boiling point and aneroid at 7,525 feet, the estimates previously given in books making it 10,000 or 12,000 feet. A very good map of their route was plotted and a copy obligingly communicated to the society. Mr. James has just arrived in England, and we may hope to have an early opportunity of hearing from his own lips an account of his journey.

The recent addition of Upper Burmah to the territories administered by the Viceroy of India makes it certain that before long the various questions that have till now puzzled geographers in relation to the course of the rivers that rise in Tibet and flow from that country will be finally cleared up, and a staff of surveyors under Capt. Hobday is already at work in this country. The sources of the Brahmaputra have already been clearly designated, but doubts still surround the origins of the Irawadi, which actual surveys will, it is to be hoped, before long dispel.

The expectations entertained of the opening of the still unknown interior of New Guinea, from the southern or British portion of the island, by the expedition of Mr. H. O. Forbes, have, unfortunately, not been fulfilled. Mr. Forbes spent the rainy season in the early part of 1886 in camp, at a short distance inland from Port Moresby, profiting by the enforced inactivity in cultivating friendly relations with the tribes, learning the languages, and making botanical collections.

The remainder of his resources during these months was exhausted, and when at the commencement of the fine season, in April, he made a bold attempt, with the great advantage of the companionship of the Rev. J. Chalmers, to reach the summit of the Owen Stanley Range, the term of service of his Amboynese escort had expired, and he could do no more than make a few observations in the rugged country at the foot of the mountains, seventy-five miles distant from the coast. Since then, he has not been enabled to renew his explorations. We learn, however, that the government of Victoria has taken the matter in hand, and that a well-equipped expedition is in preparation for the exploration of the interior, the leadership of which is to be offered to Mr. Chalmers, whose account of his varied explorations along the southeastern coast region, given at one of our evening meetings during this session, will be fresh in your memories.

The great influence which this experienced missionary pioneer has obtained over the natives, and his knowledge of their habits, inspire us with great hopes in the success of this enterprise, which so much depends on the willingness and fidelity of native followers. Several minor excursions have since been made by various travelers, but very little has been added to our knowledge of the southern portion of the island. Capt. Everill's larger expedition, fitted out in New South Wales, succeeded in ascending the Fly River and penetrating for some distance up an eastern arm or tributary named the Strickland, which is said to flow in the rear of the range of coast hills, but the map of the parts explored has not yet reached us.

In German New Guinea the discovery of the important river named after the Empress Augusta was confirmed by Capt. Dallmann, who, in April, 1886, ascended it in a small steamer for a distance of forty miles, and it has since been further navigated by Admiral Von Schleinitz and Dr. Schrader in the steamer Otilie, which reached a distance of 224 miles from the mouth, the ship's steam launch ascending 112 miles further, finding still sufficient water, but being obliged to return for want of fuel.

The progress made in the great continent of America, which still offers wide fields for the explorer, and still wider and more productive fields for the physical geographer, remains now to be briefly noticed. As a contribution to physical geography, Mr. John Ball's recently published volume on his voyage round South America, and various short journeys inland at various points, merits special mention. It is a model of what serious books of travel that aim at conveying accurate knowledge of the countries visited ought to be.

In Central America, our colleague, Mr. A. P. Maudslay, continues his explorations of the sites and his studies of ruined cities, having returned to Yucatan and Guatemala after reading to us in June last the results of his second and third visits to Central America. His work has great geographical and ethnological as well as antiquarian interest, and his excavations at Copan show that the ruins are those of a city, and not simply of a group of sacred edifices, and that the course of the Copan River has changed somewhat since the remote time at which the massive walls of the buildings had been erected. He believes that he has good ground for concluding that Copan and other cities were abandoned before the Spanish discovery of America in 1492.

Lastly, there remains to notice an admirable labor of exploration in the interior of Brazil by a private scientific expedition consisting of Dr. Karl Von Den Steinen, Herr W. Von Den Steinen, and Dr. Otto Claus. These gentlemen set themselves the task of exploring the course of the Xingu, one of the great southern tributaries of the Amazons. The work was accomplished in 1884, but the first detailed accounts of it were published only in May and June last year.

The party proceeded in the first place overland to Cuyaba, in the far interior, and, organizing there their caravan, proceeded to the sources of the great river, and descending along the banks of the principal stream, through wild Indian territory, to the point where it becomes navigable, built bark canoes, and paddled down the river a distance of about 1,000 miles to its junction with the Amazons. Throughout the journey, in addition to the geographical survey, physical, biological, and anthropological observations were made with the usual thoroughness of German travelers.

It will not be out of place at the present time, when our countrymen are celebrating in all parts of the globe the fiftieth year of the reign of her majesty Queen Victoria, to look back on the progress that has been made in geographical knowledge since the commencement of that reign, which dates seven years after the foundation of our society. The time at my disposal will only admit of an extremely brief review, and I would refer you for more ample details to the valuable memoir drawn up by our esteemed secretary, Mr. Clements Markham, and published by the society a few years back, under the title of "Fifty Years' Work of the Royal Geographical Society." A comparison of the maps of fifty years ago with those of the present day shows how great have been the additions made to our knowledge during this period.

Foremost, in this respect, must be placed the maps of Africa, the interior of which has been transformed from an almost complete blank, containing little more than hypothetical geographical features derived from reports of native traders, some of which have been handed down to us from the time of Ptolemy, to trustworthy representations, based on precise data, of a vast system of rivers, lakes, and mountains, the existence of which had been wholly unknown to the civilized world. This continent has at length been traversed and retraversed in all directions, and what remains unknown consists of details needed to fill in well ascertained large outlines, rather than essential features still to be discovered.

Closely following the progress of geographical research, some of the latest fruits of which it has been my agreeable duty to recognize to-day, when presenting one of the gold medals of the society to Mr. Grenfell, the advance of commercial enterprise is already carrying the pioneers of civilization, recruited from all the principal states of Europe, into the heart of what may without exaggeration be called a newly found quarter of the globe.

The additions to our knowledge of the great insular continent of Australia have been hardly less remarkable, and the difficulties that have been overcome, and the enterprise and endurance displayed in the investigation of its geography, have never been surpassed in the history of the earth's exploration. Here, too, hand in hand with the advance of geographical knowledge, the domain of civilization has been extended, and the Australian colonies have started into existence fully armed as it were from their birth for the battle of national life. Our fellow subjects in those distant countries have already displayed their complete fitness to undertake the task of further geographical investigation in that quarter, and to them we may now confidently leave it, assuring them of the continued sympathy and interest with which their labors will be regarded by this society.

During the period to which I am referring, much also has been done to add to our knowledge of the formerly little understood geography of Central Asia. The Russian geographers on the north, and our own surveyors on the south, have now almost entirely cleared away the darkness that shrouded this part of the earth's surface. The limits and the nature of the central plain lying between the mountains of Siberia and of Tibet have been at length satisfactorily ascertained. The long discussed problem of the true source of the Brahmaputra has been finally solved. The remarkable plateau of Tibet has been crossed in many directions, and important parts of it have been accurately surveyed, so that here also what remains to be done is rather to complete the delineation of details than to enter upon altogether new investigations.

The large geodetic and topographical operations in connection with the international demarkation of the northern boundary of Afghanistan will supply all that seems still required to complete the maps of Western Asia between the Indus and the Caspian.

Turning to the American continent, we find a measure of progress which, to say the least of it, quite equals that obtained elsewhere. The exploration of the vast tract lying between the valley of the Mississippi and the Pacific has been carried out by the United States Government with a degree of completeness, both in respect to its topographical representation and its physical characteristics, that has probably never been approached elsewhere, and the whole country has thus been thrown open to the enterprise of the energetic citizens of the United States, who have not been slow to possess themselves of its natural wealth.

In British North America, under less favorable conditions for the prosecution of such systematic surveys as those carried out in the territories of the United States, much has still been done, and the recent opening of the railway connecting Columbia on the Pacific with the eastern Canadian states, and the establishment of another through route to Eastern Asia, will doubtless before long lead to the thorough exploration of the countries through which the railway passes.

The Arctic voyages which had been originally commenced with the hope of finding a practically useful northwest passage to Asia have long ceased to be animated by such an expectation, and their repetition has been undertaken in the cause of geographical exploration alone.

The results of the numerous expeditions undertaken during the last fifty years combined with those obtained by land journeys directed from British North America have very completely defined the southern border of the Polar Sea between Behring Strait and Greenland, and have secured the precise delineation of the somewhat complicated system of channels by which the northern border of the American continent is intersected, and of the islands formed by them, along the Arctic circle. In like manner the boundary of this sea has been determined by voyages directed to the northeast along the northern border of Asia.

The highest latitude reached hitherto is rather less than 83½° N.—that is, within 500 miles of the pole. The further extension of the exploration of the north of Greenland and of Franz Josef Land may still be possible, and it is by journeys in this direction that any closer approach to the north pole will probably be most readily attainable.

I should not omit mention of the memorable voyage to the Antarctic circle under the most experienced of the Arctic naval commanders of his time, the results of which were of the greatest scientific value, though the difficulties arising from climate that stand in the way of a near approach to the south pole prevented the expedition reaching a higher latitude than 78° 11′ S.

Lastly, I may notice the remarkable additions that have been made during this epoch to our knowledge of the ocean, its depths, its temperature, the winds and climates that prevail over its various portions, its currents, and the life with which it abounds. Much of the knowledge thus acquired has supplied completely new and wholly unexpected data with which to deal in our endeavors to interpret the earth's history, and to understand the phenomena it presents to us.

It has been in connection with the extension of geographical discovery, both that to which I have thus more specially referred and other similar explorations to which specific reference has not been possible, that there has been accumulated a great mass of knowledge which has had a most important place among the causes which justify our assigning to this epoch its conspicuous character of deserving to be recorded in the history of the present time, as the age of scientific progress. There is no room to doubt that it was only by aid of the accumulation of a knowledge of numerous forms of life from various countries, developed under different conditions, that the remarkable generalizations of Darwin and Wallace as to the origin and distribution of species became possible; and that in this sense those great conceptions of the signification of the wonderful variety in the forms of animal and vegetable life, and of the remarkable manner in which they are found associated in various parts of the earth, which it has truly been said are worthy of being classed with the sublime discoveries of Newton, may be regarded as consequences of geographical exploration and discovery. In a somewhat similar manner the progress of geology follows that of geography, and the same may be said of almost all the natural sciences.

In some branches of science the student is able to submit his conclusions to the test of experiment, to vary the conditions of his investigation at his pleasure, and to draw his inferences from the varying results under the changed conditions. In the great laboratory of nature no such control of conditions is within our power. But by suitable variation of our geographical position we are able to observe the effects that the physical forces of nature have produced under varied conditions, and it thus becomes possible to some extent to obtain a substitute for the power of direct experiment.

Properly to estimate the relation between geographical conditions and any observed effect, it is obviously necessary to possess a sound knowledge of the physical forces that may be called into operation in producing that effect, and consequently such a knowledge is of essential importance to every geographer.

I shall not detain you to say anything more on the much-discussed subject of geographical education. I desire to point out, however, that for such reasons as I have briefly indicated, it is hardly possible to overestimate the value of exact and scientific geographical research, and that this can only be attained by those who have been properly prepared by previous training. Such a training, it is hoped, may be provided by the instruction which it has been the earnest desire of the society to see imparted at our chief universities, and which I trust may not only add to the number of our scientific travelers, but serve generally to throw on many other branches of study that light which an intelligent knowledge of geography alone can supply.—*Nature.*

THE AUTUMNAL CHANGES IN MAPLE LEAVES.

W. K. MARTIN and S. B. THOMAS.

THE results we would record in this paper were obtained from investigations conducted in the botanical laboratory of Wabash College. The work was done during the time of the autumnal changes, so that abundant and fresh material was constantly at hand. The object was chiefly to note the changes in the cell contents as the death of the leaf approached, and to localize, so far as possible, the changes in color.

The structure of the normal green maple leaf is shown in Fig. 1, consisting of the ordinary epidermal

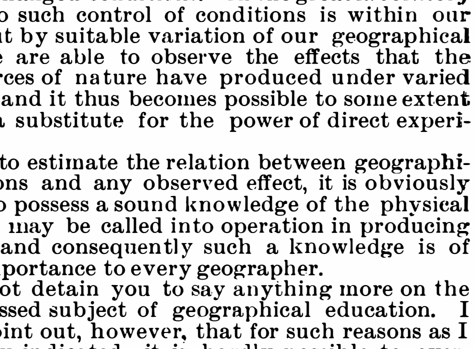


FIG. 1.

layer above and below, a single cell in depth, a single layer of rather elongated palisade cells, and usually about three layers of spongy parenchyma, more closely packed than usual. The chlorophyl bodies are small and thickly and evenly distributed throughout the mesophyl cells.

The first indication of the approach of autumnal changes is the withdrawal of the contents of the mesophyl cells. This goes on gradually, but the cells are seldom emptied. The amount of protoplasmic cell contents lost to a plant by the fall of its leaves must be

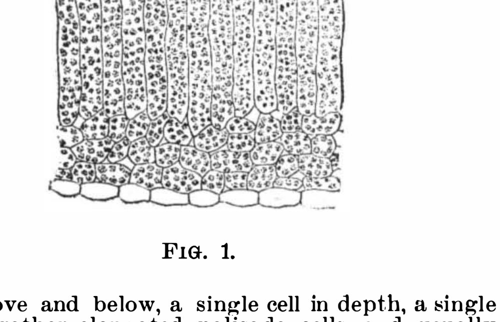


FIG. 2.

very considerable. The whole mass of the chlorophyl bodies in any cell is much reduced by this process of withdrawal (see Figs. 2 and 3). At the same time the protoplasm of the cell seems to dispose of much of its substance in the manufacture of cellulose, chiefly in the palisade cells, in which it is deposited upon the cell walls in successive layers, either uniformly or in restricted patches, or is used occasionally in building

a transverse partition across a palisade cell (Fig. 4). In every case the lines of stratification are beautifully marked. That this deposit is cellulose was determined by the ordinary tests for that substance. During these changes the chlorophyl bodies are seen both to disintegrate and to blend together in larger masses. In the case of the read leaf, these larger masses often become invested by a pellicle which appears to be cellulose.

In the leaf which has become brown (Fig. 2) a greater amount of cell contents remain than in the red, the chlorophyl bodies do not mass together so much, and the cell sap is a dirty brown.

In the red leaf (Fig. 3) the cell contents are even more reduced, some cells being almost empty. The

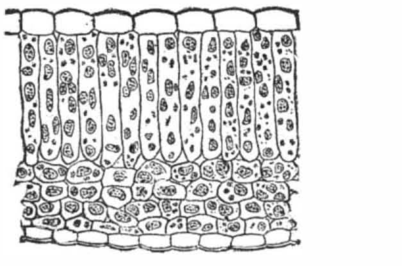


FIG. 3.

remaining contents are mostly collected in masses of considerable size and often surrounded by the pellicle referred to, and the cell sap is colored by the characteristic red coloring matter, erythrophyl.

In the yellow leaf the cell contents are much like those of the red leaf, but the cell sap is colorless and the chlorophyl masses are stained yellow by xanthophyl.

What has been said of red and yellow and brown leaves is applicable as well to groups of cells in the case of mottled leaves.

The existence of erythrophyl and xanthophyl in these positions, the former in the cell sap, the latter in the solid cell contents, is of course well known in a general way. But we wish to add an additional fact or two in the explanation of these phenomena. Chlorophyl, manufactured constantly under the influence of light, is as constantly undergoing decomposition by the metabolism of the cell. Under ordinary conditions the manufacture of chlorophyl is sufficient to cover up its decomposition and the leaf retains its green color. Under certain changed conditions, however, such as intense light or diminished vitality, the decomposition of chlorophyl exceeds its manufacture, and xanthophyl (probably one of the products of its decomposition*) appears. In other words, xanthophyl is being formed all the time, but only becomes apparent when the manufacture of chlorophyl is checked. The condition of intense sunlight gives us the occasional summer yellowness, while to lowered vitality must be attributed the failure of chlorophyl manufacture in the autumn. This lower vitality is brought about by diminution of light, lowering of temperature, and probably causes in the plant itself. The common notion that frost is the cause of autumnal coloration is true only so far as it is one of the causes which tends to diminish the vitality of the plant and so the manufacture of chlorophyl. Autumnal coloration may take place before any frost. Xanthophyl then stains the chlorophyl masses yellow, which were before stained green by chlorophyl.

The red coloration is brought about in a very different way, as chlorophyl is manufactured in the leaf and stains the cell sap, leaving the chlorophyl masses untouched. This red coloring matter cannot be discovered in any of the crude materials brought into the plant, or in any other part than the leaves, except sometimes in the phloem regions of the petioles. When the leaf falls and the cell sap evaporates, and the chlorophyl bodies die, the erythrophyl lays hold

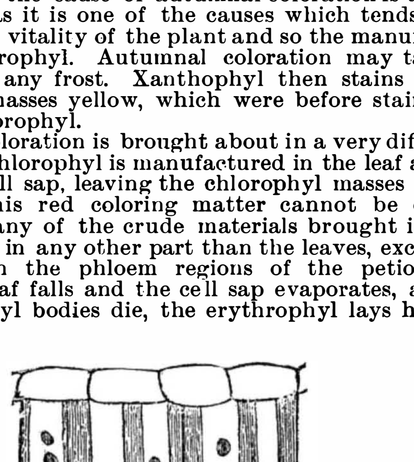


FIG. 4.

of the cell wall and solid contents and stains them. In this way dried leaves retain their red color. As erythrophyl is soluble in water, however, contact with moisture will soon cause the most of it to disappear. In the case of many cells containing erythrophyl we found the chlorophyl masses retaining their green color. In fact, the green was so slow in disappearing that it was only in the most advanced stages that it had given place to the yellow of xanthophyl. In some cases where chlorophyl masses were in contact with external cell walls they had become yellow, while in the same cell those masses completely surrounded with erythrophyl remained green. The explanation of this seems to lie in the fact that in the red rays the decomposition of chlorophyl goes on less actively than in the rays of low refrangibility.† The erythrophyl thus acts as a check upon the decomposition of chlorophyl, and so on the appearance of xanthophyl. It thus seems that all the leaves would become yellow but for the presence of erythrophyl. The brown coloration seems to be a modification of the red, the erythrophyl color of the cell sap being replaced by a dirty brown. Whether this is a resultant from the action of erythrophyl upon certain cell contents, or an entirely different coloring matter, was not ascertained.

* Vines' Physiology of Plants, p. 241.

† Vines' Physiology of Plants, p. 266.

RELATIONS OF MERCURY TO OTHER METALS.

By A. C. COUSINS.

SINCE my first paper on mercury, I have noticed other relations between that metal, gold, and thallium, which are interesting, and if not accidental, may possibly lead to the discovery of an important law.

The atomic weights and specific gravities are those previously given, and are the most recent determinations I have been able to obtain :

	Sp. Gr.	Atomic Weight.	Atomic Volume.
Gold............	19·263	196·2	10·181
Thallium...........	11·86	203·6	17·167
Mercury, liquid......	13·598	200·0	14·708
" solid........	14·39	....	....

It will be seen that not only is the atomic weight of mercury the mean of that of gold and thallium, but its specific gravity in the liquid state is very nearly the mean of their atomic volumes; and its own atomic volume is almost exactly the theoretical specific gravity of an alloy formed of equal weights of gold and thallium, the calculated specific gravity being 14·68, which is only 0·29 in excess of the specific gravity of solid mercury.—*Oil, Paint, and Drug Reporter.*

TWO NEW ALLOYS OF ALUMINUM.

M. BOURBOUZE has formed an alloy of 45 parts of tin and 55 of aluminum, which answers for soldering aluminum. This alloy possesses almost the same lightness as the pure aluminum and can be easily soldered. M. Bourbouze has invented another alloy containing only ten per cent. of tin. This second alloy, which can replace aluminum in all its applications, can be soldered to tin, while it preserves all the principal qualities of the pure metal.—*Revue Scientifique.*

DETECTION OF ALCOHOLIC ADULTERATION.

ONE method of detecting the presence of alcohol, with which ethers and essential oils are adulterated, in Germany, is the following. A glass graduated tube is filled to a certain point with the ethereal oil, and to it is added a certain quantity of concentrated anhydrous glycerine. The tube is corked and the mixture is violently agitated, and then is left some hours in repose. Glycerine, like pure water, dissolves alcohol, but not ethers. Thus the increase in volume of the glycerine, if any occurs, is due to the alcohol which it will have taken up, and this volume will be proportional to the quantity used in adulterating the ether. For essential oils, in place of glycerine distilled water equal quantities is employed, whose increase of volume, after agitation in the graduated tube, will indicate the presence of alcohol.—*Revue Scientifique.*

POLISHING FINISHED SURFACES.

OIL is usually employed for polishing delicate instruments, which tends to soil those using them. Oil may be advantageously replaced by a mixture of three parts of glycerine and one of alcohol for large surfaces. When small ones are to be treated, pure glycerine can be used.—*Revue Scientifique.*

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Scientific American Supplement.

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