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LOEB'S RESPIRATORS.

AMONG the various apparatus used in the extinction of fires that have been brought to the notice of the public, the respirators and their accessory appliances invented by Mr. Bernhard Loeb, Jr., of Berlin, undoubtedly take a front place. We say this advisedly because, in recent experiments which we witnessed, their exceeding usefulness and practical value were fully demonstrated. The respirator experimented with is chiefly intended for use on board ship or elsewhere in case of fire, to enable firemen and others to work in any confined space where dense smoke or noxious gases render respiration difficult or impossible, but it is equally applicable in mines or factories where poisonous gases prevail. It was with a view of showing its advantages in the case of fire that a series of trials was carried out on Friday, August 12, in a boiler shed in the Victoria Docks, placed by the London and St. Katherine's Docks Company at the disposal of the demonstrators, Captain Fairholme, R.N., and Mr. J. Salomon, the representative of the patentee in this country. There were present Mr. J. Thomas, Assoc. M.I.C.E., the resident engineer of the company; Mr. M. Adamson, Assoc. M.I.C.E., assistant engineer and manager of the workshops; and Mr. G. Hamilton, chief of the police department and fire brigade of the docks, with some of his men. Before proceeding to give an account of the experiments, it will be best to describe the various forms of the respirator and accessory apparatus, in order to convey to the reader a fair idea of their action.

Fig. 1 represents a perspective view of a respirator for firemen, and Fig. 2 is a section of it. The respirator consists of the square breathing chamber, M, Fig. 2, provided with the three respirating valves, N, and the aspirating valve, O. The breathing chamber is connected by the perforated partition, L, with the two cylinders, C and G. At P is the India rubber mouth piece, Q, provided with the two India rubber clouts, Q_1. The cylinder, C, has on its periphery the two chambers, A, one of which is shown in the engraving, and which are filled with loose cotton wool, and then closed. The chamber, E, contains small pieces of sponge wetted with water before use, and the cylinder is then closed by a fine sieve. The cylinder, G, contains a layer of dry cotton wool, K_3, a layer of cotton wool sprinkled with glycerine, K_2, a layer of dry cotton wool, K_1, a layer of dry animal charcoal, J, and again a layer of dry cotton wool, a layer of cotton wool sprinkled with glycerine, and a layer of dry cotton wool, H_1, H_2, and H_3, respectively. It should be observed that the two chambers, A, of cylinder, C, are filled with loose cotton wool, while the layers of cotton wool in cylinder, G, are put in the receptacles holding them. After filling, the cylinder, G, is closed air tight by the screw nut, N_1. Cylinder G is connected by the air pipe, F_1, Fig. 1, with cylinder C, which pipe ends in cylinder G at H_3.

When the respirator is required for use, the mouthpiece, Q, communicating with the breathing chamber, is taken between lips and teeth, and held by the latter at the clouts, Q_1. In drawing breath, the outer air enters at the openings, A, of cylinder, C, is drawn through the air pipe, F F_1, to H_3, in cylinder, G, then passes through the several layers of cotton wool and charcoal and the sieve, L, to the breathing chamber, whence it enters the mouthpiece through the three respirating valves, N. By means of the filling materials used, the air is successively cooled, moistened, and freed from the black flocculent matter of smoke, dust, and injurious gases. In order to prevent air being inhaled through the nose, the latter is closed by the clip illustrated in Fig. 4 or by the capsule shown in Fig. 5. To protect the eyes, the spectacles illustrated in Fig. 3 are put on. They are cushioned with India rubber, and held to the eyes by a strap passing round the head. The glass in front is removable, and may be adjusted to suit the sight of the wearer. The respirator is provided with the whistle, S, Fig. 1. If a signal is to be given, by pressing the button, S_1, the whistle is brought into connection with the aspirating valve, O_1, and is sounded by the pressure of the expelled air. A signal may also be given by pressing the India rubber bag, *d*, which ends in a whistle.

If a strange place filled with smoke is entered by the fireman, to enable him to find his way back, the rope, *g*, is attached to the hook, *f*, of the belt, *e*, worn by the fireman. Fig. 6 represents a man perfectly equipped with the respirator and accessories. The respirator is partly held by a strap passing round the neck. The weight of the respirator, unfilled, is a little over a pound, but it is now being manufactured of aluminum, and its weight thus reduced to 4 oz.

Should it become necessary to enter a room filled with specially dense smoke or poisonous gases, the apparatus shown in Figs. 7, 8, 9, and 10 is used. It is useful more particularly in mines filled with firedamp, in sewers full of foul air, in ice manufactories where an escape of ammoniacal vapors has taken place, in chemical factories, and other establishments where noxious fumes prevail. Fig. 7 shows a respirator specially constructed for the purpose. The breathing chamber, A, is provided with the three respirating valves, *d*, and the aspirating valve, *i*. At *e* the breathing chamber is connected to the hose, *f*, and is closed by the screw nuts, B and *h*. The India rubber mouthpiece, C_1, is constructed like that already described. The respirator is likewise provided with a signal whistle. The hose, *f*, leads to the purifying apparatus, which is carried suspended by a belt. It has a sieve at *a*, through which the poisonous air enters, and which is collected in the space, *e*. The bottom of the latter is perforated by the small pipes, *i*, which lead through another perforated partition to within a short distance of the lower portion of the apparatus. This portion is filled, through the socket piece, *g*, with water, or, if the respirator is to be used in spaces full of poisonous gases, with a suitable chemical solution, which deprives them of their injurious constituents, and, after passing through the various fillings of the breathing chamber, similar to the respirator just described, renders them fit for inhaling. Fig. 9 represents a man equipped with the apparatus, while Fig. 10 shows another provided with a respirator and hose to be used in mines, the open end of the hose leading into those parts of the workings where the atmosphere is free from noxious gases.

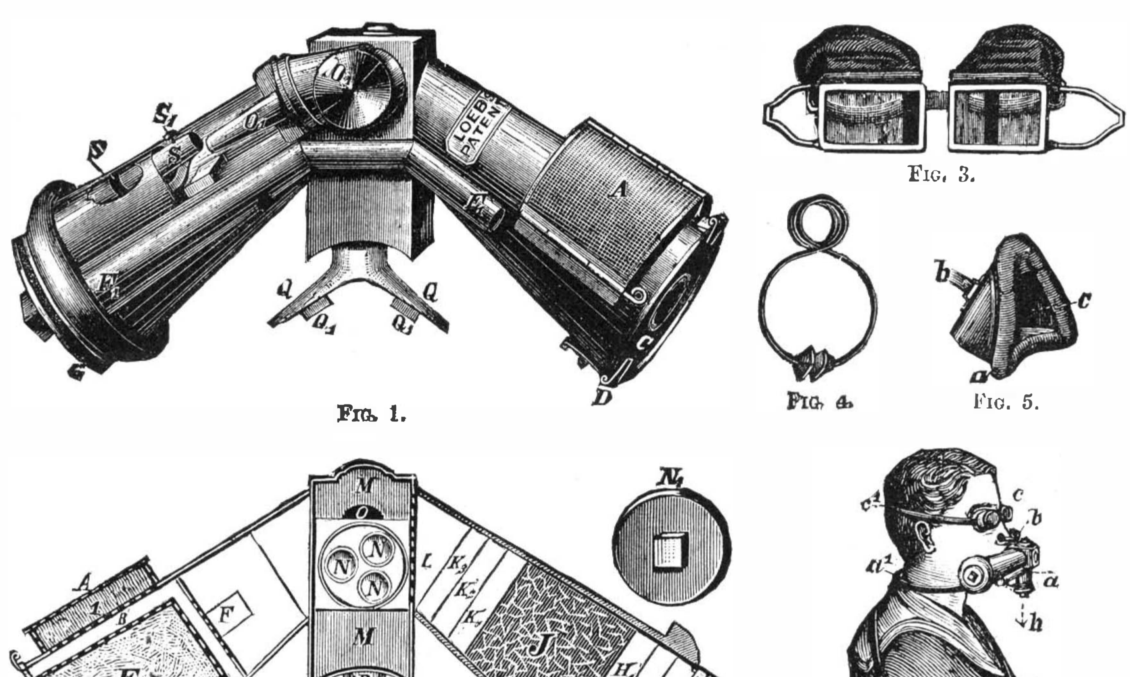


FIG. 1. FIG. 2. FIG. 3. FIG. 4. FIG. 5. FIG. 6. FIG. 7. FIG. 8. FIG. 9. FIG. 10.

RESPIRATORS FOR SMOKE AND GASES.

We have sufficiently described the respirator to explain its action to the reader, and we now proceed to give a description of the instructive experiments carried out at the Victoria Docks. The exits and other openings of the boiler shed used were carefully closed and stopped up, and a fire kindled, emitting a most stifling smoke, the latter being rendered more dense by sawdust and other refuse being thrown upon it. When the smoke was at its densest, Fireman Maidman, of the dock fire brigade, equipped with respirator, nose clip, spectacles, and auxiliary whistle, entered the shed, and remained in it for fully half an hour. He only came out when ordered to do so, and declared, on being closely questioned, that he was not in the least inconvenienced by the stifling smoke—in which Inspector Hamilton, who entered the shed also, but unequipped with the respirator, could stay no longer than one minute—and that he would have been able to stay any length of time.

Fireman Nelson next entered, and remained twenty minutes, when he was called out. He, likewise, declared his willingness to stop as long as desired. Inspector Hamilton and Mr. Adamson also entered the shed equipped with the respirator, and expressed themselves equally satisfied with its action. Other firemen of the docks company also tried it, and found it efficacious. The final test was made with the respirator adapted for use in mines, to which was attached a hose leading into the open air. A sulphur fire was lighted, and, when well developed, a man entered, and remained for some time in the shed, without inconvenience or injury, his regular breathing being distinctly audible at the open end outside. The officials of the company present were perfectly satisfied with the action of the respirator, which to them appeared eminently useful in extinguishing fires in ships' holds, where, it is well known, the smoke is of the most stifling description, and where, moreover, as remarked by Inspector Hamilton, the men have to find out where the fire really is, so as to prevent the wholesale destruction of cargo by indiscriminate use of water. In this connection we should not omit to mention a new portable electric lamp, which would prove useful in searching for the origin of a fire in a ship's hold, and which was also tried at the experiments, and found to answer.

Our own impression is that the respirator is a most

valuable invention, and that its use by the fire brigades of this country can only be a question of time. We would likewise commend it to the attention of the admiralty authorities, by merely pointing to the remarkable achievements on Friday last. The invention is of equal importance to mine owners, and we trust to see the time when every mine is provided, not with several sets, but with a large stock, of the apparatus. Equipped with the respirators, search parties in mines where explosions of firedamp have taken place would be absolutely safe, and, may be, valuable lives might be saved which now are lost. We may add that the respirator is extensively used in German mines, and is also being ordered by the German admiralty.—*Iron.*

THE ELEVATED RAILROADS OF NEW YORK.

BELOW will be found some statistics of the Manhattan Railway Company, which operates the elevated lines in New York City. The facts are not new or startling, but, nevertheless, are, in many respects, worthy of note as showing the arrangement and system necessary on a double track road which is worked up to somewhere near its ultimate capacity, and the variety and multitude of workers that can be concentrated on thirty-four miles of road. Many of the regular aristocracy of American railroaders look somewhat contemptuously on the elevated, and deem it, along with the horse railroads, as beneath their notice. It is, to be sure, prevented by circumstances from running trains at high speed, and in the line of heavy trains and variety of traffic it cannot boast of great things, but it is not to be laughed down, and the railroader who thinks he has nothing to learn from it, or that a cheap order of talent can successfully manage it, has made a mistake. The enormous amount of business done would tax a road much more favorably situated, and the fact that certain circumstances render the work easier than it would be on an ordinary road does not weaken the conviction that the latter can here learn much better than anywhere else a great many things about the best way of doing their own work. The elevated has more employes than the New York, New Haven, and Hartford, and has nearly ten times as many per mile as the New York Central, and in several departments has a list of spare or supernumerary men larger than the regular force on many roads of considerable importance.

LIST OF EMPLOYES IN MAINTENANCE OF WAY DEPARTMENT, MANHATTAN RAILWAY.

Engineer's Office.

Chief engineer	1
Assistant engineers	2
Miscellaneous	5
	8

Department of Building Repairs.

Foreman building repairs	1
Carpenters	32
Pipe felter	1
Lamp trimmers	2
Repairs, meters, etc	1
Miscellaneous	37
	74

Roadmaster's Department.

Roadmaster	1
Assistant roadmaster	1
Track foremen	10
Track repair men	110
Track walkers	15
Track carpenters	6
Yardmen	13
Night trackmen	11
Night track foreman	1
Drip pan cleaners	4
Lamp trimmers, switch and signal	3
Riveters	81
Inspector rivets and girders	6
Charge interlocking switches	16
Watchmen	3
Switch watchmen, interlocking	12
Pipe fitters	13
Painters	33
Miscellaneous	26
	365

Department of Street Repairs.

Foreman street repairs	1
Laborers	21
Mason	1
Pavers	2
	25
Total M. W. Dept	472

GENERAL TICKET DEPARTMENT.

Agents, regular	291
Agents, regular, extra	1
Agents, irregular, extra	19
Clerks	13
Collectors	5
Examiner of accounts	1
Gatemen, regular	300
Gatemen, irregular, extra	122
General ticket agent	1
Platform men	70
Porters, regular	112
Porters, irregular	20
Station inspectors, day	4
Station inspectors, night	3
Reserve inspector	1
Miscellaneous	15
	978

TRANSPORTATION DEPARTMENT.

Car couplers	62
Conductors, regular	258
Conductors, irregular	18
Dispatchers	22
Flagmen	26
Guards, regular	605
Guards, irregular	133
Hand switchmen	54
Superintendent	1
Telegraph operators	31
Tower switchmen	72
Trainmasters	2
Assistant trainmasters	3
Miscellaneous	35
	1,322

MECHANICAL DEPARTMENT.

Blacksmiths	20
Boiler makers	15
Carpenters	52
Car cleaners	152
Car inspectors	77
Coal tenders	71
Engine dispatchers	5
Engine inspectors	5
Engineers, regular	353
Engineers, irregular	18
Firemen, regular	365
Firemen, irregular	43
Engine hostlers	64
Engine wipers	59
Lamp trimmers	51
Machinists	99
Machinists' apprentices	7
Master mechanic	1
Painters	48
Pipe felters	2
Road foremen	2
Stationary engineers	28
Water tenders	22
Miscellaneous	255
	1,814
Total in all departments	4,586

MAINTENANCE OF WAY DEPARTMENT.

The first table shows the employes in the road department. The work of this department has been heretofore referred to in these columns, and its remarkable performance in rail renewing will be recalled by our readers. The officers naturally have constantly in view further progress toward perfection, and the record of a few years ago has been improved on. With a gang of eighteen men, sixty rails have been renewed in 70 minutes, those taken out weighing 50 and the new ones 70 pounds per yard. Eight men lift in and out, four pull spikes, two adjust the joint fastenings, and there are four spikers. The guard timbers, which, as every one knows, extend the whole length of the road on both sides of each rail, are from four to six inches higher than the rail, and blocks that just fit between the rail and the timber are kept always at hand, so that if an approaching train comes up a few seconds earlier than it is expected, the track can be made solid and safe (the maximum speed being 25 miles an hour) *without spiking.* On the inside of the rail the spikes are not drawn, so that the blocks are always placed on the outside, where the wheel flanges will not be interfered with. A frog and the two sharpened rails for a switch are put in, on occasion, in 3½ minutes. This is about the maximum time between trains in the day time. The perfection of the system and the satisfactory manner of its working may be inferred from the fact that on the Ninth Avenue line, where no trains are run at night, the track work is all done in the day time, the same as on the lines where trains run all night. The unloading of rails, which is made wholly automatic by means of rollers and an inclined plane at the end of a platform car, is done for a long stretch of track between two passenger trains, which are only four minutes apart, and without halting. The Fisher joint has been tried for about two years, and has been in use on a mile of the Sixth Avenue line for a year. It gives very satisfactory results.

The reader will readily guess that this sort of work, all done on a narrow bridge, is not accomplished with a gang of the ordinary kind. The forces are not recruited from passing tramps or the refuse that have been rejected as farm hands. Applicants are rigidly examined, and no chances are taken. Men who are too old to learn or too young to be cautious, or whose health or habits are likely to cause trouble, are rejected.

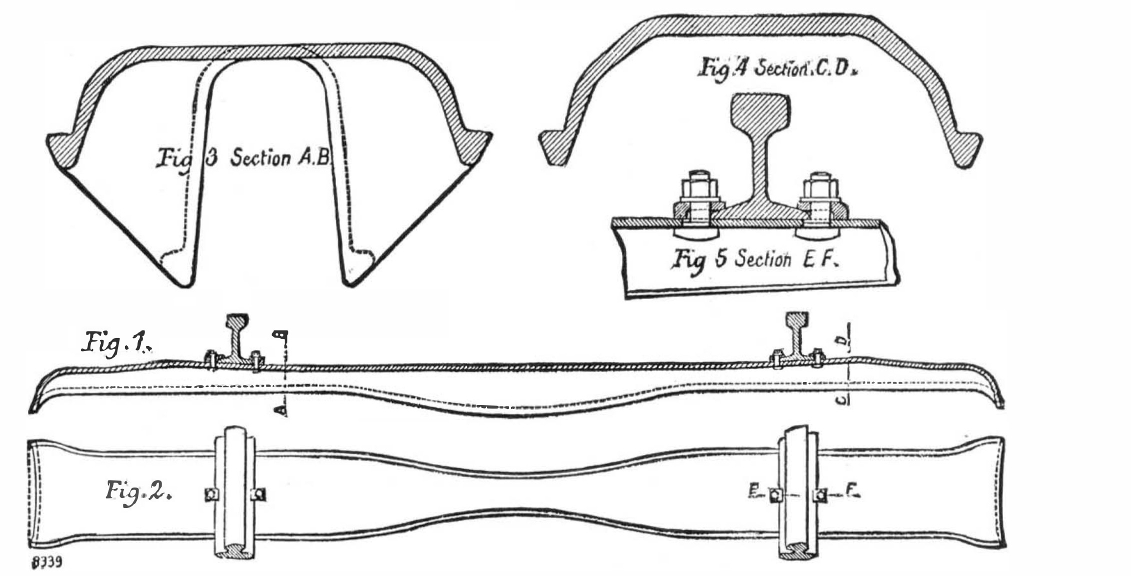
They receive $2 to $2.25 per day, and generally take an interest in the work, and look for promotion. It is a rule that each man must look to his own safety; with such numerous trains no other would be practicable. Carefully arranged "civil service" rules have to be observed even in this department. Before being a foreman, a repairman must have served as a "floating trackman," so as to become acquainted with other sections than his own; a track walker for a year; a yardman (looking after switches, lamps, etc.) for a year; a sub-foreman; and have an experience of six months with the "structure gang" which attends to the iron work below the sleepers. All the men are under strict supervision, it being possible at any time, day or night, to communicate from the road master's office to any man on the road within ten minutes, two daily reports being made by each foreman. This strictness is not maintained, however, by a rod of iron, but by the more sensible method of treating the employes like intelligent men. Slight lapses are not severely punished, and any reasonable request for a short absence is freely granted, time being "docked" only where there is a real necessity for it. All the men working by the month have a ten days' vacation in the summer without a deduction from their pay. As noted above, the roadmaster's office is open day and night, and, as will be seen by the list, a force of men has to be on duty on the road all night as well as through the day. If an interlocking machine gives out in any part, the "yardman" must be prepared to act in conjunction with the towerman without the least delay.

Canvas covers are used to obscure the signals whenever they have to be disconnected, and the trackman has to act as a flag signaler for the towerman until the apparatus is restored. The Manhattan has fourteen wrecking outfits, besides a large amount of material and tools for use on the street level in changing foundations, etc. This latter is an important department in itself. There is always more or less building and excavating going on which endangers the foundations of the columns, and the six inspectors who are constantly patrolling the road have to keep a vigilant watch for contractors' and builders' operations of all sorts, besides attending to their regular duty of watching the iron work. The latter has on the Third Avenue line alone about 2½ million rivets. The high state of perfection in which the track is kept is not wholly on account of the great train mileage, but is necessitated also by the ill effect on these rivets of any undue jar. A worn frog will be safe even for the immense traffic of this road for a year or two after the pounding is serious enough to make constant trouble for the structure inspectors.

As is well known, the trackmen have to keep themselves supplied with danger and caution signals, so as to act as signalmen to the trains in case of fog. The trains being all run as though in a yard, that is, with no rights to the road at any point except as far as the runner can see ahead, renders the use of an ordinary system of block signals of doubtful availability, as with very frequent trains many of them have to be run "under control" for a large portion of their whole trip. The principle on which the "fogmen" work is to double the length of view of the runner; assuming that a train or flag can be seen 400 ft. distant, the man, when a passing train has gone out of sight, signals "all clear" 400 ft. in the direction of the following train, so that the next engineman is assured of 800 ft. clear road, which often is all he wants. In very dense fogs the man can only advise runners as to the time elapsed since the passage of the preceding train. On the curves and most important portions of the road, simple distant signals worked by hand are provided, so that the man can show either "danger" or "clear" about 500 to 800 ft. in advance of where he stands. These signals must not be distant from the lever by which they are worked much farther than a man can see (in the fog) plus the length of a train for if they were there would be a possibility of the man's showing "all clear" while a train was yet between him and the signal, there being no telegraphic connection between the men.

The thirteen pipe fitters are engaged upon the drain pipes of the drip pans. Of these latter there are about 500, to prevent the dripping of water into the street from steam pipe connections and from engines. These pans average 8×40 ft. superficial area. Of the large number of riveters most are engaged upon new work, girders for middle tracks being in process of erection for considerable lengths on the Third Avenue line. Pipe felters look after the coverings of the water cranes, these being all heavily packed to withstand the frosts of winter. As noted above, the twenty-five men in the street repair department are constantly engaged in putting up and taking down trestles, resetting foundations and other work necessitated by abutters' operations.

There are on all the lines over 400 switches and 20 towers with interlocking machines.—*Railroad Gazette.*



THE HOERDE STEEL SLEEPER.

STEEL RAILWAY SLEEPER.

SEVERAL peculiar features distinguish the Hoerde steel sleeper, shown in the above illustration, from those of other systems. The inclination of 1 in 20 required for the rails is produced direct in the process of rolling, while at the same time additional strength and durability are imparted by increased thickness of metal at the inclined portion, as compared with other points. The middle part of the sleeper is made considerably narrower than usual, but is increased in depth, as shown in the illustration, so that the base toward the center is diminished.

Those parts most liable to strain and wear are strengthened by being made extra thick, while the

other portions may be reduced in thickness without detriment to the efficiency of the sleeper. Owing to this judicious distribution of material, by which the metal is placed where it is most required, a sleeper is produced of 10 per cent. less weight, as compared with one of the ordinary pattern of uniform section, while at the same time possessing equal strength with the latter.

The increased depth of the middle of the Hoerde sleeper offers greater resistance to bending than where the depth is uniform, so that any considerable deflection and widening of the gauge become almost impossible even with imperfect ballasting. To demonstrate this a series of comparative tests were made between a Hoerde and a standard sleeper, both being of similar weight and being of the pattern used on the Dutch railways. They were each supported at the center and loaded at the rails. The tests commenced with a load of 6,062 lb., the increase of gauge being 0·18 in. for the Hoerde and 0·37 in. for the other. With 7,275 lb. the standard sleeper failed, the gauge spreading 1·18 in. and a permanent set of 5·19 in. being left. The Hoerde sleeper had its load increased in five stages up to 12,125 lb., by which time the increase of gauge had risen to 0·38 in., of which 0·08 in. was permanent, and a permanent deflection of 0·16 in. had been set up. In short, the Hoerde sleeper bore 12,125 lb. without injury, while the standard sleeper failed completely with 7,275 lb.

Another advantage, arising out of the contraction of the middle portion of the sleeper consists in a greater resistance to creeping and in the impossibility of any ballast spreading toward the middle. This prominent defect in laying down a line is at once got rid of by the new form. The workman is, in fact, compelled to pack the ballast only where it is required, under the rails. There are thus two separate spaces for ballast formed, which prevent the latter from being forced by the traffic toward the center.

The cost of the Hoerde sleeper per ton is about the same as that of the ordinary pattern, while the saving effected in weight gives the former a decided advantage. The Hoerde sleeper is being used in considerable quantities on the following railroads: Dutch State railways; German State railways, Magdeburg, Rhine Railway (right bank), Altona, Frankfort-on-the-Main, Erfurt; military railway at Schoneberg, near Berlin; Imperial lines in Alsace and Lorraine; Pfalz railways; and on several lines in France and Belgium.

It is being manufactured in Germany by the Hoerder Bergwerks in Hutten Verein, Hoerde, Rhenish Prussia. —*Engineering.*

HYDRAULIC GOVERNOR BRAKE.

THE object in M. Ulmann's apparatus which is here described is to obtain a uniform speed in a system embracing several machines, however varied may be the demands upon the system of transmission actuated by the motor and employed in driving the machinery. M. Ulmann's machine is especially useful in works where machines of great power have to be suddenly arrested. It re-establishes the equilibrium and avoids the sudden increase of velocity, the natural consequence of such operations.

It is obtained by the apparatus represented in vertical section in Fig. 1, in side elevation in Fig. 2, and in transverse section in Fig. 3. The parts composing it are peculiarly strong and simple, it being a sort of pump with two toothed rotary pistons, *a*, gearing into each other, the axle of the upper piston having a pulley, P, driven by means of a large belt from the main line of shafting of the motor actuating the machinery.

The body, A, of this pump is mounted on a cast iron tank, B, filled with fluid, preferably soap and water; the pistons draw it up through the pipe, *b*, and deliver it by the tube, *c*, cast in one piece with the vertical cylinder, C, also in communication with the tank, so that a continual flow of water would be produced without effective work, were there not in the interior of said cylinder, C, a balanced valve, *d*, designed to regulate the opening through which the water escapes. For this purpose the valve stem is connected by rods, *e e*, working through guides with the centrifugal ball governor, E, arranged directly above it and driven by the beveled gear and band wheel, F.

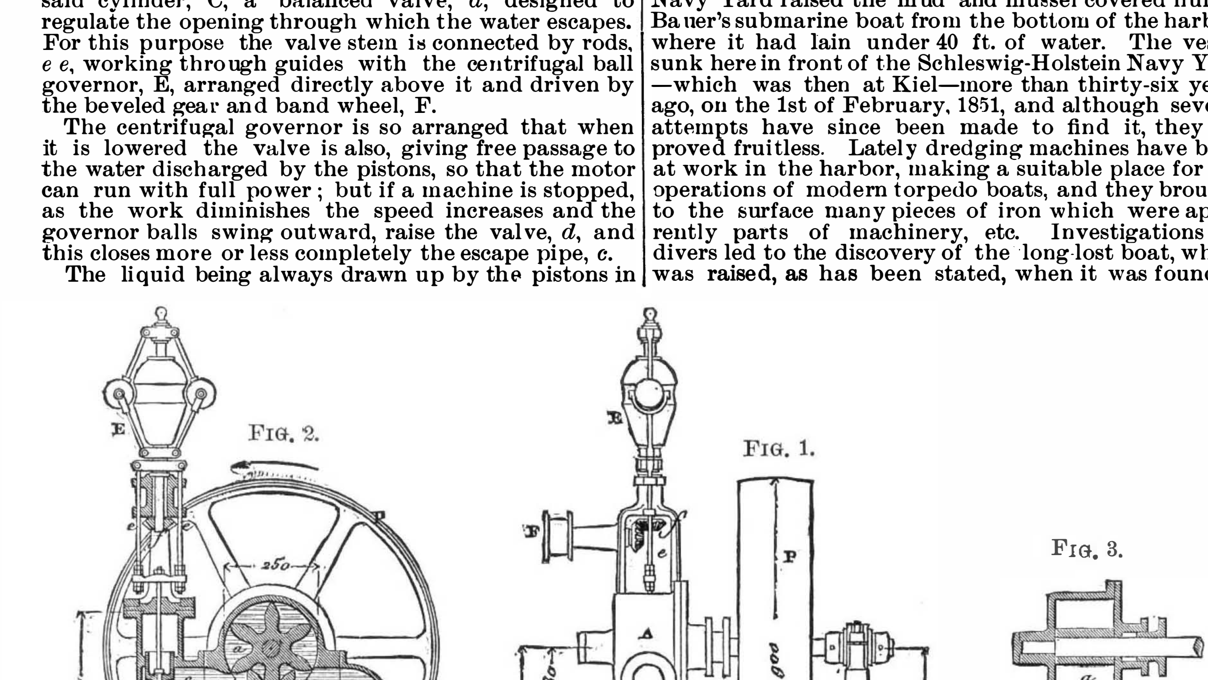
The centrifugal governor is so arranged that when it is lowered the valve is also, giving free passage to the water discharged by the pistons, so that the motor can run with full power; but if a machine is stopped, as the work diminishes the speed increases and the governor balls swing outward, raise the valve, *d*, and this closes more or less completely the escape pipe, *c*.

The liquid being always drawn up by the pistons in equal volume, and not finding an exit proportional in size to the suction pipe, is compressed, thus absorbing a quantity of work greater in proportion as the section is smaller.

It will be noticed that in normal working the governor imposes no work upon the engine; it is only when the speed increases that it absorbs the surplus quantity of work.

It is therefore evidently a true hydraulic brake, which absorbs the motive power formerly utilized to drive the machinery, now inactive; in other words, a portion of the work which the machinery would otherwise have received is employed in overcoming the effort necessary for keeping the pump in action.

M. Ulmann cites an experiment made with the Prony brake on a 20 horse power engine, in which 13 horse power was suppressed without changing the speed. A tachometer (Buss, Sombard & Co.'s system) was used, and the needle of the instrument showed no change, although, when the hydraulic governor was omitted, the speed of rotation, formerly 70 turns per minute, at once ran up to 150 turns.—*Publication Industrielle.*



HYDRAULIC GOVERNOR BRAKE.

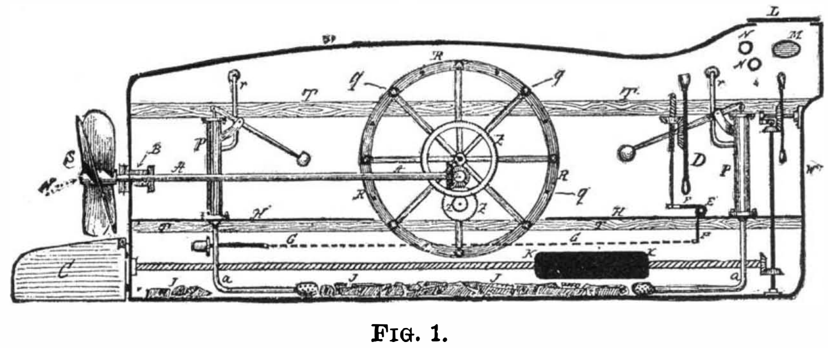


FIG. 1.

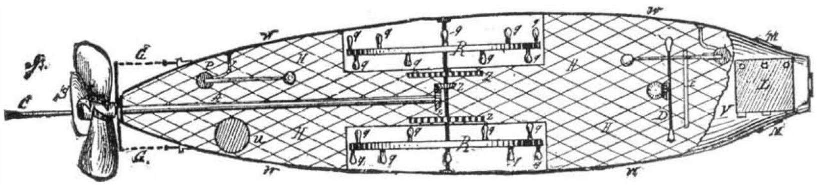


FIG. 2.

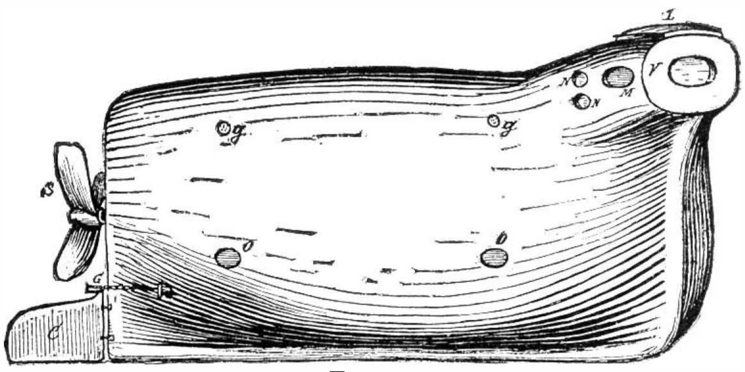


FIG. 3.

BAUER'S SUBMARINE BOAT.

THE RAISING OF BAUER'S SUBMARINE BOAT.

JULY 5, 1887, is a date that will long be remembered at Kiel, for on that day the great crane in the Imperial Navy Yard raised the mud and mussel covered hull of Bauer's submarine boat from the bottom of the harbor, where it had lain under 40 ft. of water. The vessel sunk here in front of the Schleswig-Holstein Navy Yard —which was then at Kiel—more than thirty-six years ago, on the 1st of February, 1851, and although several attempts have since been made to find it, they all proved fruitless. Lately dredging machines have been at work in the harbor, making a suitable place for the operations of modern torpedo boats, and they brought to the surface many pieces of iron which were apparently parts of machinery, etc. Investigations by divers led to the discovery of the long-lost boat, which was raised, as has been stated, when it was found to be badly rusted and much battered by the irons of the dredging machines.

Now that it has been brought to the light again, we can give a description of its construction, which was remarkably ingenious and simple. At the time that the vessel was built, nothing could be learned of the internal arrangements, because Bauer was unwilling to divulge his secret. The boat was closed on all sides, and was built to travel under water for the purpose of securing mines filled with powder to the bottoms of hostile vessels. It was made of sheet iron, was 26 ft. long and about 10 ft. high and 6 ft. wide. From the plan view (Fig. 2) it will be seen that the lines are not unlike those of a modern fish torpedo; a three-bladed screw projects from the stern, while the bow seems rather broad. The side view (Fig. 3) shows what resembles the short compressed hull of a ship, with a rudder and a screw at the stern, while on the upper forward part there is a peculiarly shaped head which is provided with several bull's eyes closed by thick glass. The driving mechanism, shown in Fig. 1, consisted of the following parts: At about the middle of each side wall there was a large wheel which was provided with lugs or projections on its periphery. These wheels, like those of a treadmill, were each turned by a man treading on the projections and holding on to the wheels. The two wheels were mounted on one axle, which extended entirely across the hull and was provided with a cog wheel which operated on gearing by which the power of the tread wheels was finally transmitted to the screw. The latter was of very primitive construction, three spiral blades, similar to those of an Archimedean screw, being wound around the projecting hub. The stuffing box through which the shaft of the screw passed was simply soldered!

The steering apparatus was similar to that used on vessels now. In the bow was the wheel, which, when turned, revolved a screw spindle, and the latter reciprocated a transverse lever with arms from which the rudder chains ran back to the cross head of the rudder. The ballast, consisting of many heavy pieces of cast iron, was placed under the floor, which extended from stem to stern, and the vessel was balanced horizontally by a long heavy weight, *k*, mounted on a screw rod extending the entire length of the boat. When the crew of three men were on board, only a very little of the vessel was visible above the surface of the water.

In the bow, near the bull's eyes, N, were openings, M, closed with rubber, through which the men could operate when securing the mines to the hulls of vessels. When the hatch, L, was closed, the boat could be made to sink by the admission of water, the internal screw valves, O, in the sides, being opened for this purpose, so that the water could collect under the floor, where the ballast was kept. Then two men worked the tread wheels, operating the screw, and thus propelling the boat, and a third man stationed at the wheel in the bow, and keeping watch through the bull's eyes, could see when they approached an enemy's vessel and then, by reaching through the rubber covered openings, could place the mines, which seem to have been hung on the outside of the submarine boat. These mines (torpedoes) consisted of water tight iron casings filled with powder and ignited by an electric spark, being connected by conductors with the interior of the boat. After the boat had retreated to a safe distance, the torpedo could be ignited from the submarine boat, or even from the shore. This mode of sinking ships is quite familiar to us now, but in Bauer's time the idea seemed a very bold one.

When it was desired to raise the boat to the surface again, the water was pumped out, thus lightening the boat and allowing it to rise. For this purpose two pumps were provided, one fore and the other aft.

Bauer's trials of his craft were very successful, and just when his fellow workers in the cause of freedom

were looking to him with renewed hope, he met with his great misfortune, the sinking of the boat, which occurred in this wise: When the boat reached a depth of 30 ft., its thin walls could no longer withstand the pressure of the water, they gave way, and, of course, the water entered so fast that all pumping was in vain, and the boat sank in an upright position, in 40 ft. of water. The crew was rescued.

The boat now lies on its side in the dock, its head (bow) torn off, and a hole in the deck offering an entrance to the interior, where the misshapen pumps, the parted rudder chains, and the broken beams and machinery are dimly visible. For the sake of its historical value the submarine boat will be reconstructed in all its parts and removed to a suitable place, where it will be preserved as the first link of the chain of submarine warfare, and as a memorial of the bold and courageous work of a patriotic man.—*Illustrirte Zeitung.*

THE GAS BALANCE: AN APPARATUS FOR THE AUTOMATIC DETERMINATION OF THE SPECIFIC GRAVITY AND COMPOSITION OF GAS.

By FRIEDRICH LUX, of London.

IN order to determine the specific gravity of gas, we have hitherto, in practice, resorted to the following four methods:

1. The direct method of weighing.
2. The aerostatic method.
3. The effusion test of Bunsen.
4. Recknagel's manometric test.

Upon each of these I purpose making a few observations.

1. *The Direct Method.*—You are aware that in this process a hollow vessel is weighed by means of a very sensitive scale, first in the exhausted state, afterward when filled with air, and lastly when containing the gas to be examined. The specific gravity of the gas is then ascertained by dividing the weight of the air by that of the gas. It is a well known fact that this, the oldest method (employed in the first place only for scientific purposes), was simplified by Dr. Letheby, who provided the vessel destined to serve as the receptacle for the gas with orifices opposite each other, and which can be closed by means of stop cocks. Thus the labor attending the evacuation was effectually avoided. The weight of the exhausted vessel and of the air contained in it under a normal temperature and pressure is once for all fixed, and the figures are marked on the outside. Consequently, in using this apparatus, all we need do is to expel the air by the inflowing gas; thus necessitating but one operation of weighing.

2. *Wright's Aerostatic Method.*—According to this method, a balloon of a fixed capacity (commonly one cubic foot) is filled with the gas intended for examination, and a saucer suspended from the balloon is loaded until the tendency of the balloon to rise is exactly neutralized. It will thus be found that the difference between the sum of the weights represented by the balloon, the saucer, and its contents and the weight of the air displaced by the balloon represents the weight of the gas contained in it; and this result divided by the weight of the air which has been displaced shows the specific gravity of the gas experimented upon.

3. *Bunsen's Effusion Test.*—This test is based upon the fact that if gases are expelled under the same pressure through a small aperture made in walls of minute thickness, the squares of the velocity of expulsion are in inverse ratio to the specific gravity of the gases. The method based by Bunsen upon this principle, and devised chiefly for the purpose of determining the specific gravity of small quantities of gas, has been further developed by Schilling and Bowditch, who, by means of specially devised contrivances, have made the apparatus accessible to the public generally, and particularly to those who are interested in the manufacture of lighting gas. With this no doubt all present are well acquainted.

4. *Recknagel's Test.*—This, the last of the methods to which I have alluded, may be known to but few among you. It is based upon the principle of communicating tubes, according to which the heights of two columns of liquids are to each other in inverse ratio to their specific weights. The apparatus consists of a brass tube about seven feet long and one inch in diameter, which at its lower extremity is connected with a very sensitive pressure gauge. If the tube is filled with air, the column of the liquid stands at a fixed point of the scale; but the level changes as soon as gas of a different density is introduced. This alteration of the level enables the operator to calculate the specific gravity of the gas.

All these methods, of which only that invented by Bunsen and perfected by Schilling has been brought into general use in Germany, have the serious drawback that they require much time and skill on the part of the operator. Hence, it has for a long time been my endeavor to construct an apparatus by the aid of which the specific gravity of gas may be ascertained in the same automatic way (that is to say, without any further tedious manipulation) in which it is possible to ascertain temperature and pressure by means of the thermometer and the barometer, and the specific weight of liquids by the hydrometer. For this purpose I constructed two years ago the "bareometer," which is based upon the Archimedean principle, and consists of a hydrometer supporting at the top a hollow glass ball hermetically sealed. The whole apparatus is put into a glass cylinder which is partly filled with water, and through which a continuous stream of gas can be conducted by the application of an inlet and an outlet pipe placed opposite each other. It is clear that, according as the specific gravity of the gas passing through the apparatus is greater or less, the glass ball at the top becomes lighter or heavier, and thus the hydrostatic equilibrium is disturbed. The apparatus rises more or less out of the liquid, or becomes immersed in it, and the specific gravity of the gas can be read off the scale placed upon the stem of the apparatus.

I found this contrivance to answer very well for practical purposes, and to give results of sufficient accuracy; but I delayed presenting it to the public from fear that it might be too fragile for ordinary use, and because under certain conditions water or any other liquid would become unavailable for the test. My efforts, therefore, were directed toward the solution of the problem by means of the principle upon which the common lever balance is constructed; and I may say that I accomplished my task to my entire satisfaction in devising the "gas balance."

It will be seen from the diagrams 1 and 2 that the pillar or stand, which is fixed to a solid platform, is divided at its upper extremity into two branches, forming a kind of fork. These branches are provided with conically depressed steel saucers, upon which the beam of the balance is made to rest by means of steel points. The beam consists of a central body, to one end of which is fixed a hollow globe (made of glass or metal), while the other terminates in a tongue, and is provided with a counterweight. From the upper extremity of the central body two narrow tubes are seen to issue at right angles to the plane of oscillation, one of which enters the tube which practically constitutes the continuation of the beam of the balance inside the globe, while the other enters the globe directly through the annular orifice in the central body. These two tubes are bent at their outer ends at right angles in a downward direction, and terminate in small saucers, which, being filled with mercury, constitute an effectual hermetic seal. In order that any solvent action which the mercury might have upon the metal may be counteracted, the ends of the tubes and also the saucers are made of ivory. Through the mercury a small tube enters from below into each of the saucers, and terminates in a joint piece. It will thus be seen that the gas introduced enters through one of the India rubber tubes, one of the saucers, and one of the angular tubes into the globe, thence passing through it systematically, leaving the globe through the tube at the other end, and finally passes through the second angular tube, mercury saucer, and the second flexible tube.

Through both the inlet and the outlet tubes for the gas there are made to pass hermetically two adjusting screws, the points of which, resting in the above mentioned conically depressed steel saucers, constitute the pivots of the whole system. By turning these screws up and down, we can fix the center of gravity of the balance at a longer or shorter distance from the center of motion, and thus we can at will lessen or increase the sensitiveness of the instrument. The arched scale, fixed by means of a coupling rod to the standard of the balance, is furnished with a division suiting the requirements of any special case—for instance, from 0 to 1 for apparatus intended for the determination of the specific gravity of lighting gas—and the extremity of the tongue moves in close proximity to the scale, by which contrivance the direct reading of the specific gravity of the gas under examination is made easy.

The working of the apparatus is very simple and readily understood. If the beam of the balance takes a certain definite position when the globe is filled with ordinary atmospheric air, that portion of the beam which carries the globe will go up or down according as a lighter or heavier gas is introduced. In the adjustment of the apparatus, the counterweight must be so placed that when the globe is filled with ordinary air, the tongue may be exactly at 1, which thus marks the specific gravity of the air. The globe is then filled with pure hydrogen gas (of the specific weight of 0 069), and the point indicated upon the scale marked at 0·07. Afterward, the upper section of the scale is divided into 93, the lower into 7 equal parts. In fixing different distances of the center of gravity from the center of motion, we can make the same apparatus work with a greater or less degree of sensibility; and thus, by making use of different scales, we can employ it for the determination of greater differences in weight with less accuracy in reading, or of smaller differences in the gravity with correspondingly greater accuracy. While, therefore, to mention one example, the specific gravity of from 0 to 1 can be correctly read as far as 0·01, and can be estimated with certainty up to 0·005 it would be possible to read with accuracy the specific gravity (say) between 0·4 and 0·5—the average limits of the weight of coal gas—as far as 0·002, and to estimate it with certainty up to 0·001. This circumstance is of importance, especially in the analysis of gases, which this apparatus (even more than the "bareometer") is intended to effect, inasmuch as, by adopting the course indicated above, the accuracy of the result will be greatly increased.

The densimetric method for analyzing gaseous mixtures, which I have been the first to propose, may be described as follows: We draw from the bulk, according to the usual methods, one component after another, and, in each case, we calculate from the specific gravity of the original, of the remaining gas, and of that which has been withdrawn, the exact quantity of the last mentioned component. In order, therefore, to ascertain x parts, it will be necessary to employ $x + 1$ gas balances, with their respective vessels of absorption inserted between each two. If we call the specific gravity of the original gas submitted to examination

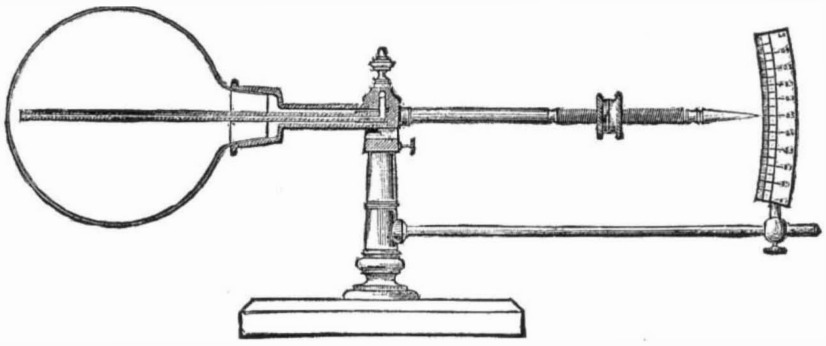


FIG. 1.

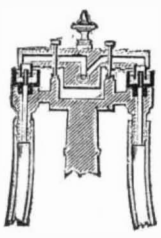


FIG. 2.

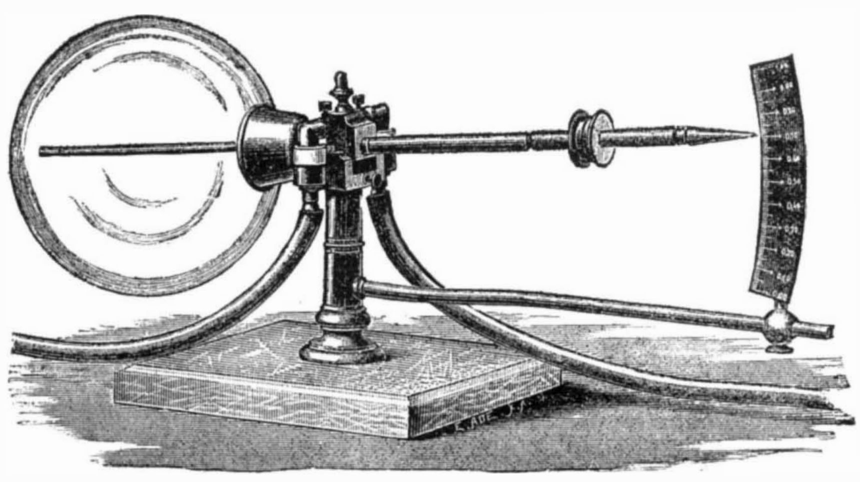


FIG. 3.

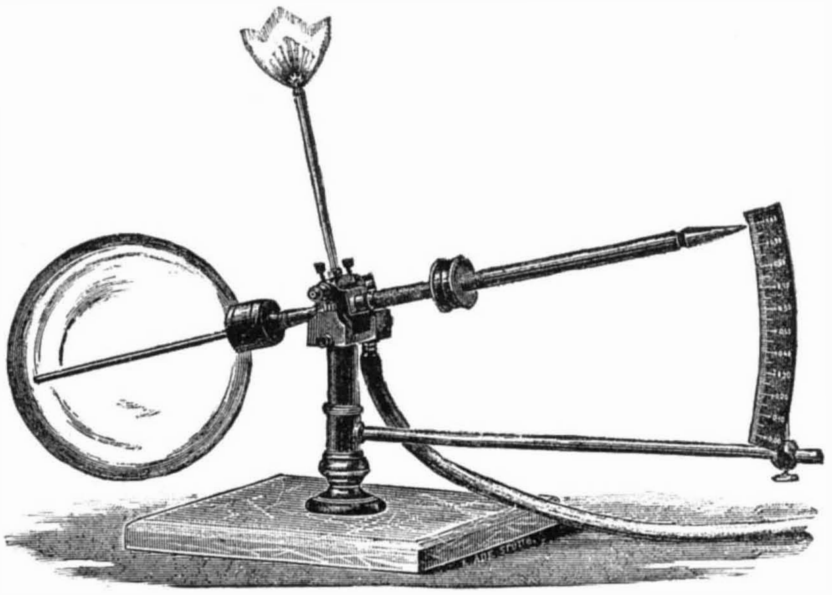


FIG. 4.

THE GAS BALANCE.

S^1, that of the gas drawn off S^2, and that of the remainder S^3, it follows that—

$$S^1 = x\,S^2 + (1 - x)\,S^3$$

and we thus find that—

$$x = \frac{S^1 - S^3}{S^2 - S^3}$$

represents the correct formula for the quantity of the gas which has been withdrawn.

This method offers the one advantage over the other volumetric systems generally in use that the current analysis of certain given quantities of gas can be ascertained, without any manipulation, by the mere reading of the different specific gravities. In proportion as the difference between the specific gravity of the original gas mixture and of the gas to be removed or withdrawn increases, the greater of course will be the accuracy of the results; and according as the gases or vapors which it is intended to remove are easier of absorption, the easier shall we find the application of this method of analyzing different kinds of gases. The favorable coincidence of these two circumstances in a long series of practical cases admits the anticipation of a very varied and wide application of the gas balance.

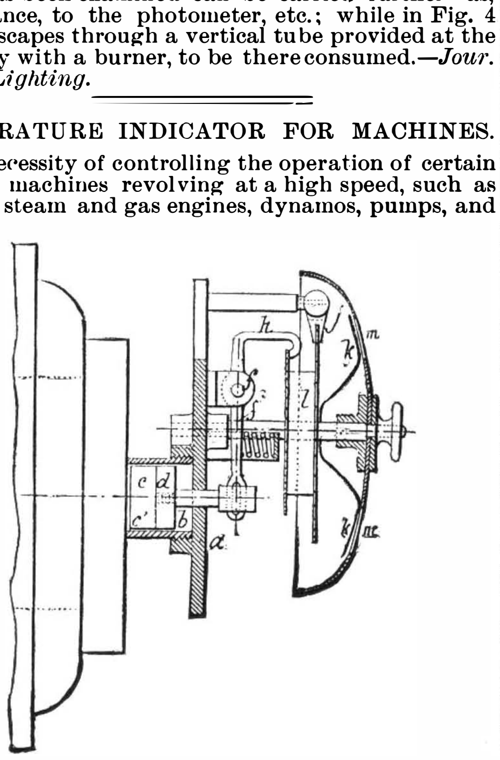
To mention but a few examples of a simple analysis, the apparatus will be found very useful for ascertaining the quantities of carbonic acid in the illuminating gas, in the saturation gases of sugar refineries and of soda manufactories, in heating, generator, and smoke gas, and also the sulphur dioxide in the gases ascending from the grates of blende furnaces, and the quantities of moisture and of carbonic acid in the atmosphere, etc. In a similar manner, it is possible to determine quantitatively two or more of the constituents which enter into the composition of a mixture of gas; for instance, the carbonic acid and carbonic oxide contained in the fire gases and in those which emanate from blast furnaces.

By means of the gas balance we are further enabled to study the incidents in connection with the distillation of coal, of wood, and of mineral oils (in the manufacture of gas), in the combustion and explosion of gases (in gas motors), in the diffusion of gases (air balloons), and in many other operations, in a manner in which hitherto it has not been practicable, and with the result that many points which up to the present time have been obscure may in the near future emerge into the light of certainty.

For the particular purpose of determining the specific gravity of illuminating gas, for which the apparatus was originally devised, I am constructing the gas balance in the two forms shown in Figs. 3 and 4, of which the former is provided with a gas supply and a discharge pipe. By means of this contrivance the gas which has been examined can be carried further—as, for instance, to the photometer, etc.; while in Fig. 4 the gas escapes through a vertical tube provided at the extremity with a burner, to be there consumed.—*Jour. of Gas Lighting.*

TEMPERATURE INDICATOR FOR MACHINES.

THE necessity of controlling the operation of certain parts of machines revolving at a high speed, such as those of steam and gas engines, dynamos, pumps, and



turbines, has long been recognized, and an endeavor has been made to extend such control to parts working under a heavy load and at slight velocity, in order to see that such parts do not exceed the temperature above which their operation becomes bad or dangerous. The apparatus devised for this purpose generally consist of a wheelwork alarm or of an electric bell whose mechanism is thrown into gear by the melting of a substance at a temperature near the limit corresponding to the defective operation.

If but one member of each machine necessitated the application of the apparatus, the acoustic signal would suffice; but such is not often the case, so that, in the presence of a multiplicity of indicators, the engineman cannot easily recognize the part whose bell has been set in motion. Moreover, if he is absent at the moment the alarm rings, there are many chances that the part will continue to heat until manifest deterioration supervenes.

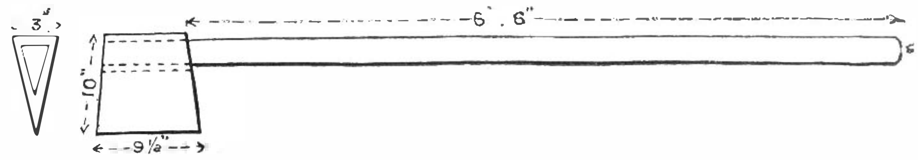
Mr. P. C. Gerboz has invented an apparatus in which an optical indication completes the bell signal. The annexed figure represents in section the apparatus as applied to the extremity of a connecting rod pin. It consists of a metal plate, *a*, fixed to the face of the connecting rod brass by means of clamps. Were it a question of a vertical pillow block, it would be simply inserted in the aperture in the gland. In all cases, the form of the plate corresponds to that of the part that it is to accompany. To the right, the plate carries a wheelwork alarm, the movement and number of movable parts of which vary with the duration and intensity to be given to the acoustic signal. On another hand, it is provided to the left with a small chamber, *b*, in which is placed a fusible pastille, *c*, against which presses a small piston, *d*, thrust by a spring *l'*. Between this pastille and the piece to be controlled is interposed a piece of wire cloth, *c'*, with wide meshes. When the pastille melts, the piston, *d*, advances toward the left at the same time, and the lever, *f*, oscillates around its pivot and lifts the hook, *h*, which in turn frees the hammer, *j*, of the bell.

A double index, K, fixed upon the barrel, *l*, of the bell movement, places itself, after once having returned to its initial position, opposite the apertures, *m*, in the bell in such a way as to indicate the operation of the bell after it has struck. In the apparatus shown in the cut, the barrel is wound up by the bell itself; but it may be arranged in any other way.

It will be seen that, by means of a displacement of the lever, an electric contact might be established for sending a current to a receiver placed in the office of the superintendent or elsewhere.—*Revue Industrielle.*

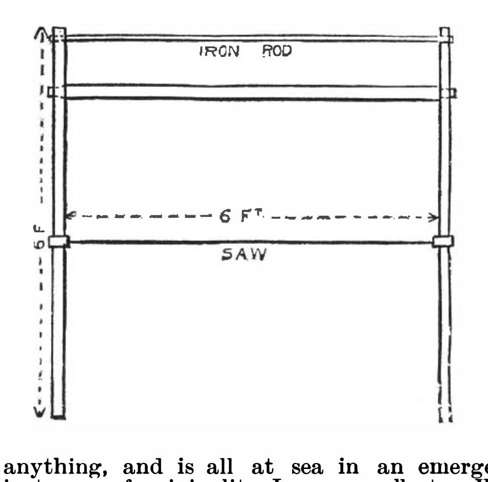
CHINESE PLANK SAWING.

IT has been my fortune at different times to have seen, and taken part in, a good deal of "bush work." I have seen prodigious feats of rude engineering performed by little parties of timber getters in the cedar scrubs of Queensland and the vast timber of the Dandenong ranges, but I never saw means and tools apparently so inadequate to their ends as those of the Chinese sawyers. At Deli, Sumatra, where Chinese labor and a lucky accident of soil have created for the Dutch those tobacco plantations whose astounding profits are the envy of the Far East, saw mills do not exist, and planks must be had. To import them from the



Straits settlements, and cart them at a fearful expense through miles of mud, is not to be thought of, so a gang of Malays or Bataks are hired and proceed to fell the required timber by weeks of laborious hacking. When they have finished, arrives the Chinese "tukang pappan," or plank cutter, with seven or eight brawny Chinamen in cotton jackets and trousers and gigantic rattan hats. They proceed to where the "merban" or "mivanti" lies like a fallen lighthouse, and crosscut the log into lengths of 12 ft. or so, using a European saw, which, when, as is often the case, the trunk is 6 ft. thick where they commence, 30 ft. from the butt, has to be lengthened by strips of iron neatly riveted on, and worked by four men aside. This done, the Chinese tools come into play. If my friends Terrible Billy and Jack the Whaler were requested to undertake a "cedar contract" on the Daintree river with such implements, the reply would be a verbal consignment of the requester to a very tropical region indeed; but the Chinaman knows what he is about. First he mounts the section of log with the axe figured, and swinging it right and left, pendulum fashion, the long handle projecting over his shoulder, chops out a deep notch at intervals of 2 ft.; then beginning again, he splits off the wood between the notches until he completes one side of the square. The log is then rolled over, and the othe sides squared with surprising exactness in the same way. Then a young tree is cut for a lever, and all hands, with as many additional coolies as required, raise the end of the log, packing up as it rises until it is elevated at an angle of 45° on a pile of split stuff.

Lines are marked out with a wet string and charcoal for as many planks as the log will give, and then the sawyer mounts the inclined surface and, single handed, saws from daylight to dark, under rain or sun, with scarcely a pause. The saw is figured here. It varies in length, but is about 3 in. width, with very little "set." The blade is shifted along the handles as the work proceeds until the center is reached, when it is reversed and moved back as it again approaches the side. When all the lines have been cut as far as possible, the other end of the log is elevated and sawn in the same way till the cuts meet, which they generally do to a hair's breadth. The instrument, however, makes wild work in English hands. I once tried it, and in half an hour had nearly liquefied myself without getting more than a foot very irregularly into a 4 ft. square log, while a Chinaman alongside had done over 5 ft. The Chinese have a curious liking for long and unwieldy instruments, and the handles of their bows, bill hooks, etc., are always three or four times as long as those used by Malay or Japanese laborers. They always contrive to get rid of the "dogleg" handles of the American axes supplied them, and replace them with straight sticks. I have had as much experience of the Chinese laborer as most people, and the result of it is that while you can teach him anything except morality, he never origin-



ates anything, and is all at sea in an emergency. One instance of originality I can recollect. While seated in a rickety old steam launch about to start for a 30 mile trip up a river swarming with crocodiles, I overheard the Chinese engine driver explaining the engine to a Malay who was asking the use of the pressure gauge. "Then," said the latter, pointing to the 150 at the end of the scale (the top pin was gone), "when the hand gets there you stop?" "No," said the Chinaman, with a grin of superior knowledge, "*it goes round again.*"

TUKANG BESI.

—*Eng. Mechanic.*

THE SELF-REGISTERING TIDE GAUGE OF R. FUESS.

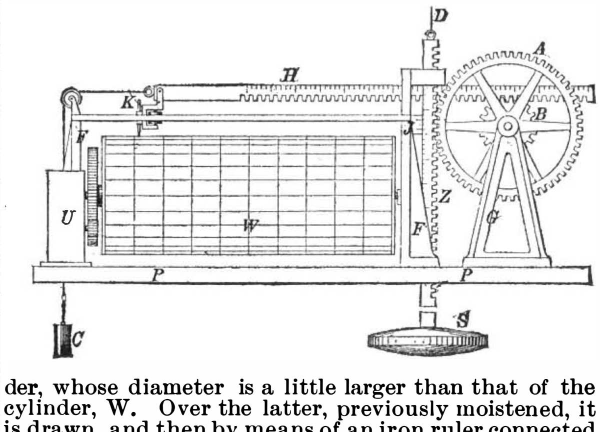
THE two strong side pieces, F F and G, made of metal, along with the clock, U, are firmly screwed to the heavy iron plate, P P. The plate is secured over the tide well, so that its position shall be unchangeable, and so that the opening of the plate, through which the float rod descends into the well, shall be directly over the center of the same. The tide well is in communication with the sea by means of a horizontal tube, and therefore the level of the water in the well varies with that of the sea. The clock, U, by means of a gear wheel placed alongside the dial, turns uniformly once every twenty-four hours the horizontal cylinder covered with paper. Its journals work in the side pieces, F F. The frame, G, standing on the right hand of the base plate, carries the bearing of an axle common to the two wheels, A and B. Both wheels are fixed on the axle, and thus can only turn with it. In instruments set up at Arkona and Marienleuchte, the proportion between their circumferences is such that the number of teeth of the wheel, B, to those of the wheel, A, is as 1 is to 5; in the tide gauge on the Insel Sylt (Sylt Island) as 1 is to 20.

To the float, S, made of copper plate, is attached a brass rod, Z, of rectangular section, divided into teeth according to the metric system (5 mm. to every tooth), which is so guided between rollers that it can have no movement sideways, and can move vertically with hardly any friction. The teeth of this rod engage with those of the wheel, A, and cause it and the wheel, B, to rotate as long as the float, S, following the rise and fall of the water, alters its level. The rotation of the wheels by the rod, H, whose teeth engage in those of the wheel, B, is developed into a right line, and the latter by a lead pencil held in the socket or pencil holder, K, is marked upon the paper on the cylinder, W. An unbroken curve is marked upon the paper, which reproduces the changes of the sea on a small scale, and on which the height of the water can be found for each moment, if the lines of depth and hour lines have previously been drawn upon the paper, and the level of the water at a particular time is known.

The toothed rack, H, sliding between friction rollers, has its teeth cut in metric divisions and is also provided with a scale of centimeters, so as to enable any desired length in centimeters to be shifted to right or left. A weight, C, keeps continually a slight pressure of its teeth on those of the wheel, B, so that no lost motion can exist.

The float rod, Z, is also provided with a centimeter scale, whose origin or zero corresponds with the circular line to which the float is immersed.* A vernier, J, placed near the rod admits of a direct reading of the water level at any time within a millimeter. The rack hangs by a cord, D, which passes over a sheave journaled on friction rollers, which is attached to the roof of the house. This cord carries at its other end a counterweight.

The registering paper has the form of a hollow cylin-



der, whose diameter is a little larger than that of the cylinder, W. Over the latter, previously moistened, it is drawn, and then by means of an iron ruler connected with the cylinder is tightly stretched. This ruler is somewhat longer than the paper cylinder, and is pressed into a longitudinal groove in the cylinder and there fastened. The ruling of the paper is thus executed: After the paper is stretched upon the cylinder, the latter is placed in a wooden frame provided for the purpose, on which is screwed an iron ruler having small notches, and the spring catch found on the side of the frame is stuck through one of the twenty-four perforations found on one end of the cylinder. The first horizontal line is now drawn along the ruler with a well sharpened lead pencil, then the cylinder is turned until the pencil springs into the next hole of the cylinder, and so gives the starting point for the next line. When this is drawn the cylinder is again turned, and after a second catching of the pencil in one of the twenty-four holes a new line is drawn. These lines are marked with the figures of the hours, and the hours of twelve, both night and day, are of course marked 0. After this is done the pencil is removed. The lines of altitude that cross the hour lines at right angles have now to be seen to. The ruler is turned through 180° for this purpose, which brings in front the other edge, marked with the notches. In these notches the pencil is successively placed, and for each placing the cylinder is once rotated. This gives the lines of altitude. In the Arkona and Mairenleuchte gauges the hour lines are 24·5 mm. (1 in.) and the lines of altitude 50 mm. (2 in.) apart. Three little points attached to the cylinder, and which occupy the corners of a right angled triangle, stick through the paper and show whether the lines respectively parallel are at right angles to the axis.

* The depth of immersion of the float is first tested by immersion in water whose specific gravity is equal to the average density of the sea water at the station. At Arkona there is so little variation that the line of immersion only varies half a millimeter.

Each apparatus has two cylinders, which can be used interchangeably with each other.

If the changes in the water level during a day are not great, as is generally the case in the East Sea, more curves of changes of water level are marked upon the paper, generally three, sometimes four or five. The cylinder then is changed only every third or fourth day. But the toothed rod, H, at a particular hour, is moved each day a known number of centimeters from the curve previously drawn. As this can only be done in integral centimeters, the extent of the movement can be daily measured, which provides for the shrinking of the paper. Before removing the cylinder from its bearing, two holes, 400 mm. apart, are made in it with a gauge supplied for the purpose. The interval between these holes is measured later for ascertaining the water level, and the necessary correction of the water level due to drying of the paper can be then ascertained. At the beginning and end of each day's curve the water level as read on the rack, Z, the temperature of the air in the gauge house and in the well, as well as that of the water outside, are noted. By comparing this determination of the water level with the position of the corresponding point of the curve, a control is obtained.

From the temperature observed, the error of the indications which, to a slight extent, are caused by changes in the length of the rack, Z, can be ascertained. The error in the indications which are produced by changes in the length of the bar, H, during twenty-four hours, on account of daily changes in temperature, is very trifling, and in the Arkona and Marienleuchte gauges only amounts to one millimeter.

The changes of the cylinder are easily effected. The lead pencil holder, K, is caught back in a ring near by it, the cylinder is lifted from its bearings, and the other is set in its place. This is turned until the hour lines marked on the paper correspond with the hour as shown by the clock. Then the pencil holder is carefully turned downward, and examined to see if the point of the pencil again touches the hour line. If this is not the case, the holder is raised with one hand and the cylinder is turned slowly with the other until the hour line and pencil point correspond perfectly. By well known apparatus the pencil is so sharpened that its point lies in its axis.

The hourly water levels are ascertained in the hydrographic office from the curves described on the paper. The measuring is performed with a heavy brass rule, whose edge has the reduced scale for the fluid measure used for the North and East seas marked upon it. For the first the scale gives a direct reading to 5 mm. The number of millimeters between 5 and 10 is estimated. An apparatus attached to the rule provides for the correction for drying of the paper to be introduced in each reading.

In the construction of these tide gauges regard must be had to the fact that they have to be used on distant parts of the coast, and therefore they must be durable and so simple in the arrangement of parts for the necessary accuracy of their registry that their use shall be intelligible readily to those in charge of them. The instruments set up at Arkona and Marienleuchte have already worked quite satisfactorily for five years, with a few intervals made necessary by the cleaning of the clock. The same is to be said substantially for the apparatus on Sylt Island.—*J. Asmus, in Zeitschrift fur Instrumentenkunde.*

CENTRIFUGAL EXTRACTORS.*

By ROBERT F. GIBSON.

A CENTRIFUGAL extractor is a mechanical device in which the centrifugal forces generated by revolution about an axis in the particles of any substances mechanically mixed are utilized for the separation of these substances. On this definition is based the following discussion. The subject, embracing all machines which answer the above description, is evidently too comprehensive to be dealt with minutely in the limits of this paper, especially as regards construction. But the aim shall be to explain and illustrate, as concisely as possible, the principles underlying the working; the curious phenomena exhibited in action; the analogies to be drawn with more simple mechanical devices; the considerations and laws governing shape, size, material, etc.; and such other points as may come up incidentally.

A centrifugal extractor consists essentially of a basket, A, which is a receptacle for the substances during the operation; of a spindle, B, which supports the basket and gives it its rotary motion; of bearings, D D, for the spindle; of some method of giving the spindle rotary motion, E; and of a casing, C, which serves to catch the product or products of separation. Fig. 1

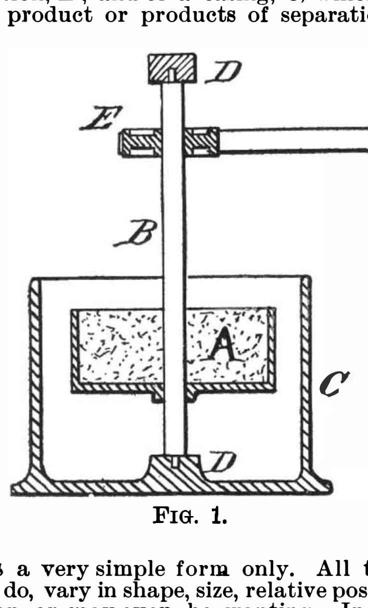


FIG. 1.

illustrates a very simple form only. All these parts may, and do, vary in shape, size, relative position, number, motion, or may even be wanting. In operation, those of the particles in the basket which can escape through the perforations are hurled through; those that cannot must remain, and a separation is consummated. The question naturally arises as to what causes this tendency to escape, and this brings us to a discussion of centrifugal force.

According to Newton's first law, a body tends to move uniformly and in a straight line. Its inertia will resist any change of velocity or of direction of motion. When a body moves uniformly in a curved line, it must be subject to a constant force deviating it from its original path; and as its motion is uniform, this force must act toward the center of curvature. The acceleration of this force at any instant, or the normal acceleration, as it is called, is equal to $\frac{v^2}{\rho}$, v being the linear velocity of the body, and ρ the radius of curvature at that instant. This force is called the *centripetal* force, and the resistance which the body makes to it by reason of its inertia is called the *centrifugal* force. In the case of a circle of radius, r, and with a mass, m, this normal force, and hence its equal, the centrifugal force, is equal to $\frac{mv^2}{r}$.

Let us next find its mechanical effect. Suppose a heavy particle, m, moving in a circle of radius, x, with velocity, v_0, and angular velocity, w. Suppose it to move dx further from the center under the action of centrifugal force. Then, as the work equals the product of the force into the distance through which it acts, we have (E being equal to the work)

$$d(\mathrm{E})=\frac{mv_0^2}{x}dx; \qquad (1)$$

as $v_0=wx$

$$d(\mathrm{E})=\frac{mx^2w^2}{x}dx=mw^2xdx. \qquad (2)$$

Suppose particle to start on circumference of circle of radius, r_1, and cease motion on circumference of circle of radius, r. To obtain mechanical effect between these limits, we integrate between r_1 and r. We have from (2)

$$\mathrm{E}=\int_{r_1}^{r} mw^2xdx=\left[\frac{mw^2x^2}{2}\right]_{r_1}^{r}=\frac{m}{2}(w^2r^2-w^2r_1^2) \qquad (3)$$

If the initial and final velocities are respectively v_1 and v, we have from (3)

$$\mathrm{E}=\frac{m}{2}(v^2-v_1^2) \qquad (4)$$

If the particle starts from the center, we have from (4), as $v_1=o$,

$$\mathrm{E}=\frac{mv^2}{2} \qquad (5)$$

That is, the work which the centrifugal force is capable of performing on a particle varies directly as the *mass* of the particle, and this is the whole secret of the working of a centrifugal extractor.

CLASSIFICATION.—The subject can best be classified with reference to the work to be performed by the machines. We have, then, the following:

Class I.	The separation of	solids	and	liquids.
" II.	"	liquids	"	"
" III.	"	solids	"	solids.
" IV.	"	"	"	gases.
" V.	"	liquids	"	"

Class I. includes by far the greatest variety of applications, and those special applications which have been manufactured and are in use to the greatest extent. The most important division is that of sugar extractors, or, as they are universally called, "centrifugal machines," for there are many times more of these in use than of all the other varieties together. The special reason, however, for beginning with sugar machines is that in them great difficulty has been experienced in bringing to a quiet running and in charging and discharging conveniently. Hence they have been the object of much study and the inspiration of much invention; and in them will consequently be exhibited most of the possible combinations and styles of parts and methods of meeting the troubles and evils which high rotary velocity entails.

It would aid us if, before entering upon a description of the different styles of centrifugal machines and a study of their disturbances, we should look at the laws governing the motions of corresponding *simple* systems of rotating particles. A centrifugal may have two rigid bearings, or it may be suspended by means of, or standing upon, a universal joint, with virtually no other bearings.

To discuss the analogue of the first case, suppose a solid rotating about a fixed axis with accelerated velocity. (This includes the case of a body rotating uniformly.) Let the angular velocity be w, the angular acceleration be k. It can be analytically shown that the direction of the centrifugal force passes through the center of gravity of the body. If the axis is a free axis, the centrifugal force is zero. But let us suppose that it is not a free axis; that is, that it does not pass through the center of gravity. Let one particle, m, of its mass be distant r from the axis.

The centrifugal force of the particle equals

$$\mathrm{C} = m\,w^2\,r \qquad (1)$$

The inertia of the particle equals

$$\mathrm{P} = m\,k\,r \qquad (2)$$

For this latter force may be substituted the couple P—O M, and the force P, acting on the axis. The resulting strain on the axis is

$$\mathrm{R}=\sqrt{\mathrm{C}^2+\mathrm{P}^2}$$

or substituting from (1) and (2), we have

$$\mathrm{R} = m\,r\sqrt{w^4+k^2}$$

Let two co-ordinate planes be passed through the axis. Let the components be found along these planes of the resultant strains of all the particles of the body. Let the resultant of all the components along each plane be taken. Let these two resultants be shared properly between the bearings. Combine again at each bearing, and the pressure at each is found. These pressures can readily be found analytically for a body whose weight and center of gravity are known.

From this we draw that a centrifugal in rigid bearings should have a balanced charge, as the strains on the bearings vary directly as the mass of the unbalanced portion. We draw also that starting up and stopping (*negative acceleration*) should be gradual; for the greater the angular acceleration, the greater the strains.

The analogue of both the second and third cases, in which there is but one bearing, a universal joint, is the gyroscope.* The laws of motion for a solid of revolution moving about a fixed point in its axis of figure analytically deduced from the general equations of rotary motion) show the following facts: that if such a body have its axis placed in any degree of inclination to the vertical, and have a high rotary motion about the axis, it will not under the influence of gravity sensibly fall; that any point in the axis will describe an undulating curve, whose superior culminations are cusps lying in the same horizontal plane; that this curve approaches more and more nearly to the cycloid as the velocity of axial rotation is greater; that when this velocity is very great the undulations become very minute, and the axis of figure performing undulations too rapid and too minute to be perceived moves slowly about its point of support; that the direction and velocity of this gyration are determined by the direction and velocity of axial rotation and the distance of the center of gravity of the body from the point of support. A particular and extreme phase of this motion is exhibited in the theoretical gyroscope—the opposite extreme in the simple pendulum: the former with high velocities and minute and nearly true cycloids; the latter when the velocity is zero; for, when the undulations become larger and larger as the velocity decreases, there are finally but two with cusps diametrically opposite and the arcs of undulation coinciding.

It can also be shown analytically that whenever to the axis of a rotating solid an angular velocity is imparted (in gyroscope vertically downward, due to gravity), a force, called the deflecting force, acting perpendicular to the plane of motion of that axis, is developed whose intensity is proportional to this angular velocity and likewise to the rotary velocity of the body. It is this deflecting force which is the immediate sustaining agent in the gyroscope. The equations of motion show also that however minute may be the velocity of rotation, it is sufficient to prevent the axis of rotation from falling to a vertical position; and however great, it cannot sustain itself without any depression. It should be noted too that motion about the point of support will be exceedingly slow, compared with the axial rotation of the body.

When we take more practical cases, we find that other forces enter. In the toy gyroscope there are mountings, which have weight; there is the resistance of the air, and also considerable friction at the point of support. The weight of the mountings gives the above mentioned deflecting force more work to do, and it can be calculated how much extraneous weight can be sustained with a given velocity. As a result of the friction on the bearing, the axis of the gyroscope, if placed upon starting at an angle above the horizontal. will rise to the vertical; if below, it will fall.

We are now in a position to discuss certain peculiar phenomena observed in the action of bodies revolving about free and fixed axes. When a solid revolves about a fixed axis, the heavy side tends *from* the axis of revolution and produces pressure on the bearings; but when a free body is caused to revolve, the heavy side tends *toward* the axis of revolution and describes the smallest circle, instead of, as in the other case, the largest. The problem is to explain this seemingly contradictory action.

We have seen that with a fixed axis there is an outward radial tendency or pull through the center of gravity. As the centrifugal force acts through the axis and the center of gravity, and as the center of gravity lies on the heavy side, necessarily the latter (the heavy side) pulls on the axis and describes the largest circle.

Now, when a body revolves freely, all its mass moments will arrange themselves instantly about an axis through the center of gravity, causing the heavy side to move toward the axis of revolution. In the first case there is a pull on the bearings. In the second we know that with a free axis the centrifugal forces are balanced, and nothing but an external force can give the axis of revolution angular motion. This is proved by the gyroscope. It is true that deflecting forces are developed, which are very sensible; but they cannot be developed until some external force, such as gravity, gives the axis some slight angular motion.

SOURCES OF VIBRATIONS.—The foregoing theory will enable us to trace the sources of vibrations and gyrations in centrifugal machines and to explain the various methods for meeting the difficulty.

Supposing an unevenly loaded basket in a centrifugal machine with fixed bearings, the observed facts are that there is a jarring; that there are vibrations of the bearings, felt not only in the frame of the machine, but in the whole building; and that there is great wearing of the shafts and bearings. Jarring and wearing are dangerous, and these vibrations have frequently been quite detrimental to the building. Formerly it was necessary to place machines on the first floor, on firm and consequently expensive foundations. Besides this, the waste of power was considerable and the speed was limited.

It has already been shown that there is a strain on the spindle and bearings of an unevenly loaded centrifugal with fixed bearings. This accounts for the wearing. And, as this strain is continually changing its direction, being during each revolution diametrically opposed to what it was an instant before, vibrations naturally follow. Jars are merely sudden periodical overpowerings of the resistance to vibrations of full extent.

Now, these strains and the consequent vibrations can be avoided by allowing the centrifugal to revolve about an axis through its center of gravity, in other words, making it a gyroscope. Here again we must assume the most unfavorable conditions, unbalanced load and accelerated motion. And notwithstanding the fact that we have no strains due to centrifugal force, there are vibrations. Let us see first what has been observed as to the actions of both suspended and standing ma-

* The literature on this subject is very scant indeed. It consists of patent records and stray magazine articles, which are mere descriptions of special machines. There has been no hesitation in drawing freely from the specifications of the various patentees, nor in inserting their drawings. I take especial pleasure in acknowledging my indebtedness to Mr. T. H. Muller, of New York, by whose long experience in designing and manufacturing centrifugals I have been aided greatly.

* Barnard's Am. Journal of Education, vols. 3 and 4. Theory of the Gyroscope, by Maj. J. G. Barnard, A.M., Corps of Eng., U.S.A.

chines: "The axis describes an oscillatory path about a vertical line and will frequently describe small circles, while it moves in said main oscillatory path. When an unevenly loaded machine is in operation, two phenomena are observable; first an impulse or vibration of the shaft, which takes place at each rotation thereof, but is independent of the angular position of the shaft, and second a lurch or gyrating swaying of the said shaft, which may be compared to the traveling of a top in spinning." Standing machines have lurched so violently at times as to do damage and even stop.

In both standing and hanging machines the geometrical axis will describe the surface of a cone. We might expect the vertex of this cone to be at the center of the universal joint, but the mass of the spindle is sufficient to force the geometrical axis and the axis of revolution to an intersection near the center of gravity of the spindle and pulley together. This constitutes a source of vibrations to the pedestal or support, through the bearing. In extreme cases they are transmitted to the building.

It is to be noted that the accelerating force of the charge consists only of its friction on the basket walls. It follows that particles at different distances from the axis of revolution will have different angular velocities and accelerations, and therefore the inner surface of the rotating liquid mass is not a true paraboloid.

Then there is the inertia of the liquid mass against the rim of the basket, evidenced in spilling over.

Now, whether it be due to the above causes or to the jars depending upon the position of the vertex of the cone described by the spindle, or to all, it is a fact that waves, more or less intense, are formed during acceleration, and tend to throw the machine out of balance.

Apropos of this there is a neat analogy which may be drawn, which will aid in simplifying our ideas of centrifugal force. Fig. 3 shows sections of the charge

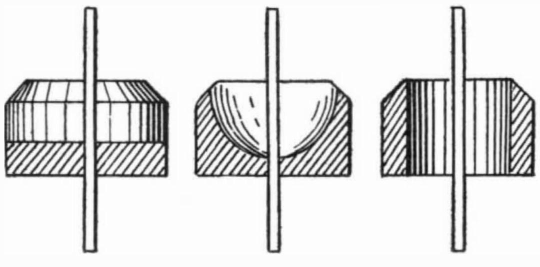


FIG. 3.

(supposed to be liquid) at some point in each of the three periods of rest, accelerated motion, and uniform motion at high velocity. Let us take this latter case. The inner surface of the liquid mass is a cylinder, all the particles being repelled in lines passing through the axis and normal to this surface. Gravity causes the ocean to assume a spherical form, the lines of attraction being all through the center of the earth and normal to its spherical surface. The ocean is broken by waves; and they appear likewise on this cylindrical surface. By old methods of separation, sirup is allowed to drain from the sugar crystals and cream to rise, in both instances gravity being the agent. In centrifugal extractors, centrifugal force performs the same work in an analogous but more complete manner, but whereas the old methods took many hours, the separation is now consummated in a few moments. And so centrifugal force may well be accorded the name of "intensified gravity."

It will be of interest and of use to trace the path of a heavy particle, say of a liquid, from its entrance into the basket to its exit. Let us first consider the particle on the inner surface of a medium revolving with constant angular velocity, that is, relative to the basket the charge is at rest. Suppose the whole system to be at rest, but the centrifugal force still acting. The particle will move, relative to the basket, radially outward—uniformly, if the resistance of the medium is just equal to the centrifugal force; with accelerated motion, if the resistance is less. A case at hand to prove radial path is the action of oil on car wheels.

Let Fig. 4 represent the plan of the basket of a centrifugal. P O N is the curb or casing, C M K is

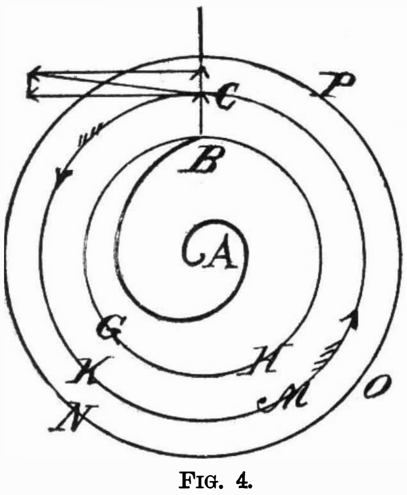


FIG. 4.

the basket wall. Let us start with the particle at A, near the center, it and the whole system at rest. Let the basket begin to revolve with accelerated velocity. We have seen that with uniform velocity the path of the particle is radial. But if it has to assume with each increment to its outward trip an acceleration to its angular velocity, its inertia will resist, and consequently it will lag and its course will be spiral (relative to basket), in a direction opposite to that of the motion of the basket. This will be somewhat exaggerated owing to the fact, which has been noticed before, that the only force tending to produce rotary motion in the charge is the friction on the sides of the basket. Let B G H be the plan of the inner cylindrical surface of the charge at the end of the period of acceleration, when it has the same uniform angular velocity as the basket. At this point in the operation the particle will leave the spiral and move radially outward (B to C). When it reaches the basket wall and escapes, it will have an outward radial acceleration if the resistance has been small enough. But this is very variable. For the sake of discussion, let us suppose this radial acceleration exists. Then there are two forces acting on the particle—the acceleration of centrifugal force and the inertia due to rotary velocity, which acts tangentially to the circular path. The particle will therefore move, by an impulse equal to the resultant of these two, in the direction of this resultant. In most cases of course the resistance, especially that of finding and escaping through a perforation in the basket, is so great that the acceleration due to centrifugal force is zero and the path is a tangent.

The air between the basket and casing has a rotary motion, and, too, a continual current of air is drawn through the machine, both of which would influence the path. It is, however, impossible to take these into account.

To return to the movements of centrifugals. We have seen that a gyroscope, owing to the friction on the bearing, has two positions to which it moves naturally. When it starts above the horizontal it becomes erect, and *vice versa*. So we may conclude that vibrations and gyrations are not due at all to purely gyroscopical tendencies. In fact, the latter would be toward producing even running, though their influence is but slight in any case.

So many forces which, even if we recognize their presence, we cannot measure or trace enter the problem that it is futile to attempt to deduce the theoretical centrifugal. Experience, here as everywhere, is the best guide; though, but for the theoretical study which the subject has received, centrifugals would have been far from their present advanced state of development. "Owing to the constantly varying demands of the sugar industry," says Mr. Müller, "it has been so far for us impossible to deduce any coefficient for disturbing forces, etc., for these machines; and all applications of the calculations for revolving bodies had to be abandoned for certain peculiar materials, since most disturbances which had to be met by the construction of the machine arise from the more or less even distribution of the material in the basket during the period of accelerated motion."

DEVICES FOR MEETING VIBRATIONS.—How are these vibrations, whatever their cause, avoided, or, if allowed, made harmless?

In machines with fixed bearings, if great care is taken in manufacture that every part be perfectly balanced and fitted, and good hands be employed in running, the vibrations can be checked by making the frame very heavy and strong and having firm foundations.

One plan to avoid extreme wear is to have an adjustable bearing above the basket. It is to be firm during acceleration, but when full speed has been gained it is to be suddenly removed. The objection to this is that it requires a skillful operator to detach at the proper moment.

To avoid the vibrations, though with great wear, the basket may be attached to the spindle by a ball and socket joint, or by rubber annuli. The basket may be above both bearings, as in Fig. 5. (The figure

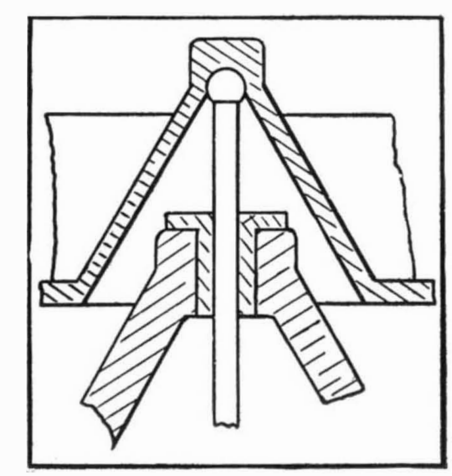


FIG. 5.

is designed to show arrangement, and not proportion of parts.) It may be between them, as in Figs. 6, 7, and 8 (Pat. 335,690—G. Fletcher), or it may be below both, the attachment being the same. If rubber annuli are used, they tend to force the basket to a horizontal running, and thus aid in properly settling the charges. Motion is imparted to the basket either by the friction of the bearing or by means of a feather so arranged as to allow the geometrical axis of the basket motion in vertical planes only. In case the basket bearing is in the plane of the bottom of the basket, radial elastic arms, emanating from the spindle below, serve to support it in case it topples too much.

It might be observed here that the patents cited throughout the article constitute but a small portion of all those that refer to centrifugal extractors. Only representative ones have been chosen for insertion.

Instead of opposing rigidity of frame, we may permit the vibrations, but absorb them in such a manner that no injury follows. We may make one bearing a universal joint and the other "elastic." This latter bearing should have sufficient freedom of motion to allow the revolving parts to find and revolve about their common center of gravity. The shaft in leaving the vertical should meet with a rapidly increasing resistance, so as to prevent extreme gyrations and compel revolution about the center of gravity, as near as may be. The bearing should be connected with its fixed support by means of some elastic medium, which by virtue of its elasticity will permit the necessary movement of the bearing without making or breaking its contact with the support or with the shaft. Otherwise the rapid succession of such contacts and impacts of their surfaces would produce a very objectionable noise and jar, and would soon derange the machine. The action of the elastic bearing by its sudden reaction also helps to arrange the semi-liquid mass centrally to the basket, and thereby materially assists the centrifugal force.

By an "elastic bearing," then, is understood a bearing which will allow the revolving parts to rotate about an axis through their common center of gravity.

The swinging basket, mentioned before, is really a special case under this head, as can readily be seen by considering the ball and socket joint as one fixed bearing and the other bearing wanting. It is classed, however, among machines with "fixed bearings," because a bearing as commonly understood is rigidly attached to the frame and does not have rotary motion.

It might be remarked here that for substances which part with their liquor reluctantly it is sometimes necessary to run the basket in fixed bearings until the material is so far drained as not to be liable to shift inside of the basket or change its position relative thereto. To this end centrifugals, when they have elastic bearings, may be furnished with a device

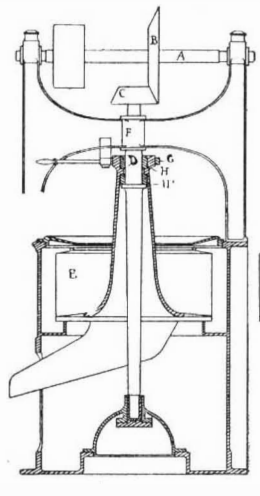


FIG. 6.

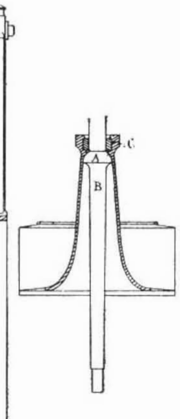


FIG. 7.

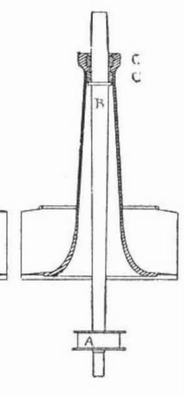


FIG. 8.

for locking the position of the spindle so that the elastic connections cannot operate. This is very similar to one method described above.

The simplest forms of elastic bearing machines have but one bearing, the bottom one. It extends far enough up the sides of the shaft to afford a support to retain the shaft in a vertical position—virtually two bearings. The lower end of the spindle is embraced by a box, which is surrounded by a flexible, easy yielding spring, usually rubber; or it has attached an annular flange on which rests a rubber annulus, above which is a rim cap, fastened to the base step.

An extension of the above idea is to secure the machine to the floor by bolts encircled in elastic cushions beneath the floor, so arranged with an elastic cushion above the floor that the upward movement of the base of the spindle standard will be resisted by the cushions.

A very common and a very good style of elastic bearing consists in a sleeve surrounding the spindle, held in place by a number of eye bolts, passing through rubber springs. See Figs. 15, 17, and 18. The caps for these springs are cupped on inside, so as to touch the rubber only at the circumference. The nuts on the bolts are adjusted so that the caps barely touch the rubber when at rest. This allows the spindle to run a quarter of an inch eccentric without imparting much

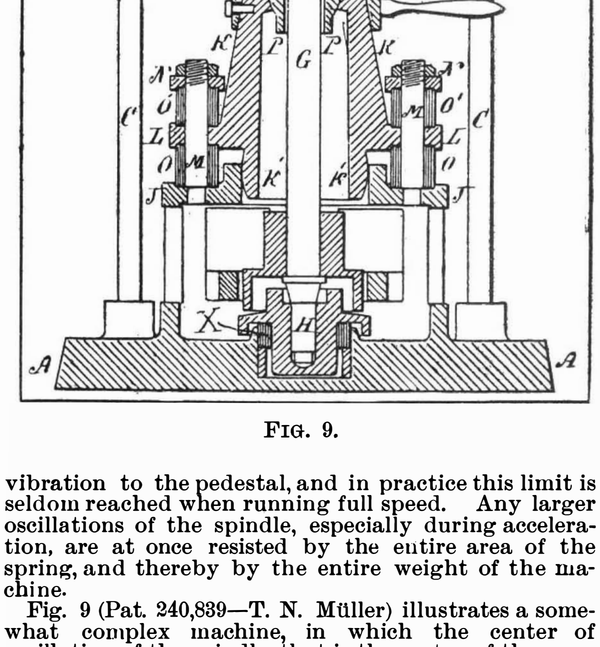


FIG. 9.

vibration to the pedestal, and in practice this limit is seldom reached when running full speed. Any larger oscillations of the spindle, especially during acceleration, are at once resisted by the entire area of the spring, and thereby by the entire weight of the machine.

Fig. 9 (Pat. 240,839—T. N. Müller) illustrates a somewhat complex machine, in which the center of oscillation of the spindle, that is the vertex of the cone of oscillation, is variable in position. When this vertex is not at the point of support, vibrations, as we have seen, are apt to be transmitted to the pedestal. This machine is designed to meet this difficulty. It need not be described, save to say that O and O' are rubber springs and X a rubber annulus.

Fig. 10 shows roughly a combination, which has been tried, of the swinging basket and an elastic bearing.

The following are worthy special notice. They are two peculiar combinations of elastic bearing with devices to resist gyrations by means of some other force than that of elasticity—in one case friction, in

FIG. 10. FIG. 12.

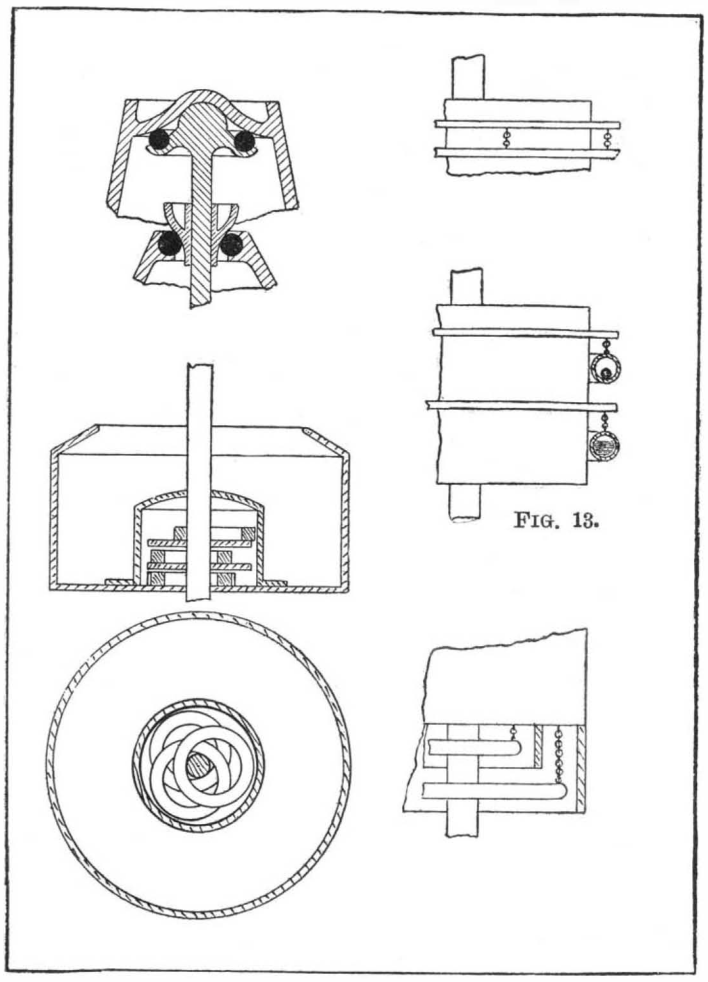


FIG. 13.

FIG. 11. FIG. 14.

the other the resistance of inertia. In the first (Pat. 288,-129—G. L. Shorey) the sleeve of the bearing is contained in a box having a flange, which flange is frictionally held between plates pressed against it by springs. This friction resists the gyrations, and an ordinary spring bearing will center the spindle again. In the other case (Pat. 240,840) the spindle passes with a ball and socket joint through a ponderable mass, which is swung on three supports outside the casing of the machine. This casing rests on and constitutes part of

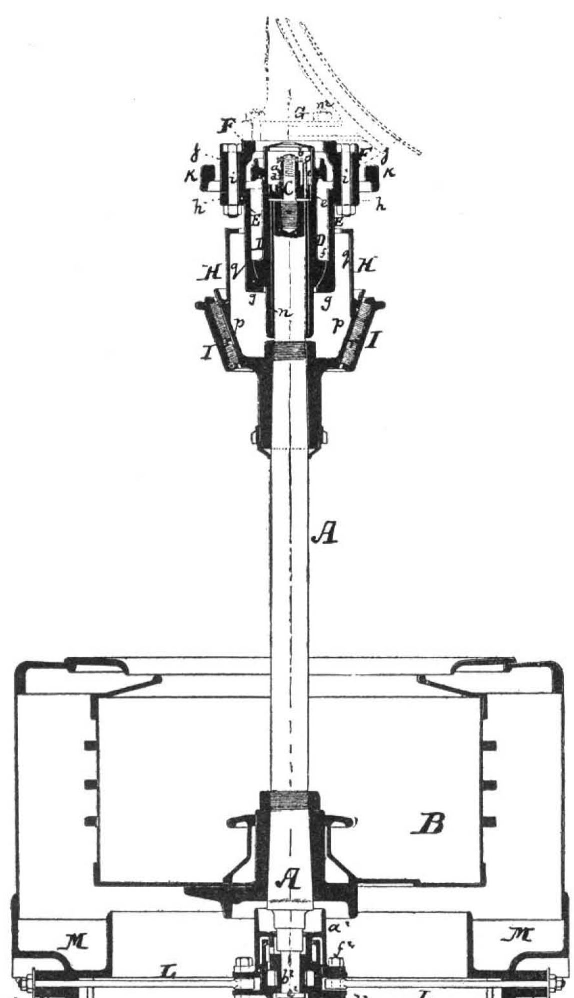


FIG. 15.

the mass. A gyration is resisted by the inertia of this mass, and the spindle is centered by means of rubber springs which may be variously applied.

There are several devices which aim to meet the difficulty by striking at the main cause of vibrations—the unbalanced charge. In one a central chamber, concentric with basket, is provided, in which is a liquid or granular substance. This latter will arrange itself so as to produce equilibrium. A modification of this (Pat. 305,026) is to divide this chamber into compartments, provided with means for automatically effecting the discharge of the liquids therefrom until equilibrium is established.

To achieve the same object, attempt has been made to use radially swinging arms upon the spindle, which were designed to act as drags, tending to pull it in a direction opposite to the overcharge But they were not sensitive enough. When a movable weight is deposited in a centrifugal, it tends to assume a position diametrically opposite to the position of the overcharge. To be of use it must respond quickly to the forces acting upon it. Rings whose inner diameter is much larger than that of the spindle about which they turn are very sensitive, and serve the purpose very well (Pat. 7,455, reissued Jan. 2, 1877—A. Fesca). See Fig. 11. The disks shown in vertical section are not inserted in plan, to avoid confusion. While the spindle is out of the vertical and describes the surface of a cone, it pulls on the rings and tends to swing them behind it. The cen-

FIG. 16. FIG. 17.

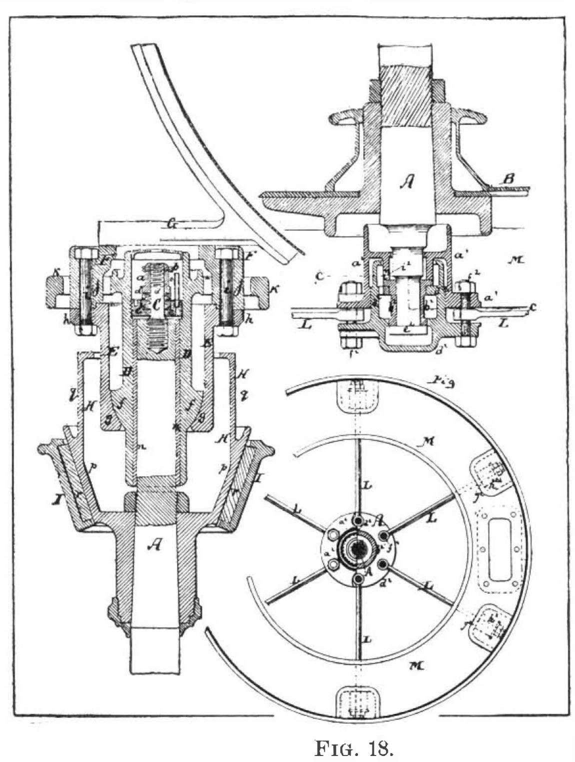


FIG. 18.

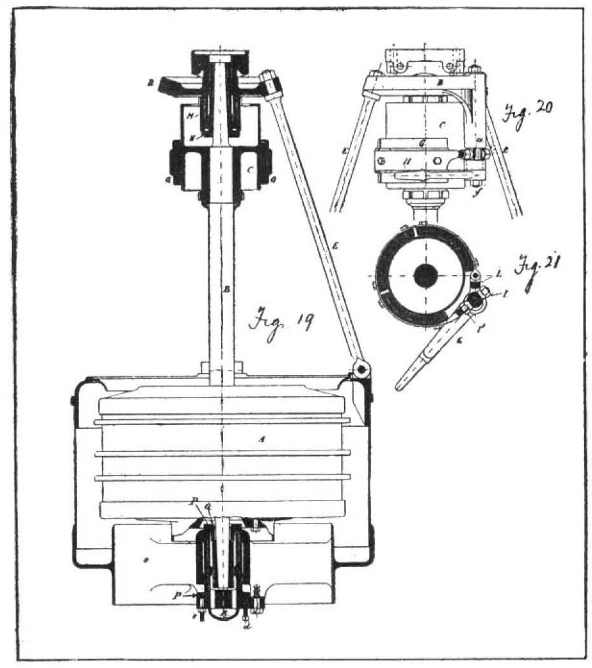
trifugal force of the rings is thus exerted in a direction contrary to that of the overcharge. There should be at least three rings. It is essential that a certain amount of friction should be exerted upon them for the purpose of arresting their momentum when they have received a sudden impulse tending to throw them too far in one direction. Hence disks separate each pair.

A method on the same principle as the above has been devised lately (Pats. 322,069 and 331,450—E. Rothe). It consists in its simplest form (Fig. 12) of a solid annulus suspended by several short chains or cords from a flange on the outside of the basket. This annulus may be hollow and partially filled with liquid, or wholly filled with liquid with balls in it, or partially full of balls alone. See Fig. 13. A chain or rope will serve the purpose. One advantage of this method is that the annulus will lean against the overcharged side of the vessel, increasing security from explosion. These annuli may be less in diameter than the basket, and hung below it and protected by producing the basket wall downward. Fig. 14.

In hanging machines vibrations may be met by freely moving masses attached to the spindle or the bottom of the basket. This is in action in all respects like the last named method for standing machines.

One of the latest and most perfect sugar machines is illustrated in Figs. 15, 16, 17, and 18 (Pat. 298,395—T. H. Müller). There are a number of points illustrated in them besides the universal joint and the elastic bearing, which will be referred to later.

The spindle may have fixed bearings in a hanging



centrifugal. In such case the entire machine is suspended by a ball and socket joint from its support. The whole moves like a conical pendulum, the entire mass being almost wholly available for centering the machine. We have here of course the strains and consequent gyrations which a fixed bearing brings, but they pass harmlessly off into the air. Figs. 19, 20, and 21 (Pat. 244,473—T. H. Müller) illustrate a machine of this character in partial detail.

In the centrifugal just described, the shaft itself may give or bend with a heavy unbalanced load. To meet this we have the further complication of ball and socket joints replacing the two rigid bearings in the swinging frame.

This ends the list, though by no means all the devices for meeting gyrations have been enumerated. The design has been to show all the distinct methods merely, and even here some may be omitted owing to total lack of any connected information on the subject and the impossibility of knowing when the list is complete.

(*To be continued.*)

PHOTOGRAPHING A BULLET IN FLIGHT.

NOTHING tends so much to the advancement in public estimation of the art of photography as some new application of it to the purposes of scientific research. We now have the pleasure of recording such an application, by means of which some of the phenomena attending the passage of a projectile at high speed have been made to register themselves upon a photographic plate, and so to illustrate in a forcible and unequivocal manner the theories which have been formed by artillerists and those concerned in the theoretical department of gunnery, as well as to demonstrate facts of interest in a department of physical research in a way not attainable by any other means.

In a paper recently laid before the Imperial Academy of Sciences of Vienna, the authors, E. Mach and P. Salcher, with whose names must be associated that of Professor A. L. Riegler, of Fiume, describe the method by which they have succeeded in photographing a bullet in flight, and at the same time of reproducing upon the photographic plate the image of the lines of condensation and rarefaction of air which are caused by the rapid motion of the solid body. Extracts from so much of their paper as relates to the purely photographic portions of their labors we lay before our readers, not only on account of the interest which such a triumph of photography must excite, but as showing the way in which the art may be made available in the service of scientific investigation.

The vivid illumination of the bullet and its surrounding envelope of air is effected by means of the

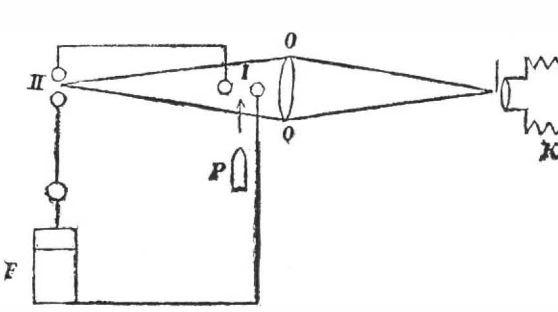


FIG. 1.

discharge of a Leyden battery, the spark from which is of so short a duration that the bullet, notwithstanding its high speed, has not time to move far enough to destroy the sharpness of its image, and the arrangement for the purpose is as follows: The circuit of a Leyden battery, F (Fig. 1), is broken at two places, I and II. At I the electrodes consist of wires inclosed in very fine

glass tubes. The projectile, P, breaks these tubes in its flight, and sets free the current which passes at I and II. The partially hidden spark at II illuminates the projectile in front of the objective, O, which last throws an image of the spark II upon the objective of the photographic camera, K. The image of the projectile with the electrodes, the spark as I, and the changes in the density of the air are thus thrown upon the plate at the exact moment when the darkened chamber in which the experiment is conducted is lighted up by the current set free by the projectile itself.

The apparatus comprises the photographic objective by Voigtlander, O, of 10·5 cm. aperture and 38·2 cm. focus, and the photographic camera, K, fitted with a Steinheil objective. The distance from II to O was 48 cm., and from O to K 230 cm. The distance of the muzzle of the barrel from the electrodes was varied in different experiments from two to four meters. The strength of the battery was also varied, but finally a jar was settled upon whose capacity was of 410 square cm., which was charged to give a spark of from six to seven mm. Too great capacity involved too long duration of the spark, so that, with a high velocity of the projectile, the picture was not sharp.

The experiments were carried out with projectiles having initial velocities of from 327 to 530 meters per second, and in the results it was found that an optically recognizable condensation of air in front of the projectile only occurred when the speed of the bullet exceeded that of the transmission of a sound wave, *i. e.*, 340 meters per second. Experiments made with a carbine shot, having no greater velocity than from 327 to 339 meters per second, showed no effect of compression. This, indeed, had been previously found in some former experiments of Mach and Wentzel. On the other hand, when using infantry barrel of Werndl and Guedes' construction, producing velocities of from 338 to 530 meters, very sharp and beautiful results were obtained.

When a sufficient velocity of the projectile is obtained, the compressed air in front of the bullet takes the form of a hyperboloid curve, the vertex of which is in front of the projectile, and the axis of which is the line of the fire In a similar manner a symmetrical figure is formed in the air to the rear of the projectile, but in this case the lines marking the margin of the figure are straight, and form the sides of a cone truncated at the base of the projectile. With the highest velocity, a third phenomenon appears in the shape of characteristic clouds filling the space behind the projectile. These are indicated by the curved arrows in Fig. 2. The aerial displacements are closely analogous

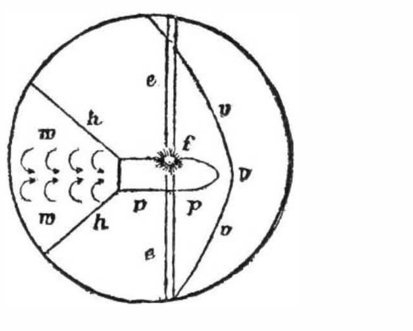


FIG. 2.

p p, projectile; *e e*, electrodes; *f*, spark, shown at I in Fig. 1; *v v*, border of the air wave in front; *h h*, border of the hinder air wave; *w w*, whirls of air in the rear of the bullet.

to what may be observed in the case of a ship cleaving the water. The borders of the waves thrown up at the stem and stern of the vessel, and the whirl immediately behind the keel, are counterparts of the aerial currents that have now been demonstrated by photography. These currents and whirls in water can be studied on a small scale by using a model drawn through water in which a little gold bronze has been stirred up.

The use of the Leyden discharge as the source of illumination for photographic work was known and ap preciated even in the daguerreotype days, and we are glad to see it applied in the practical manner which has been described. Electrical discharges of the Leyden or condenser character, whether generated by the induction coil or by machines of the Voss or even of the older types, may be made to serve the photographic purposes for which the arc light is now used; similar precautions, when desirable, being taken to diffuse or shield the direct light, and work by that reflected from extended surfaces.

This method of working should be particularly useful when it is desired to photograph objects in motion, and in place of opening the lens by the movement of the object, as was done by Muybridge and others, this movement would be made use of to join the circuit and set free the discharge.

The work of Mach and Salcher is illustrated not only by woodcuts, two of which we reproduce, but by a series of collotypes, enlarged, some of them, three diameters from the original small negatives. These pictures show the bullet as if stationary, and repro duce the air waves and whirl in a very remarkable manner.—*The Photo. News.*

PHOTO-ENGRAVING PROCESSES.

THE "WASH-OUT" PROCESS.

THIS popular method for making high relief plates is based upon the well known property of bichromatized gelatine to become insoluble under the influence of light. When films prepared with this substance are exposed to light under a photographic negative, and then immersed in cold water, only those parts not acted upon by the light will absorb water and swell. Hot water washes these parts away entirely In either case a relief will be formed. In the first, where light has not acted; in the other, where, by the same influence, the nature of the gelatine has been changed, and rendered insoluble. In the former mode swelled gelatine plates are made, and upon the latter action the "wash-out" process is based.

The peculiar kind of negative best suited for these processes, and the kind usually adopted for most photo mechanical printing methods, is descriptively termed a "black and white" negative.

Only line drawings of engravings, wood cuts, type, when used for book or newspaper illustrations, etc., can be reproduced by these methods of photo-engraving, although blended or washed water colors, India ink and sepia drawings, as well as half tone negatives taken from natural objects, may be made suitable for the ordinary printing press by the introduction of systems of lines or stipple. The negative for the "wash-out" process should, under all circumstances, be taken reversed, or have its film stripped from its support and turned.

Of all the methods of photo-engraving, no one has probably given so satisfactory results as the "wash-out" process, for the gelatine plates can always be kept on hand, the resulting lines are sufficiently sharp and clear, and from a *cliché* once obtained any number of electrotypes can be made.

The first and most important operation is to prepare the sensitive gelatine sheets.

Of Coignet's gold label or any other kind of soft gelatine, immerse three and a quarter ounces into sixteen ounces of cold water, and after sufficient swelling heat, in a porcelain dish, and with repeated stirring, allow to stand for forty-eight hours at a temperature of from 100 deg. to 120 deg. Fahr.

During this time the gelatine will decay, emitting a disagreeable odor, and to prevent the formation of a scum on the surface, or from adhering to the sides of the vessel, it must frequently be agitated. When the decomposition has been completed, add six and one-half drachms of white sugar, two and one half drachms of glycerine, and seventy-five minims of ammonia; the mixture having been previously colored with as much finely pulverized lamp black as will spread over a glass plate and not destroy its transparency. Finally two drachms of bichromate of potash, dissolved in the smallest possible quantity of water, are intimately mixed with the emulsion. After several times filtering the mixture through linen, it may be removed to the drying closet, where the temperature is raised to 130 deg. or 135 deg. Fahr., and left for about fifteen or twenty minutes.

The glass plates to be coated with the sensitive gelatine are rubbed over with an oil rag to prevent the sticking of the films.

The plates must be carefully leveled to secure an even coating. Then take the gelatine from the closet, and filter again into a jar which is provided with a mouth piece. Care must be taken that all the vessels used, and plates also, are warm, so that the gelatine will not set before it becomes perfectly level upon the plate. After all is filtered, remove with a stiff card air bubbles or scum that may have formed on the surface, and measure out equal quantities and coat. In order to secure films of equal thickness, a measured quantity for each plate is a necessity.

The dark room, when the gelatine plates are set, should be kept at about 70 deg. Fahr. In two or three days, according to the arrangements of the room and weather, the plate will be dry and ready for use. The gelatine should not be stripped until perfectly dry, for otherwise it may be pulled out of shape, and will shrivel up during washing. When dry, cut around close to the edge of the plate with a penknife, and start the film on the corner, gradually pulling it from the glass, and lift it off. The glass side of the film is now brought in the printing frame into close contact with the negative, and exposed to sunlight. Some operators sprinkle the side of the film which has come in contact with the negative with fine gelatine powder, to prevent sticking. The superfluous gelatine powder is, of course, brushed off with a soft piece of flannel or fine brush.

All the negatives to be used are generally nearly of the same character. Hence the time of exposure, about fifteen minutes in direct sunlight, and in shade proportionally longer, can easily be estimated. The time of exposure is highly important. If too short, the finer lines and details will wash away; and if too long, the more delicate parts will become confused and sharpness will be destroyed. The progress of printing can be watched by examining the back of the film.

After the right exposure has been given take the frame to the dark room, remove the gelatine film and lay it face up on a strong glass plate which has been previously coated with rubber solution.

To develop the picture, dip a brush into a can of warm water and rub it on the gelatine in the direction of the lines on the film. After each dip of the brush and gentle rubbing, flow water over the film, and continue to do this till all the soluble gelatine has been removed. Toward the end of the operations the lines will begin to shrivel up and present a crooked appearance. But a subsequent bath of alcohol will absorb all the water from the gelatine, and straighten out the lines again. After about fifteen minutes the plate can be removed and set up to dry, after which it is laid and squeegeed upon a zinc plate coated with thick shellac varnish. All air must be expelled and the edges of the gelatine must lie perfectly flat. When perfectly dry a proof may be taken, and if the plate is correct it may be electrotyped.

This simple method is, of course, applicable only to line work, but may also be made useful for the reproduction of half tone negatives taken from natural objects. To do this the half tones must be translated into lines or stipple, as the printing press is not cap able of producing tone gradations. Several processes have been adopted, among them that of the Moss Engraving Company, a specimen of which we showed our readers recently.

Mr. Ives, of Philadelphia, places the bichromated gelatine film, after exposure to light, in cold water, which swells it into relief, highest where the negative was most intense. A plaster cast is then taken from this wet gelatine relief. The surface of the cast is highest where the negative was most transparent (representing the blacks of the photograph), and lowest where it was most opaque (representing the whites).

Variations in height between the two extremes represent the half tones of the photograph.

The plaster cast produced in this manner is utilized for translating the body shades of the photograph into lines and dots by a purely mechanical means as follows:

An elastic stamp of V shaped lines or dots is inked and pressed against the relief until the flattening of the lines or dots causes them to make an even black impression on the highest parts of the relief increasing in size where it is higher, until they meet to produce the perfect blacks on the highest parts. To obtain a transfer of the inked surface without making another photograph, the film is coated with plain collodion, by which the ink is almost entirely taken up. When dry, the collodion pellicle is stripped with the aid of gelatine and acidulated water. A copy is taken from it on a photographic plate, upon which all half tones are resolved into lines, cross hatchings, or stipple.

More complicated, but invariably giving most excellent results, is the Meisenbach method. A diapositive is made of the original negative, and from that another negative is taken, while in perfect contact, with a very finely lined transparent plate. At about three-fifths of the time required, the exposure is interrupted, the line plate turned far enough to give any desirable system of crossing the lines first impressed upon the plate, and the exposure is continued. The collodion plate is then developed and intensified in the usual manner, and printed from upon the bichromatized film.

THE SWELLED GELATINE PROCESS.

The process offers to the beginner many seemingly insurmountable obstacles, but with a little patience and practice all may be easily overcome. The negatives must be of the same character as in the "wash-out process," viz., be "black and white." The difference between the two methods lies in the treatment of the bichromatized gelatine film after exposure to light.

The best way of working is either to coat well-leveled plate glasses or plain and finely polished zinc plates with the gelatine mixture. Similar to the wash-out process, one part of gelatine is soaked for about an hour in four parts of cold water, then placed in an iron cooking pot and heated to about 120° Fahr., when, by constant stirring, the mixture of glycerine, sugar, and ammonia is effected, and finally the bichromate of potassium is added. Then the gelatine may be taken to the dark room and filtered into a previously warmed earthen pot, and, while still warm, poured upon the cleansed plates. When coated, the plates are laid upon a smooth and level block of ice, and, after being thoroughly set and distilled, are placed in a drying closet over calcined chloride of calcium.

In a perfectly dry, airy room with sufficient draught, often artificially created by means of fan wheels and air shafts, drying proceeds speedily. When perfectly dry, which can be determined by touching the film with the finger, printing may be proceeded with.

As two casts are to be made from the gelatine relief, no reversed or turned negative need be made; it must be left as it comes from the camera. As in ordinary printing, the negative is placed in the frame, film side up, and the gelatine plate laid upon it; the frame is closed and then exposed to light. For this and similar kinds of printing a very strong pressure only will establish absolute contact between negative and sensitive film. To do this the ordinary photographic press is not sufficiently strong to produce perfectly sharp copies. Very heavily constructed frames fitted with thick plate glass, and various levers and screws, are made particularly for this purpose.

Twenty minutes of sunlight is sufficient to print. The frame is then returned to the dark-room, the plate removed and put in the swelling pan, which contains just enough water to entirely cover it.

To remove the chromium salts from the parts of the film not exposed to light, the water must be several times changed. During this operation much water is absorbed by the gelatine; it swells up, and a relief is formed.

The time a plate may be allowed to remain in the water is highly important, for it determines the shape of the lines. If allowed to remain in the water too long, the lines will be rounded on top thus /⌒\, so that from a finished plate only the top of the curve will make an impression. Insufficient swelling makes a shallow relief, shaping the lines in the form of a cup thus /‿\. With a correct time of swelling, the line should present this form /‾\. After a little practice beginners are able to judge how long a film should be allowed to swell.

After swelling, the film is washed again and hardened or tanned in a solution of one part of chrome alum and fifty parts of water; rinsed again with water and laid upon a smooth stone slab which has been previously rubbed with oil. The casting irons, made exactly type high, and brushed out with oil to prevent the plaster from adhering, are then laid around the plate.

Take enough of the best casting plaster or alabaster gypsum to fill the cast, and mix it with water to a thick paste; then add a pinch of salt or powdered borax. Then pour the plaster paste over the casting, in order to fill all the parts well, and with a brass-edged bar level it off evenly with the top of the casting iron, by resting the rule on the casting iron and working it gradually down. Care must be taken to have the casting perfectly level on top. Allow it to remain until the plaster is perfectly set, then remove the casting irons, and take the cast off from the gelatine plate. The result is an intaglio cast of the relief in gelatine.

A cast may also be made in paraffine, wax, or a mixture of both; but on account of its better stability it is advisable to work with plaster.

From the intaglio plate a high relief is never cast, also in plaster.

After the plaster is thoroughly set, remove the casting irons and with a wide-bladed table knife cut between the two casts and force them apart, being careful not to break the casts. If handled with care they will separate very easily, provided the plaster has been allowed to set thoroughly. Never try to remove a cast until it has set. The plaster cast is then taken to the stereotyper and put in a metal pot, and a stereotype plate cast in the usual manner.

The swelled gelatine does not allow of any great depth of lines. So when the plate comes from the stereo typer's pot, the high lights must be cut deeper by hand. This can be easily done with engravers' and wood-cutters' tools, as the metal is quite soft. While engraving the plate, care must be taken not to blur or injure any of the fine lines. The wide and open spaces are taken out with the routing machine.

The plate is then mounted on a wood block and is ready for the printer.—*Photo. Times.*

PROGRESS OF METALLURGY IN 1886.*

In 1884 the price of magnesium in New York was quoted at $50 per pound in the price lists of the chemical companies, but it can now be bought for about $5 per pound. It is manufactured on a large scale by a firm in Hanover by electrolysis, using the waste chloride of magnesium of the Stassfurt mines in Northern Germany.

Besides various uses in the chemical industry to replace finely divided zinc as a reducant, it is mainly used for light and to make nickel ingots solid. The ocean steamers use considerable of the metal for signals and when entering port at night.

A torch containing magnesium is now used abroad for processions, which we will probably see during our next campaign here. A pure nickel ingot is very honeycombed, but by the addition of only about ⅛ per cent. of magnesium a perfectly sound ingot is obtained. Nickel ingots can now be rolled into thin sheets and can be welded to iron. Such nickel-covered sheet iron is now used extensively for the manufacture of household goods. This material wears better than electroplated ware, and, as nickel is very hard, it will stand any amount of hard rubbing to keep it bright without any danger of its wearing away.

But the principal improvement is the use of oxide of magnesium for the manufacture of soft steel out of materials which heretofore could not be used for the manufacture of steel, such as pig iron with phosphorus higher than contained in ordinary Bessemer pig and general mixed scrap, and to produce therefrom a material with less than 0·040 per cent. of phosphorus and other constituents as desired.

So much has been written on the basic process for the manufacture of steel out of phosphoric pig that I shall not attempt to make a detailed description of this process; but in order to show you the advantages to be derived by the use of magnesia for furnace linings, a short description of the basic process will help you to more easily understand the matter. Dolomite or limestone is subjected to a very high heat, generally in a cupola, so that the material will not only lose its carbonic acid, but will change its molecular condition so much that when a piece is moistened, it will not slake in the time ordinary burned limestone will, and furthermore, it must have been heated so highly that when it is subjected to a high heat in a process, it will not shrink in volume.

This material is crushed, mixed with tar free from ammonia and water, and is then ready to be rammed in as a lining for a Bessemer converter or on the hearth of a steel melting furnace. As soon as the lining has been rammed, it is heated up to coke the tar, the coke acting as a binder for the shrunk material. As soon as the lining is ready and heated up, from 14 to 20 per cent. of burned lime is added, and then the pig iron is charged and the converter erected to be blown. As soon as the carbon is nearly all eliminated, the so-called after-blow takes place, during which period the phosphorus is eliminated. As soon as the desired amount of dephosphorization has taken place, the slag is poured off by tipping the converter slightly, and then after the addition of ferro-manganese the steel is poured into a ladle and cast into moulds.

Heretofore the slag was poured off from the charge at the end of the process, but lately some of the Westphalian works pour off the slag when the bulk of the phosphorus has been removed, and then add fresh lime to remove the last low percentages. This manipulation is a decided improvement. It not only dephosphorizes more effectually, but it also gives a slag more suitable for agricultural purposes than when the whole quantity of slag is carried to the end of the process. There are very many interesting facts connected with this subject. which I cannot mention at present.

The pig iron used for the process must be as low as possible in silicon, in order to protect the basic lining and in order to be able to easily produce a highly basic slag, for Mr. Hilgenstock, of Hörde, has shown that for successful dephosphorization the constitution of the slag must be so that a tetraphosphate of lime can easily form. As the silicon is very low in the pig iron, and as it is the heat-giving element in the Bessemer process, some other heat-giving element must be present in such a quantity that sufficient heat is generated to carry through the blow and to cast the ingots. This is the reason why about 2 per cent. of phosphorus is desired in basic pig iron.

Pig iron containing 2 per cent. of phosphorus, from 1 to 2 per cent. of manganese and silicon, and sulphur as low as possible, is not very plentiful here, and when we consider the extra expense for refractories and labor connected with the basic process, and the large supply of low phosphorus ores in the country, it will probably be a long time yet before the basic Bessemer process will be carried out here to such an extent as it is abroad.

The basic open hearth process, though, seems to have quite a future at present, because one is not bound to any special composition of the raw materials. Pig iron, regardless of the percentage of phosphorus it contains, can be used—brands which contain too much phosphorus for the acid Bessemer process and not enough for the basic Bessemer, especially those containing from 0·20 to 0·50 per cent. of phosphorus, which can be produced cheaper than Bessemer pig, and, what is the most important, a large amount of miscellaneous scrap is used, of which there is a large amount in the country, especially in the West. These materials are charged into a furnace having either a lining made out of shrunk dolomite, magnesia, or chrome ore. As soon as the charge is melted, the slag is drawn off with broad hooks. Fresh lime is then charged on the melted metal, which is again removed.

This manipulation is repeated until the metal has been dephosphorized to the desired extent. Ferro-manganese is then added and casting commenced. Where there is a basic Bessemer plant, the basic open hearth with dolomite is the most economical, because freshly shrunk dolomite can always be obtained from the Bessemer works, but where this is not the case, magnesite or chrome is preferred.

After calcination, the magnesia can be stored for a long time, whereas shrunk dolomite must be used fresh.

The magnesite has the remarkable property not to flux with the silica sides of a furnace, whereas shrunk dolomite must be separated from any silicious parts of the furnace by a layer of magnesia or chrome ore.

A magnesia brick can be placed into direct contact with a silica brick without any fluxing taking place. This property of magnesia and chrome to allow a lining of them to lie up against a silicious lining and at the same time to resist the corrosive action of a highly basic slag is highly important for the manufacture of soft steel out of materials which could not be utilized in a furnace lined with sand, on account of the variable amounts of phosphorus the product would have.

Magnesia is also one of the most powerful refractories we have. I have placed a piece of the calcined mineral in the hottest part of a Siemens steel-melting furnace without having any melting effect on it whatever. Nearly all the wire works of the country have tried soft basic steel, and can attest its extreme softness, and the consequent larger reductions possible in afterward drawing the same.

The process is at present in operation in Germany for soft wire rods, and in France for rods and sheets, where I have had occasion to study the process. It is also in operation in Russia for rails out of scrap, which has accumulated in Russia, and which scrap contains too much phosphorus to otherwise work it up.

The basic steel is the nearest thing to metallic iron which has as yet been produced.

The process is not covered by patents. Emil Muller took out patents in 1869 on a lining made of magnesia and basic additions for the purpose of dephosphorization. These patents have expired. At that time they had not been successful in making a lining, because no matter how highly the magnesia was heated, the material remained in a pulverulent form. The magnesia employed was too pure. Recently, however, large deposits of magnesite have been discovered in Styria, which has a small percentage of silica, lime, alumina, and iron, just sufficient to cause a lining as described to stick together. The process is out of its experimental stage, as many tons of soft steel low in phosphorus are being produced, and there seems to be no doubt but that the magnesia process will soon be an important addition to our great steel industry.—*Jour. A. of Eng. Societies.*

* Extract from a paper by Geo. W. Goetz, Member of the Civil Engineers' Club of Cleveland. Read January 25, 1887.

THE JUBILEE OF THE TELEGRAPH.

The dinner to commemorate the fiftieth anniversary of the successful establishment of Cooke and Wheatstone's telegraph line, between Euston Station and Camden Town, took place in the Venetian Hall, London, on Wednesday evening, July 27. The Right Hon. Henry Cecil Raikes, M. P., Postmaster-General, presided, and the company present numbered 250. The *Electrical Review* says the proceedings were characterized by the utmost enthusiasm, repeated outbursts of hearty applause greeting the names of well-known pioneers of telegraphy, both by land and sea. To every speaker was extended a cordial reception, but the loudest and most prolonged cheering was that which broke forth when Sir William Thomson rose to speak. Sir William was anxious that early inventors should not be forgotten in the congratulations deservedly poured upon those who remain alive to witness the outcome of their faith and enterprise, and he recalled the names of Oersted, Ampere, Gauss and Weber, Steinheil and others, as those of men well deserving to be honored by the telegraph engineers of the present day.

Among the speakers were Mr. Edwin Clark, Mr. John Pender, Sir William Thomson, Sir Lyon Playfair, Professor Stokes, Dr. Gladstone, Mr. Shaw Lefevre, Mr. Bruce, Mr. Latimer Clark, the Earl of Onslow.

The chairman, who was received with prolonged cheers, in the course of his speech said: I venture to believe that when we look back upon the progress of those 50 years, we shall find in them the materials for a greater hope of the future of humanity than in almost any other record of any other period in the history of our race. In 1844 the government of Sir Robert Peel first conceived the idea of utilizing the telegraph for other than railway purposes—at least they were the first to realize how far it might be applied to the service of the state—and that year saw the establishment of a telegraph line from Waterloo to Gosport of four wires, of which two were to be utilized by the railway company and two by the government, and that I think you may say constituted the first public recognition of the value of the electric telegraph. (Applause.) In 1846 the first telegraph company was formed—the Electric Telegraph Company.

The first Atlantic cable was laid in 1858, and other companies arose during those years to compete with the first electric telegraph company, and multiplied throughout the length and breadth of England the agency of the telegraph. In 1870 the multiplication of the companies had become so great that their competition, though in some respects advantageous to the public, was yet so imperfectly regulated by state requirements that the government of the day determined to acquire the whole of their enterprises and to place the telegraphs of the kingdom under the direction of the post office.

When the first electric telegraph was established, the speed of transmission was from four to five words a minute on the five-needle instruments. In 1849 the average rate of transmission of a certain number of messages addressed to the *Times* newspaper was 17 words a minute. The present pace of the electric telegraph between London and Dublin, where the Wheatstone automatic instrument is employed, amounts to 462 words a minute (cheers); and thus what was regarded as miraculous 60 years ago has multiplied a hundredfold in the course of one half century. Now you may perhaps like to know, though it is rather descending from the higher walk of this great subject, the number of telegrams which were sent through the post office in the United Kingdom last year. The number was 51,500,000 (cheers); that is nearly 1,000,000 per week, and that number is still steadily increasing. 41,000,000, or rather over that number, of these were inland messages, and of course a very great proportion of them were press messages. I think you should realize the immense boon which the electric telegraph has bestowed upon the press. I gather from such information as I have been able to obtain that the rate of press messages, which, as everybody is aware, is very much less than the rate for other messages, is on the average not much more than 2d. per 100 words; and it is owing to these extraordinary facilities, afforded by the post office to the transmission of press news, that the whole of the United Kingdom is put in possession at its breakfast table every morning of everything which it is necessary or important for anybody to know, as well as of a great many things which are neither necessary nor important. (Laughter and cheers.) I believe that I am not wrong in saying that the cost to the public revenue of this reduced rate to the press is not less than £200,000 a year, and the newspapers of this country practically receive a subsidy of £200,000 a year in order to enable them to assist in the diffusion of intelligence. (Applause.) I imagine that the country is well satisfied that this should be so, and that there are very few people who would wish to abridge that privilege, having regard to the enormous importance to all classes of the community of being placed at the earliest moment in possession of the fullest knowledge of what is going on. (Applause.) But it is a fact that, owing to the recent reduction in the tariff of telegrams, the value of the telegram on the average to the state is now only 8d., whereas two years ago it was 1s. 1d.; and before the state took over the telegraphs it amounted to as much as 2s. 2d. I think you may measure something of the enormous gain which the public has achieved by the acquisition by the state of the telegraph system when you look at these figures and reflect that the average price of a telegram at the present time is only about a third of what it was only 17 years ago.

Sir William Thomson then rose to respond, and was greeted with an enthusiastic outburst of cheering. He said:

I feel that when the telegraph has been so important a bond for all the nations of the world, we ought to go even beyond our fifty years jubilee, and think for a moment of the great names from other countries to whom the possibility of the jubilee of the electric telegraph has been due—the great apostles of electric science in France, Coulomb and Ampere. (Cheers.) Ampere, whose work and whose discoveries constitute the foundation of the most important of modern telegraphic and electrical instruments generally; Ampere, whose name has become anglicized and is invariably used in measuring the currents which produce the electric light. Then Gauss and Weber, who made the first electric telegraph. Mr. Edwin Clark justly and fairly expressed himself just now, when he said that the telegraph of Cooke and Wheatstone was the first practical working telegraph, but he knew that others had worked in that field before, and that it was the practical realization of their work we owe to our own great countrymen, of whose splendid works he has spoken so ably. The telegraph of Gauss and Weber and the Munich telegraph of Steinheil, and the Steinheil key, which is the manipulating telegraph key of the present day—those were the elements of telegraphy. We justly rejoice that in England so much was made of the work of those grand pioneers in science. In America the race of practical work commenced almost simultaneously with our own in the splendid telegraph of Morse. In speaking of the telegraph we almost forget time and space, and I must go back to the previous work of Henry, who anticipated in some points some of the finest discoveries of Faraday, and laid a large part of the theory of current induction, which is at the very root of some of the most splendid realizations of modern electric science, not merely for the electric telegraph, but for electric lighting. But I am reminded that my own position to-night is to speak for my fellow-workers in ocean telegraphy, and in doing so I may say I have very mixed feelings. Most of them have gone away, few are here now, I am almost alone. By the work of 1857—a few years before the half of the jubilee—the two brothers Edward and Charles Bright and Whitehouse—those three men, with Mr. Cyrus Field, reduced to practice that brilliant dream of Cyrus Field to connect England and America by means of submarine telegraphy. Then there were the brothers Werner and William Siemens working in the same direction, and the great navigator Moriarty, who was out in the Agamemnon in 1857—I had the honor of being shipmate with him on the Agamemnon. He navigated the Agamemnon in 1868, and was on the Great Eastern as navigator with Sir James Anderson. In 1865 he picked up the cable where it was broken, and in 1866, coming back a year after to the same place, hit upon it just a quarter of a mile away by his splendid navigational powers. Canning and Clifford were also engaged in the work; then there were Varley and Jenkin (who was my special partner), with both of whom I worked for many years. I alone am here to speak for the three. Willoughby Smith, who did such fine work in 1865–66 in testing the cable, applying the newest developments of science, many of them his own inventions, to do what had never been done before, to test a submarine cable with a delicacy that was necessary under circumstances so peculiar, so utterly new. I am exceedingly sorry he is not with us this evening. I hope we shall see him many times more, upon some such occasion as this, and that he will soon recover from his temporary illness. But I can never forget that we scientists alone could not have done what has been done. I well remember the dead period of eight years, the middle of which was just the middle of our jubilee that we are celebrating to-night, the years from 1857 to 1866. We were on our backs, we could do nothing in science; the cable had been laid, it proved to be a success, it had delivered messages, a message had passed from the President of the United States to her Majesty the Queen, and was answered by gracious message from the Queen, and an important message countermanding the return of two regiments from Canada to England, in order to go to India to quell the mutiny; the countermanding of the return from Canada was done by the Atlantic cable of 1858. The mutiny had happily come to an end, their presence at the end of the diameter of the earth, or pretty nearly so, was not needed, and the Atlantic cable of 1858 conveyed the intelligence to them that they might remain in Canada. The cable failed. I do not remember at present how much money was spent upon it—half a million, I believe—and science could do no more. To two men, I believe, is due the existence of the 1865 cable, and all the consequences that followed from the 1865–66 cable—John Pender and Cyrus Field. (Applause.) With American spring, life, and energy, Cyrus Field flashed across the Atlantic—not by wire, though to our slow minds it almost seemed so; he was here trying to get up an un-

dertaking somehow or other, trying to induce English capitalists and scientific men to join together. But one man, Mr. Pender, was steadfast to the work. He was a director in 1858 of the Atlantic Telegraph Company; he with some of his colleagues remained on, and with Cyrus Field persevered until the successful undertaking of 1865. I call it successful because it was really a successful undertaking, although the cable was only half laid; it led, with further tremendous effort and self-sacrifice on the part of those devoted men and others who joined them, to the great and enduring success of 1866. But I am asked to speak of the present time of telegraphy, and not merely of submarine telegraphy, and I must remember that there are other things besides ocean telegraphs. We have our land telegraphs, of which you, sir, have spoken. You have told us how splendidly the land telegraphs are worked; you have pointed out how admirably, under the influence of the government system, the application of science to telegraphy has been developed. I think you may feel proud, sir, in knowing that under government management within these last seventeen years, the applications of science to telegraphy have not stood still, but on the contrary have been pushed forward with every possible energy and with the most marvelous success. (Applause.) You have told us that the rate of working between Dublin and London has reached 462 words per minute, and I think we may say 500 words per minute, and that is ten times what it was ten years ago. That is something for a government department to be proud of, and for a government, I must say, there is some little political importance in the fact that Dublin can now communicate its requests, its complaints, and its gratitudes (laughter) to London at the rate of 500 words per minute. It seems to me an ample demonstration of the utter scientific absurdity of any sentimental need for separate parliaments in Ireland. (Laughter and applause.) I should have failed in my duty in speaking for science if I had omitted to point out this, which seems to me a great contribution of science to the political welfare of the world. (Applause.)

PRINTING BY ELECTRICITY.

DR. BOUDET, of Paris, has recently taken out a patent for a process of reproducing a medal or drawing in facsimile upon a sheet of metal or any other substance rendered a conductor of electricity. In the same manner, it is also possible to reproduce a medal in relief, or any kind of engraving upon metal, upon glass, paper, or wood.

In Fig. 1, the medal, covered with plumbago, is at *a*,

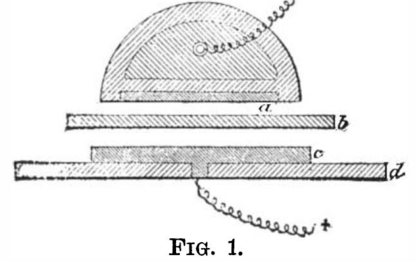


FIG. 1.

and is connected with the pole of a static machine; *b* is the glass plate upon which the reproduction is to be made, and under which is placed a plate of metal, *c*, that rests upon a plate of ebonite, *d*, and is put in communication with the second pole of the machine.

There is thus formed a condenser of which the object to be reproduced is one of the armatures, and a few revolutions of the winch suffice to make the reproduction.

When it is desired to operate with paper or a fabric, things are arranged as shown in Fig. 2. On the whole,

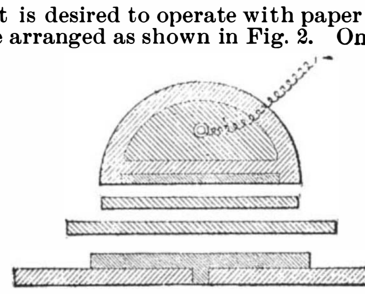


FIG. 2.

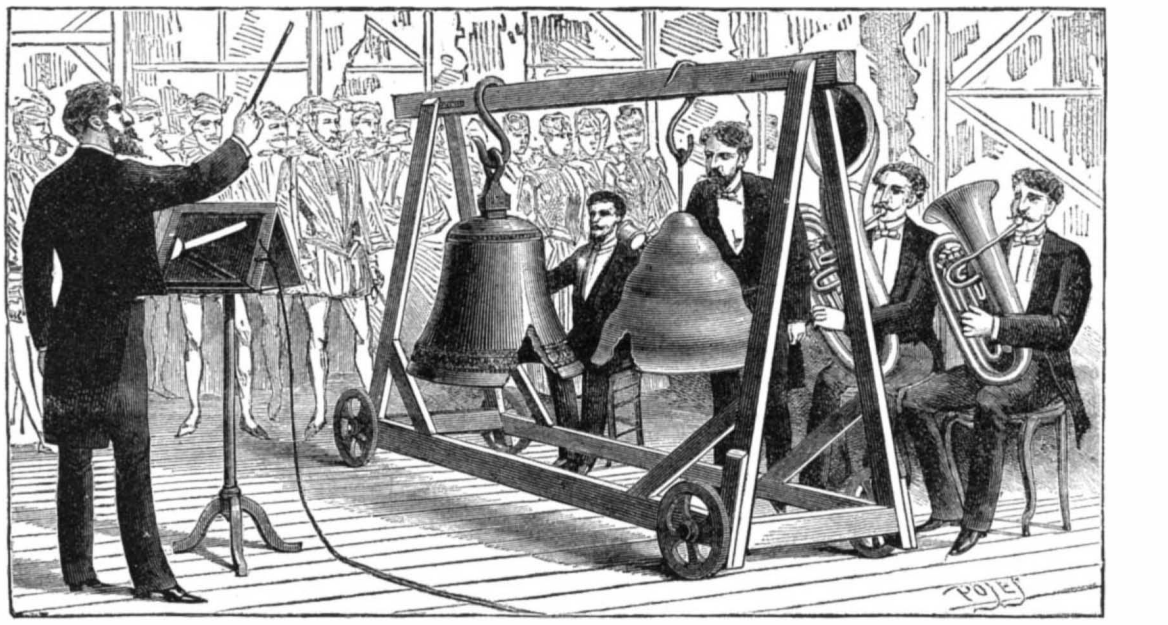
the same condenser is formed as before, except that the sheet of paper is placed upon the glass, *b*.

It is usless to add that an induction coil may be used instead of a machine.

MUSICAL BELLS.

THE spectator who witnesses a representation of Sardou's beautiful drama "Patrie," recently put on the boards at the Opera of Paris, with the music of Mr. Paladilhe, is probably not aware of the difficulties that were at first met with in the musical execution of one of the most stirring passages, and he will understand it the less because it appears the easiest to execute—since it is only a question of ringing a bell. It is the bell with which the heroic bell ringer Jonas notifies the Prince of Orange of the failure of the plot.

The authors rightly insisted that the bell should have that grave and lugubrious tone which contributes so much to the pathetic effect of the scene, but among the instruments of the Opera there was none capable of answering such a purpose. There are many bells that are used under different circumstances—in the Huguenots, in William Tell, in the Cid, etc.—but none gives anywhere near the note desired. The largest weighs 220 pounds, and gives the grave *re* of the soprano, which corresponds to the fourth *re* of a seven-octave piano, and it would require one giving the same note two octaves below—the gravest *re* of the violoncello, the second *re* of the piano. Now, conformably to the laws of acoustics, the number of vibrations of a bell is in inverse ratio of the cubic root of its weight, that is to say, the latter increases very rapidly with the gravity of the sound. If, as a starting point, we take the 220 pound bell of which we have just spoken, the cubic root being 4·8, we obtain, by doubling it, in order to descend one octave, 9·6, the cube of which is 1,945 pounds—a very respectable weight; and to descend two octaves, 19·2, the cube of which is 15,527 pounds. A bell to give the desired note, then, would have to weigh 15,000 pounds. It will be understood that in the presence of such a weight, the authors and directors experienced some little hesitation and sought to evade the difficulty. They then applied to Mr. Sax, the inventor, so well known from the instruments named after him—the saxophone and saxhorn—and so many others, such as the trumpets of Aida, etc. The numerous experiments that he has for years been making on the use of parabolic resonators led him to think that, through the combinations that had given him good results in his former inventions, he could, by means of a simple sheet of metal wound in a certain way, obtain sounds as full, grave, and imposing as with a church bell of infinitely larger proportions. He experimented in this direction for five years, and finally, in 1886, found himself sufficient master of the effect that he desired to produce to manufacture, on the order of Mr.



SAX'S MUSICAL BELL.

Lamoureux, a bell of this nature designed for the execution of Mr. Indy's "Song of the Bell," a work crowned by the City of Paris and handsomely mounted by Mr. Lamoureux at the Eden Theater. The effect produced by this instrument was surprising. It was the first time that, in an inclosed space, any one had heard sounds similar to those that escape from a church bell in powerful waves in the open air. We say "similar," because it is very clear that Mr. Sax's bells cannot replace those of churches. The latter are perfect for the purpose that they have to subserve, but in an inclosed space, those especially that give grave notes would be insupportable. The mode of construction does not require much material. It consists in rolling an ordinary sheet of 0·06 inch thick brass into the form of a cornet and soldering it, and then, through a hammer, producing superposed inflations that finally give the whole a parabolic form. It is according to the number, form, and arrangement of these inflations that the timbre, pitch, and intensity of sound obtained vary. These are details of construction that the inventor keeps to himself. Certain of his apparatus are even capable of producing several different notes, according as to where they are struck, but all with a precise intonation.

Some have the sonorousness of the tom-tom (such as the one used for executing Mr. Indy's work), while others have the true timbre of a church bell, like the one used in Patrie, and on the subject of which we shall enter into some explanation. It gives the same note two octaves lower than the 220 lb. bell at the opera, and consequently, as we have said, takes the place of a church bell that would weigh 15,000 lb. It is 20 in. in height, 27 in. at its widest diameter, and weighs 15 lb. It can be easily carried with a single finger. It gives a very clear, sonorous sound that exactly resembles, as regards timbre, that of a church bell. In order to prolong the vibrations, a bass and a counter-bass saxhorn give the same note in unison, while the ordinary bell gives it also, but two octaves above.

It is in the fourth act that this instrument is operated to give the funeral knell and produce the illusion of a large church bell.

Our artist gives in the accompanying engraving the arrangement of the side scenes during this act. In the foreground to the left is seen the leader of the chorus beating time from the electric metronome. In the center is a frame on rollers, necessitated by the 220 lb. bell, and which is utilized also as a support for the Sax bell. A portion of each bell is removed to show the difference in thickness of the two bells. Finally, to the right are the two saxhorns, and, in the background, the supernumeraries and chorus waiting the moment to go on the stage. The illusion is complete, the auditors believe that they hear a bell analogous to the large one of Notre Dame, and as we said in the beginning, there are very few who inquire how such a weight has been introduced. The fact is that directors are now performing such miracles for increasing the splendor of the *mise en scene* that the public has a right to be no longer astonished at anything. In a fairy scene now being given by a Paris theater, can we not see a genuine regatta upon a genuine river?

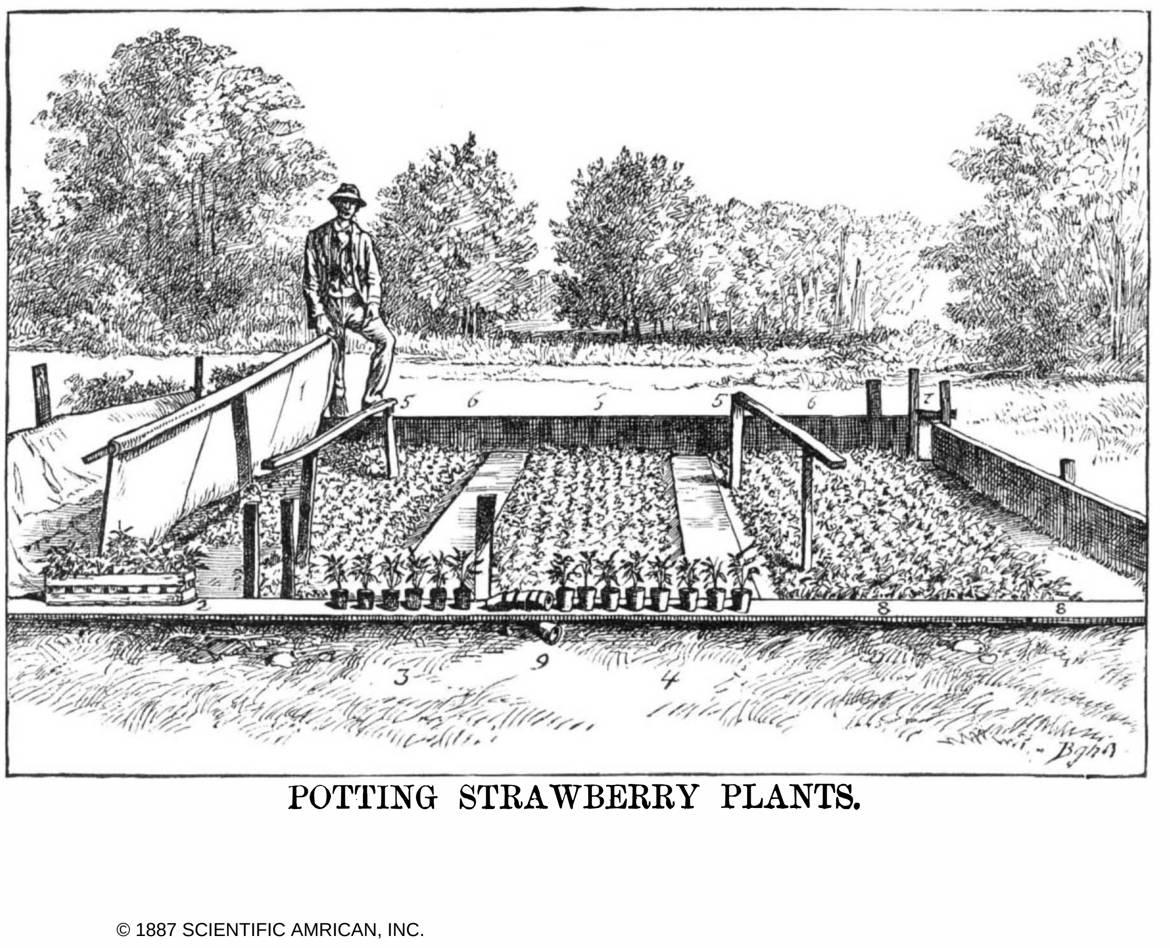
Scientific applications to theaters are becoming more and more numerous, and they probably have still more surprises in store for us. The one that Mr. Sax has just made with his new bells continues the series of happy innovations that he has already introduced into copper instruments, and that permit of introducing effects that were formerly impossible in the interpretation of *chefs d'œuvres*.—*La Nature.*

POTTING THE STRAWBERRY.

By CHARLES A. GREEN.

I HAVE not been over-enthusiastic on this subject. I have at times considered that those people who purchased potted plants, or potted for themselves, were wasting money. But H. W. Beecher has said that to change our minds is a sign of growth, therefore I am not ashamed to say that I am changing my mind regarding the potting of strawberry plants. As in everything else, we must learn how to do the work. There is a knack about it.

We have been potting for several weeks, but recently we began it in earnest. The previous night there was a fine shower, and the roots of plants dug after such a shower retain considerable earth, which is a great gain either for potting or shipping. Four good men were employed. One was sent to the field



POTTING STRAWBERRY PLANTS.

early with bushel baskets, each containing three inches of wet moss spread over the bottom, and moss to cover the young plants when dug. With one thrust of a fork he raised every plant growing on one side of the parent plant, numbering with those rooted and not rooted often 50 to 100 to each plant of the Jessie, first detaching the runners from the parent plant, permitting no exposure. One moment's exposure of such immature roots would injure them. While he was digging, the other men prepared a bed, by loosening the soil and removing all stones, etc. Then four planks, one foot wide, two of them 16 feet, two 14 feet long, were placed on edge and held in position by stakes driven into the soil, forming a parallelogram-shaped bed, with air spaces at the ends of the two shortest planks. Over this was stretched strong sheeting (white cotton cloth), stitched together by a sewing machine, the borders hemmed to make it strong. This sheet was tacked fast at one side, the opposite side being tacked to a pole 18 feet long, which enables two men to roll it up when it is desired to water the plants or to give air. The other two sides of the sheet were fastened with strips of leather hooked to a nail, and the center was upheld by two poles supported by stakes. The bed was divided into three divisions, by placing an inch board a foot wide flat across it, to be used as a walk. It would have been better to have had three boards, making four divisions.

By this time the man sent to dig the plants had returned, so all hands began to pot, setting up benches in a cool packing house, each man having a box of earth moist enough to pack well, yet none wet enough to be sticky. There must be some clay in the potting material, for if it is all sand or muck, the soil will crumble when the plant is knocked out of the pot, for shipment or planting; yet there should be some sand mixed in, and the soil should be rich, but no fresh manure should be used. As the plants had been hoed each week and the runners covered slightly, most of these young plants had some roots, but at the end of each runner was a plant on which no roots had formed. Those with no roots we did not pot, but simply left dangling, to be pressed into the moist earth bordering the pots, and held there by a small stone after the pots were placed in the bed. The partly rooted plant was held in the pot, the crown slightly below the surface, while the soil was sprinkled in evenly on all sides, without crowding the plant to one side; then the earth was pressed as firmly as possible, and the plant laid in an ordinary berry-picking stand holding thirty pots, using forty to fifty such stands. That part of the runner extending from the young to the parent plant was cut off within an inch of the young plant, but no runner promising to make a plant was removed in any case, except where several plants were rooted on one runner, in which case we removed all plants but the last one rooted, and its runners. One man was kept digging and supplying the needs of the other three. We found that a man could pot 100 in one hour, and that it required nearly as much time to set the potted plants in the bed as to pot. The entire work of the four men was the making of the bed, and potting and planting in the bed and watering 1,600 plants, besides layering the runners left on the potted plants by placing a pebble over each, which is the best plan, for if covered with earth they are apt to be buried too deep.

Many of my readers will not consider this a big day's work for four smart men, yet they worked faithfully and I was well satisfied, but the second day they will accomplish more, no doubt. I have heard of one man potting in the field, on the old plan, 1,000 per day, but conclude that this was a fable, as I think as many can be potted by this new method as by the old.

We have never potted and planted in the shaded bed without the plants wilting. Sometimes they would look as though they would never revive, yet they never failed to do so, usually looking as fresh as daisies the second morning, after having been watered each evening copiously, and kept carefully shaded. We continue the shading for nearly a week if the weather is at all hot; but the plants grow faster and root better after the removal of the shade, if not removed too soon. The plants should not be watered for forty-eight hours previous to packing or planting, as it is desirable to have the ball of earth hardened when turned out of the pot.

What is gained by this method of potting? You can multiply a new variety nearly twice as fast as by field layering without pots, and some claim a much larger increase. These potted plants can be set out in the open field during August or September, without much danger of loss (provided they are not exposed to the hot sun a moment before planting), and they will produce the finest specimens of fruit the next season—not as large a crop as old hills under hill culture, but more than plants in matted rows yield, plant for plant, under good culture, planted the year previous. These beds of potted plants, growing vigorously, are a pretty sight, and the planting of potted plants possesses a fascination to those who can afford it. They have a vacant space in the gardens, have no strawberries of the kind wanted; they can see the fruit eight months after planting; it is a novelty, and most people enjoy the experience. They may grumble when they pay expressage on so much weight, but they should understand that when ordering. But the method is most profitable to the person desiring to plant for himself that which he thus propagates.

The theory holds that the parent plant, relieved of its numerous progeny that have been sucking at its vitality, at once renews its vigor and sends out another family of young plants, and these in turn being removed and others formed, many times greater increase is given than if all were permitted to remain without molestation. This is partly carried out in practice, for the parent plant does lose vigor when the young plants begin to draw on the moisture and fertility, and it is quite impossible to reach the old plant with the hoe while thus surrounded; but just how great the additional increase I cannot state. The natural design of the plant is frustrated, and I like nature's methods as a rule, but it does appear that we can lend a helping hand at nursing these baby plants that excels fancy incubators for chickens.

Fig. 1 is a cloth 16x16 feet, used to shade the bed; 2 is a berry-picking stand filled with potted plants; at 3 are potted plants knocked out of pots; 4 are potted plants in pots; 5, support for sheet used in shading plants; 6, 6, 6, potted plants put in 24 hours previously; 7, space left at end of plank for ventilation, there is another like it at the opposite corner; these are not considered essential; 8, front plank laid down flat, to secure a better view of the interior of bed or cold frame. After this bed has been shaded a week, the planks forming the sides and the cloth cover may be removed to another spot and a new bed started.—*The Rural New-Yorker.*

DR. CORNING'S SYSTEM OF ADMINISTERING COCAINE IN PAINFUL NERVOUS AFFECTIONS.

WE present in this number of the SUPPLEMENT the portrait of Dr. J. Leonard Corning, of New York City, the well-known practitioner and writer on nervous diseases, whose ingenious inventions have done so much to popularize the use of cocaine in medicine. It is now well-known to most intelligent persons that cocaine is a substance obtained from the coca leaf of South America, and possesing the property of abolishing sensibility in nervous filaments, when brought in contact with them. In consequence of these valuable attributes cocaine has been largely employed in surgical operations, particularly about the eye. While these facts are known to most people, few are aware that cocaine promises to fill another sphere of usefulness, to wit, in the treatment of painful nervous disorders, a field quite as important as that afforded by surgery. For devising and perfecting the methods involved in the application of the drug in the treatment of those painful nervous affections, the profesion is indebted to the ingenuity of Dr. J. Leonard Corning, whose previous researches in connection with the physiology of the nervous system served in an eminent degree to qualify him for dealing with the various practical questions involved in the problem. It is in the treatment of neuralgia, that most distressing of nervous disorders, that Dr. Corning's system of administration finds one of its most useful fields of application. In carrying out his plan of nerve-medication, Dr. Corning has recourse to a systematic mode of administration, the various steps in which it will be most convenient to consider separately:

1. *The Painless Introduction of Cocaine into the Skin.*—When a sufficiently concentrated solution of cocaine is applied to a mucous surface, such as the lips, for example, the mere contact of the fluid with the tissues is sufficient, in the course of a few minutes, to abolish sensation. It is not, however, possible to apply cocaine to the skin in this manner, owing to the density and imperviousness of the tissues. For this reason it is customary to introduce the drug into the skin by the aid of the hypodermic needle and syringe, a procedure provocative of more or less pain. To remove this objection, Dr. Corning resorts to the following ingenious expedient:

To the end of a curved handle, eight inches long, a ring, an inch and a half in diameter, is secured by an appropriate bifurcation. This ring serves as the frame of a dome of fine wire gauze, with its convexity directed downward. In employing the implement, the convex surface of the wire dome is pressed against that portion of the skin which it is desired to render insensible. The instrument is held with a full grasp of the hand (Fig. 1), and considerable pressure should be exerted. If now a spray of ether, or, better, rhigolene, is thrown upon the concave side of the gauze, anæsthesia may be induced in from a second to a second and a half. This rapid action of the spray is readily understood, if it be borne in mind that the pressure of the gauze upon the part effectually occludes the vessels below it, particularly the cutaneous capillaries. As a consequence, there being no warm blood to neutralize the effect of the spray, its refrigerating action is given full play, not only on the skin, but on the parts below as well. As soon as the refrigeration is sufficient to remove all sensation in the part (this requires only about one second), the hypodermic needle is thrust in to its full length, and, while it is withdrawn, the solution of cocaine is injected into the tissues in any desired quantity. It is thus possible to anæsthetize, with great rapidity and absolutely without pain, any desired amount of tissue.

This is, beyond doubt, the most effective and practical mode of inducing painless local anæsthesia. Attempts have also been made to utilize the electrolytic action of the galvanic current as a means of introducing cocaine into the skin; but, aside from the cumbersome and expensive apparatus required, the results are uncertain, especially if the skin be somewhat thickened, as in the palms of the hands, the soles of the feet, and about the back.

2. *Medication of Deep-seated Nerves.*—When it becomes necessary, as in sciatica, to apply the cocaine to nerves which are profoundly located in the tissues, the plan to be preferred is as follows

From one hundred to two hundred minims of a one half per cent. solution of cocaine are to be injected down to the vicinity of the painful nerve. A strong and broad strap of India-rubber is then to be placed around the limb in such a way as to press upon the fluid deposited in the vicinity of the affected nerve (Fig. 2). The strap is secured with a buckle. The effect of this is twofold. In the first place, both the arterial and venous circulation being arrested, the cocaine solution is not washed into the general circulation, but remains stationary, thus exerting its effect upon the nerve as long as the strap remains. Secondly, the pressure of the strap upon the injected fluid causes the

latter to gravitate and collect about the nerve. As the strap may be allowed to remain in place for half an hour or more, the effect of this protracted exposure of the nerve to the influence of the drug must of course be great. Several cases of obstinate sciatica cured by this method have been reported.

3. *Medication* (*Anæsthesia*) *of Superficial Nerves.*—When the affected nerves are more superficially located, as in neuralgia of the face, Dr. Corning resorts to the following method in order to expose the painful nerves for protracted periods of time to the influence of the drug.

A solution of cocaine is first introduced into the skin by means of the ordinary hypodermic syringe, according to the method already described. When the painful area has been well saturated, it is covered with a

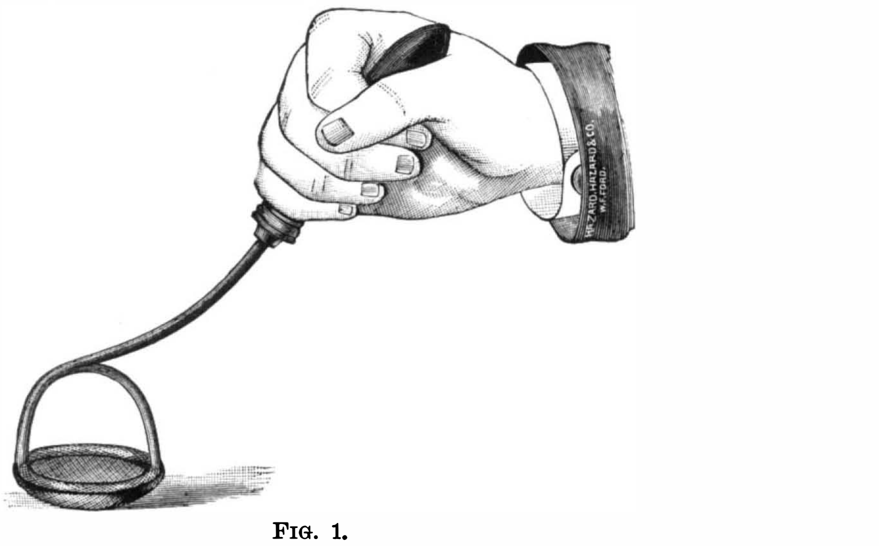


FIG. 1.

piece of fine wire gauze. By means of a T-shaped block of wood and an appropriate elastic strap (Fig. 3) uniform pressure is maintained upon the wire gauze. Fig. 4 shows this simple apparatus in position, when applied to abolish pain in the region of the temple. Fig. 5 is an exact facsimile of the wire gauze best suited to the purpose.

By means of this appliance complete cutaneous insensibility of two hours' duration has been produced upon the forehead, and several obstinate and severe cases of facial neuralgia have been entirely cured.

The physiological principles involved in this mode of treatment are easily understood. Thus, when pressure is applied upon the injected tissues by means of the gauze, block and elastic strap, occlusion of the capilla-

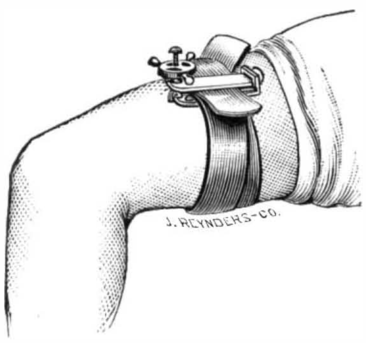


FIG. 2.

ries immediately beneath is the inevitable result. The object of the wire gauze is to distribute the pressure at given intervals throughout the anæsthetic zone, and to avoid pressing out the anæsthetic fluid into the general circulation, as would happen if pressure were made with a smooth surface. The solution of cocaine is thus enmeshed, as it were, in the gauze. This mode of inducing protracted local anæsthesia is far more effective than that involving the use of clamps, rings, bands, and the like.

In cases where the pain extends throughout the lower portion of the face, and particularly over the cheeks of thin persons, it is difficult to press the wire gauze against the integument with sufficient precision to cause occlusion of the capillaries beneath. Under these circumstances, the inventor is in the habit of tamponing the space between the teeth and the inner surface of the cheek with cotton.

This method, which is highly ingenious, reflects the greatest credit upon Dr. Corning, and it is not surprising that the profession, both here and abroad, have hastened to show their appreciation of these admirable

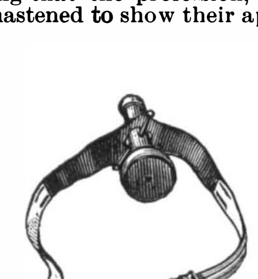


FIG. 3.

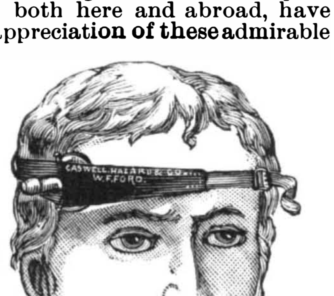


FIG. 4.

scientific achievements. As we have stated above, several severe and obstinate cases of neuralgia have already been cured by this system of treatment.

We now come to a fourth and comparatively recent step in Dr. Corning's researches in connection with the use of cocaine in the treatment of painful nervous affections.

4. *Medication of the Spinal Cord.*—Heretofore, when endeavors have been made to treat affections of the spinal cord, it has been customary to resort to medication in a purely general way—that is to say, by introducing remedies by the mouth or hypodermically. Dr. Corning conceived that a much more powerful effect might be produced if the remedy to be employed were injected down between the vertebræ into the immediate vicinity of the cord. He was led to believe, moreover, from a series of careful experiments on animals, that exceptional results might be obtained by the employment of cocaine in this way. These anticipations were subsequently verified, notably in the treatment of certain painful affections of the spinal cord.

To put this method of treatment to practical use, however, it was necessary to ascertain some method by which the physician could inform himself as to how deep the hypodermic needle could be thrust down between the vertebræ without wounding the cord. Dr. Corning solved the problem in the following manner. Having carefully examined the vertebræ of the lower portion of the spinal cord, he observed that the posterior aspect of the transverse process was about on a level with the rear surface of the cord. Perceiving at once the practical significance of this anatomical coincidence, he devised the following procedure:

A fine needle provided with a sliding nut is first thrust down to the transverse process (Fig. 6). The nut is then pushed down to the level of the skin, secured in place, and the needle withdrawn. It is now evident that the distance from the point of the needle to the nut corresponds almost exactly with that from the surface of the skin to the cord. Two or three millimeters are then subtracted to make assurance doubly

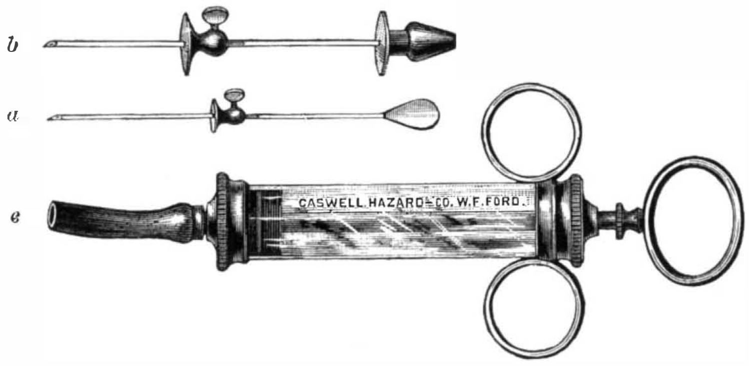


FIG. 7

sure, and the distance thus obtained is measured off upon a fine hypodermic needle, and carefully noted by the fixation of a nut provided with the necessary screw attachment. (Fig. 7, *b*.) The needle, thus guarded, is now thrust down between the spinous process until the nut rests upon the skin. A large glass syringe (Fig. 7, *c*) containing a two per cent. solution of cocaine is now attached to the needle; and by a movement of the piston the anæsthetic is forced down into the vicinity of the cord, immediately after which the needle is withdrawn.

The effect of this mode of medication is said to be exceedingly rapid and effective, especially in certain painful nervous difficulties due to disease of the spinal cord. The method itself certainly reflects great credit upon the scientific and practical intuitions of its author.

5. *Method of Avoiding Injury to the Veins.*—As the introduction of the anæsthetic into the part involves

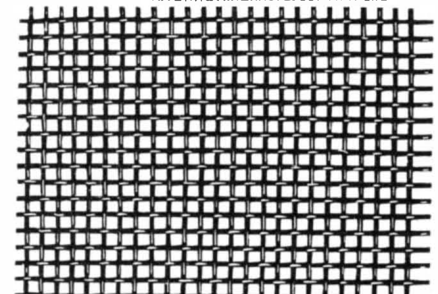


FIG. 5.

the employment of the hypodermic needle, it is of importance to avoid injury to the veins by reason of the numerous punctures. To attain this end, especially about the extremities, where the veins are exceedingly numerous, Dr. Corning resorts to the following expedient, which he terms "mapping out the veins:"

A piece of ordinary elastic webbing is passed around the limb, above the point to be operated upon, and drawn sufficiently tight to interrupt the circulation in the superficial veins, but not sufficiently so to cause interference with the arterial blood flow. (Fig. 8.) While the elastic is securely held in place by the hand of an assistant or by a simple buckle, he is in the habit of tracing out the course of the distended veins by means of an ordinary blue crayon pencil, which latter should be soft, in order to prevent scratching or other injury to the integument. In making injections the operator easily avoids these pencil marks. The whole process occupies but a few minutes, and may be performed by the veriest tyro in pictorial art.

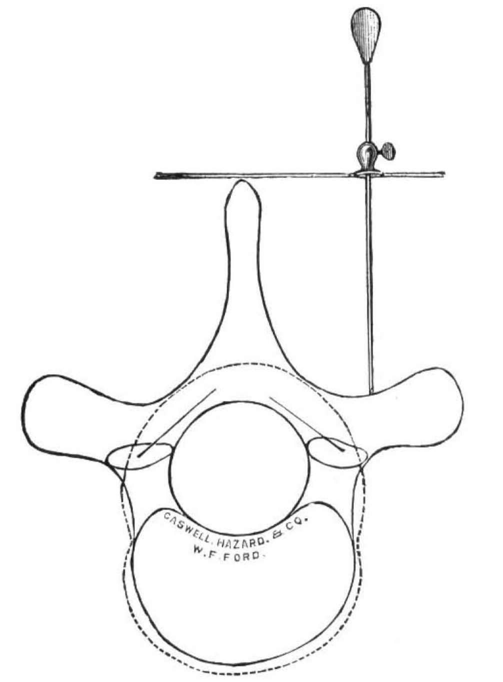


FIG. 6.

We are indebted for most of the above scientific data to the *New York Medical Journal* and the *New York Medical Record*. The excellent portrait of Corning is an enlarged copy of a likeness which appeared in the *Virginia Medical Monthly*.

Dr. Corning comes of an old New England family, his maternal ancestor, John Deming, having been a patentee of the State of Connecticut, under the famous charter of Charles the Second (1662).

His grandfather, Julius Deming, held two commissions under George Washington, and served with the continental army at Valley Forge.

Valuable as are the researches which form the subject of this sketch, they constitute but a small portion of Dr. Corning's scientific contributions, as the following list of his more recent writings, taken from the *Virginia Medical Monthly*, abundantly testifies:

"Prolonged Instrumental Compression of the Primitive Carotid Artery as a Therapeutical Agent," *Medical Record*, Feb. 15, 1882; "Carotid Compression," a

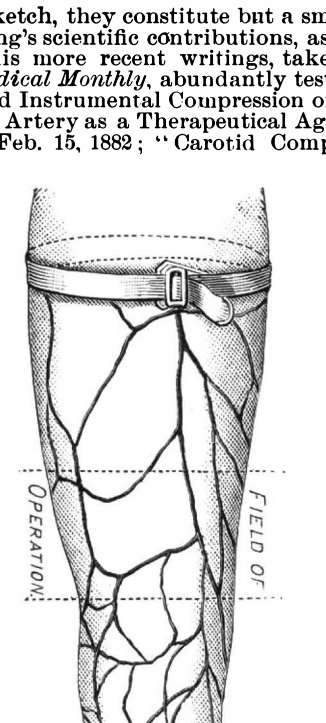


FIG. 8.

monograph published by Anson D. F. Randolph & Co., New York, 1882; also a paper on this and kindred topics read before the New York Neurological Society, and published in the Philadelphia *Medical News*, June 17, 1882; and an article on "Sleep," in the *Medical Record*, July, 1882; an article in the *Medical Record*, April 7, 1883; "Brain Rest, being a Disquisition on the Curative Properties of Prolonged Sleep," G. P. Putnam's Sons, New York and London, first edition 1883, second edition 1885; a paper "On the Nature of Nervousness," *Medical Gazette*, Nov. 24, 1883; a paper on "Cerebral Exhaustion," read before the Medical Society

of the County of New York, and published in the *New York Medical Journal*, Dec. 29, 1883; a paper entitled "Can Insanity be Philosophically Defined?" *Medical Record*, Dec. 1, 1883; a paper entitled "Considerations on the Pathology and Therapeutics of Epilepsy," *Journal of Nervous and Mental Disease*, vol. x., No. 2, April, 1883; an article on "Electrization of the Sympathetic and Pneumogastric Nerves, with Simultaneous Bilateral Compression of the Carotids," *New York Medical Journal*, Feb. 23, 1884; a paper "On the Prolongation of the Anæsthetic Effects of the Hydrochlorate of Cocaine when Subcutaneously Injected, an Experimental Study," *New York Medical Journal*, Sept. 19, 1885; "Prolonged Local Anæsthetization by Incarceration of the Anæsthetic Fluid in the Field of Operation," *New York Medical Journal*, Jan. 2, 1886; "Local Anæsthesia," D. Appleton & Co., New York, 1886. Among his other works are "Brain Exhaustion, with Some Preliminary Considerations on Cerebral Dynamics," D. Appleton & Co., a book which met with a large sale, and an altogether favorable reception by the profession. Besides the last mentioned works are a paper on "Artificial Epistaxes," *New York Medical Journal*, June 13, 1884; and "Spinal Anæsthesia and Local Medication of the Cord," *New York Medical Journal*, Oct. 31, 1885.

SPENCER FULLERTON BAIRD.

PROFESSOR BAIRD, for many years at the head of the National Museum in Washington, died at Wood's Holl, Mass., on Friday, August 19, 1887. He was among the best known of American naturalists, and his monographs on the subject of his researches were extremely numerous. Nearly 1,200 titles have been catalogued, representing a life of great industry. He was born in Reading, Pa., February 3, 1823. He was named from an ancestor, the Rev. Elihu Spencer, a famous patriot preacher of the revolution, upon whose head a price was set by the British government.

Prof. Baird showed his taste for natural history early in life. When but 14 years old he, with his brother, began to make a collection of the birds of Cumberland County, Penn. This formed the nucleus of the great collection in the Smithsonian Institute. The brothers soon began to contribute papers to the Philadelphia Academy of Sciences. Audubon, the great ornithologist, became interested in the young scientist, and by correspondence and exchange of specimens did much to advance his work. Their friendship lasted until the death of the older man. He graduated from Dickinson College when but 17 years old, and a few years later was appointed professor of natural history in the same institution. This was in 1845. Before this, in 1842, he had studied medicine at the New York College of Physicians and Surgeons. This course he did not complete, though in 1844 he received the degree of M. D. *honoris causa* from the Philadelphia Medical College. In 1847 he became associated with Agassiz, and projected with him a work on the fresh water fishes of this country. The work was never executed.

In 1850 his long connection with the Smithsonian Institution began, in his election to the post of assistant secretary. On the death of Prof. Henry, in 1878, he was appointed secretary, and succeeded to the general management of the Institution. Meanwhile in 1871 he had received from President Grant the appointment to the position of United States Commissioner of Fishes and Fishery. In these two positions the greater part of his life's work was done.

As assistant secretary and secretary of the Smithsonian Institution, he for 35 years edited the annual reports of the Smithsonian Institution, thus largely shaping the public records of the Institution. As fishery commissioner he did much to propagate fresh and salt water fish, and to import new available species. He established hatching stations along the coast, from which in each season vast quantities of living fish were distributed. Three or four million shad were hatched each season; Spanish mackerel were successfully raised; salmon, great quantities of whitefish, and German carp were sent out to the lakes and streams. Thus the food supply of the country was largely increased.

The majority of his writings were on subjects of natural history, but they sometimes took a wider range. Thus, in 1849, "The Iconographic Encyclopedia" was published in New York. This was largely a translation from the German "Bilder Atlas" of Heck, a supplement to the well known Bockhaus' "Conversations Lexicon." It was issued in four 8vo volumes of text and two 4to volumes of plates. Prof. Baird was assisted in it by several specialists. In 1857 and 1858 two works by him on "Mammals of the United States" and the "Birds of North America" appeared in a series entitled "Report of the Survey of the Railroad Routes to the Pacific," forming vols. viii. and ix. of the series. Under the auspices of the Smithsonian Institution he published his "Review of American Birds in the Museum at the Smithsonian Institution."

His services to natural history were everywhere recognized. Over 30 distinct genera and species have been named in his honor. Medals were received by him from various societies, the Acclimatization Society of Melbourne in 1878, the Societe d'Acclimation of France in 1879, and the International Fisherei Austellung (the gift of the Emperor William) in 1880 thus honoring him. The same emperor awarded him a silver vase set with precious stones. The King of Norway and Sweden decorated him as knight of St. Olaf in 1875. He was one of the early members of the National Academy of Science, and was for two years permanent secretary of the American Association. He received several college degrees, and as trustee or member was widely connected with societies and institutions.

He was large and robust, covering, it is said, in his pedestrian excursions as much as sixty miles in a day. He was very communicative, and was always as anxious to learn as to impart his own knowledge. From his labors he sought relaxation in the lighter literature of the day. His labors represent, however, work enough for several ordinary lives.

THE following is a good etching solution much used among German printers for zinc plate in lithographing: Boil one and one-quarter ounces of bruised nut galls in one pint of water, until it is reduced to one-third; strain, and add two drachms of niter and four drops of acetic acid.

[NATURE.]

THE PARIETAL EYE IN FISHES.

THE discovery of the parietal eye in lizards by De Graaf and Spencer* is so recent that it is hardly necessary to preface an account of the structure of that organ in another group with the history of their researches.

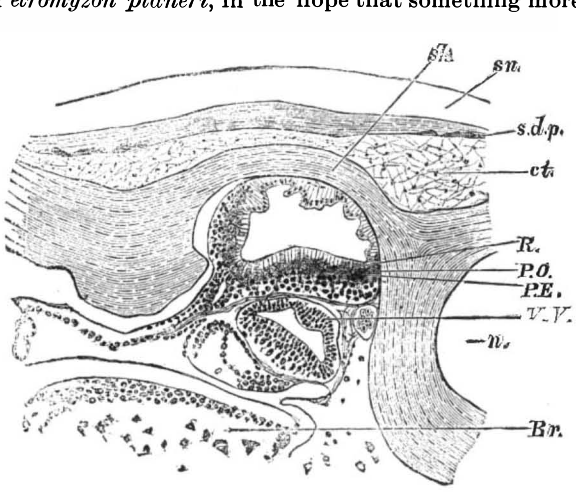
Its high development in some lizards and, so far as we know, its rudimentary nature in all other existing groups of vertebrates, including fishes and amphibia, and lastly its entire absence in amphioxus, are, for those who see in the latter the "urvater" of the chordata, points which made it difficult to form any satisfactory morphological conception of its origin.

True, something that admitted of comparison with it could be found in larval ascidians; and Spencer, at the end of his able paper, endeavored to trace its "rise and fall" from its supposed homologue, the larval tunicate eye.

With Wiedersheim and Carriere, I consider that Spencer has placed the eye of the larval tunicate at the wrong end of the series—if it should come in at all; for, as experience has abundantly shown, it is very easy to compare organs of the higher vertebrates with what are supposed to be homologous organs in amphioxus and the tunicata, and at the same time to be entirely in error. I need hardly refer the reader to the instances in which such comparisons have been shown by Dohrn in his famous "Studien" to have been entirely wrong; and holding with him that amphioxus and the tunicata are very degenerate vertebrates, and that from them but little can be got for the elucidation of the problems of vertebrate morphology, I felt the necessity of looking elsewhere for the solution of that of the parietal eye in its relations to the paired eyes.

With these problems in view I began to study the development of the pineal eye, and also its structure in such fishes as might be expected to retain it in a more developed condition than most of those we know.

At Prof. Wiedersheim s suggestion I examined the structure of the "pineal gland" in ammocœtes of *Petromyzon planeri*, in the hope that something more



Longitudinal vertical (sagittal) section through the parietal eye of an adult *Petromyzon planeri* [Zeiss C. oc. 2 cam.] *br.*, brain; *c. t.*, connective tissue; *n.*, position of nose; P. E., pigment of the retina; P. O., parietal eye, *i.e.*, dorsal vesicle of the epiphysis; R., retina; *s. d. p.*, subdermal pigment; *sk.*, skull; *sn.*, skin; V. V., ventral vesicle of pineal gland.

might come out beyond that which the able work of Ahlborn has already made known to us. The result was, in a sense, disappointing, but not unexpected, for remembering Dohrn's researches, and bearing in mind that the paired eyes of petromyzon are rudimentary in ammocœtes, first becoming capable of vision in the adult, I had firm hope of good results from the examination of sexually mature animals.

In the adult the discoveries made exceeded my expectations; and after examining this animal I proceeded to make sections through the brain of myxine. Here, again, the finds were important, and the research was extended to specimens of *Bdellostoma* and *Petromyzon marinus*, which I owe to the generosity of my former teacher, Prof. Howes.

Before giving the detailed account of my investigations, I may say that neither the anatomical nor developmental studies so far made give any direct clew to the origin of the organ.

That which seems to me the most likely hypothesis I shall give at the end of this paper, and in its favor I can at least say that it is a morphological explanation of the evolution of the parietal eye, which, so far as I know, is not inconsistent with any known facts.

The epiphysis in ammocœtes has been described by Ahlborn (*Zeitsch. f. wiss. Zool.*, Bd. xxxix.). His description is mainly correct, and but little can be added to it. The epiphysis itself is divided into a dorsal and a ventral vesicle, and as we are not concerned here with the ventral one, I shall ignore its existence.

In large ammocœtes the dorsal vesicle lies deep under the skin, and far removed from the light; its position being marked externally by a clear white spot just behind the opening of the nose.

It is a simple closed sac, and retains its attachment to the brain. The dorsal wall is thinner than the ventral, and is made up of a layer of flattened cells, which are not modified to form a lens.

The ventral wall is a much more complicated structure. Toward the inside of the vesicle it presents a layer of rod-like cells, which are more like the rods of a retina than like anything else. Externally (with regard to the vesicle) to this layer are two or three irregular rows of nuclei. There is no lens and no pigment, except a few very minute dots.

In this stage the retina of the parietal eye of ammocœtes somewhat resembles that of *Cyclodus*, figured by Spencer, but is somewhat better developed and tends toward the condition found in *Varanus giganteus*.

Except in the presence of the minute dots of pigment, and in the fact that the dorsal wall of the vesicle is not connected by fine strands with the ventral wall, as Alhborn supposed, there is nothing new in this description, and even now we cannot say that the parietal eye of fully grown ammocœtes is very highly developed.

In the adult petromyzon, just as the paired eyes are highly developed, so also do we meet with an increased development of the parietal eye. As is well known since Wiedersheim's researches, the brain of the adult is much compressed in an antero posterior direction. The dorsal vesicle of the pineal gland lies much further forward, and more dorsally than in the larva, so that it comes to be nearer the external surface of the body while it lies buried in the roof of the skull. Its posterior wall is densely pigmented, so much so that it is impossible by ordinary means to make anything out of the structure of the cells composing it. These points can be seen very plainly in longitudinal vertical sections through the brain and skull (see figure).

I ought to mention that the clear white patch of skin lying above the organ is much larger and more marked than in the ammocœtes. It is, however, difficult to suppose that the white patch is here of much physiological importance, and it can only be referred back to a time when the eye in petromyzon was of more use than at present. The anterior wall is composed of cells which are thrown into folds (possibly in part due to contraction) projecting into the cavity of the vesicle.

I mentioned above that in the full-grown ammocœtes there are only a few minute dots of pigment present. So few and so small are these, that unless specially sought for they would be overlooked, as indeed they have been by previous observers. The state of things is much different in the young ammocœtes of about two inches in length. There, as in the adult, the retina of the parietal eye contains a large deposit of pigment. This was first shown me by Dr. Schwarz (a pupil of Prof. Weismann's), who has made, for the study of the paired eyes, some very fine sections of very young ammocœtes, at stages which I had failed to obtain. I shall figure these sections in the complete account I have in preparation. In the young ammocœtes the parietal eye is large, and exceeds in size either of the paired eyes. Its posterior wall is really a well developed retina, with long rod-like elements embedded in pigment, and a series of outer layers of spherical nucleated bodies. Its anterior wall consists of several layers of rounded cells, but it does not form a lens.

In the specimen of *Petromyzon marinus* mentioned before, owing to the soft state of the brain, I could only make out a very deep fossa in the skull in the position in which the "eye" is situated in *P. planeri*. The white patch of skin is here very large indeed, and on the whole I am inclined to think that the parietal eye in *Petromyzon marinus* would well repay further investigation.

In myxine the state of things is even more surprising. Here the parietal eye is a large flattened vesicle lying on the brain and connected with it by a very short solid stalk. There is externally no white patch of skin, but lying in the skin above the vesicle there is a flattened body, which, in structure and position, more nearly resembles the "Stirn-drüse" of amphibians than anything else. This "Stirn-drüse," as is well known, is a rudimentary portion of the epiphysis, and hence of the parietal eye.

There is no lens and no pigment in myxine. The anterior wall of the vesicle consists of a single layer of somewhat flattened cells.

The retina has essentially the structure of that of the parietal eye of varanus, but it lacks the pigment which is there present (*vide* Spencer, "Pineal Eye in Lacertilia," *Q. J. M. S.*, vol. xxvii., Part 2, Plate XIV., Figs. 1 and 6).

Bdellostoma seems in this and, as was first shown by Johannes Muller, in other points in the structure of its brain, to resemble myxine. Without discussing the matter at length, I may say that in the parietal eyes of petromyzon and myxine we have to deal with structures which are still well developed, and which were probably once much more developed than now. In this connection the history of the changes in ammocœtes is very interesting, and all the more so as confirming and extending Dohrn's opinion that the cyclostomata have degenerated from highly developed fishes. The parietal eye in ammocœtes, like many other of its organs, makes a good start, and only degenerates as the ammocœte degenerates. When the petromyzon state is reverted to, the parietal eye, like the animal in which it occurs, reverts toward an ancestral condition, and its doing so is an additional point in favor of Dohrn's opinion that the change to the adult petromyzon is a sort of atavism.

Myxine, though in other respects more degenerate than the adult petromyzon, retains the structure of the retina in a somewhat more specialized condition, one which most nearly recalls the highest parietal eye presented to us by the lacertilia.

With regard to the development of the eye in lizards, the only point I will now mention is one which was to be expected to hold, viz., that the lens develops as a thickening of the anterior wall of the vesicle. I may add, however, that it shows signs of a tendency to involution.

And now, without discussing Spencer's speculations, I will briefly state my idea of the manner in which the parietal eye was evolved in connection with the paired eyes.

From the start of my investigations I was fully convinced that the evolution of all three eyes must be viewed from one common starting point. The fact that, as Wiedersheim states, even in man nerve-fibers have been traced from the optic thalami to the pineal gland, is sufficient evidence for this, even if we did not know that all three eyes arise in connection with the same portion of the brain. The hypothesis is an extension of that given by Wiedersheim, Carriere, Dohrn, and others, to account for the evolution of the paired eyes.

The starting point is a dorsal optic plate before the neural folds begin to form. This gives us a dorsal eye on the so-called invertebrate type. When the neural folds began to form so as to involute the brain and spinal cord, the optic plate was of course, being part of the brain, involved in the involution. With the progression of the latter it probably increased in size, and extended somewhat over the lateral margins of the neural folds.

When the neural folds closed and shut in that which forms the optic vesicles, part of the optic plate was left, forming the rudiment of the parietal eye. This, just as all known sense organs tend to get involuted, got also

* See SUPPLEMENT, No. 582.

secondarily involuted, and that but slowly, so that the outside wall of the involution had time to become a lens, an eye being thus formed on the invertebrate type. The parietal eye, being closely bound up with the paired eyes, got secondarily involuted with them; and losing its primary mode of origin by delay in its development, it now appears as a secondary outgrowth of the brain, in which the lens is still formed from the outer wall. The lens, moreover, possibly retains traces of an involution.

Spencer has not attempted to grapple with the difficulty involved in the fact that the rods of the retina of the paired eyes are turned from the source of light, while in the parietal eye they are turned toward it.

The explanation given above is not in contradiction with this state of things; it, in fact, receives support from it.

In the complete paper I shall discuss the matter at length, and give ample illustrative figures.

J. BEARD.

Anatomisches Institut, Freiburg i/Br., June 21.

SOME IMPORTANT DISCOVERIES IN THE LIFE-HISTORY OF THE HOP PLANT LOUSE (*Phorodon humuli*, Schrank).*

By C. V. RILEY, M.A., Ph.D.

THE author has been for several years carrying on investigations with a view of ascertaining the full annual life-history of *Phorodon humuli*, and especially with a view of settling the hitherto mooted question as to its winter life. The importance of the inquiry, from both the economic and the scientific sides, is self-evident. The hop crop, in all parts of Europe where it is grown, and especially in England, annually suffers more or less from the ravages of this, its worst insect enemy, and in some years is a total failure. The same is true in North America, at least east of the Rocky Mountains, and last year the injuries of this Phorodon in the hop-growing regions of the State of New York were so great that many hop yards were abandoned and have since been plowed up, while but ten per cent. of an average crop was harvested. From the purely scientific side, entomologists, notwithstanding the great interest attaching to the subject, have been divided in opinion as to the identity or specific relationship of the hop Phorodon and one that occurs on Prunus, while the full annual cycle of the insect's life has remained a mystery. After full and satisfactory investigations, Prof. Riley has satisfied himself that, contrary to the prevailing impression among hop growers and previous investigators, the hop plant louse does not hibernate under ground on the roots of the hop, nor in, on, or about anything in the hop yard, but that upon the advent of the first severe frosts the hop plant and the hop yards are entirely cleared of the species in any form. He finds that all statements to the contrary in this country are based on misapprehension or mistaken identity of species, and expresses the belief (though admitting the possibility of variation in this respect in milder climates) that the same will be found to hold true in England, where hibernation on the hop root has been accepted by high authority. The positive statements made about eggs being laid in autumn, whether on roots or upon the vines left in cutting or which are carted away, are based on conjecture, and have been blindly copied without credit by one writer from another—a practice too common among second-hand writers on economic entomology.

The conjectures of some of the best students of aphidology that *Phorodon humuli* had a form (*mahaleb*, Tonsc.) living on Prunus, and that there was a consequent migration from one plant to the other, have been positively proved to be correct by direct colonizing from Prunus to Humulus and by continuous rearing from the original stem mother hatched from the winter egg.

The observations have been made on growing plants and in vivaria at Washington and checked by others made simultaneously in hop yards at Richfield Springs. An incident is recorded as illustrating the effect of meteorological extremes upon Aphides. The extreme heat and dryness of July 17 and 18 killed every one of the insects under observation at Washington, entirely clearing the plants. The economic bearing of such exceptional phenomena is discussed, as also of the biologic observations made.

The more important conclusions of the author, from his studies so far made, are summed up as follows:

PHORODON HUMULI

hibernates in the winter egg state, which is fastened to the twigs of different varieties and species of Prunus, both wild and cultivated. The egg is difficult to detect because it is covered with particles which resemble the bark in color and appearance.

2. The annual life cycle is begun upon Prunus by the stem mother which hatches from this winter egg.

3. Three parthenogenetic generations are produced upon Prunus, the third becoming winged and instinctively abandoning the plum and migrating to Humulus. The habit of moving from plant to plant after giving birth to an individual, and thus scattering the germs of infection, is well marked in this winged generation.

4. During the development of the three plum-feeding generations the hop is always free, and subsequently, until the return migration, the plum becomes more or less fully free from infection by this species.

5. A number of parthenogenetic wingless generations are produced on the hop (seven, or the tenth from the stem mother on plum having been traced up to August 5), and finally there is a return migration of winged females to the plum in autumn.

6. Exact observations are not yet complete as to the full number of generations produced upon the hop before the winged return migrate appears, and another month's careful watching and experiment is needed to fill this hiatus in the annual cycle, as also to ascertain the exact number of generations produced in autumn on the plum. From knowledge extant and previous general observation, the facts will probably prove to be as follows:

7. The tenth or eleventh generation will produce winged females (about the middle of August) which will deposit their young upon the plum, and these will become the only sexed individuals of the year, the male winged and the female wingless, the latter after coition consigning a few impregnated or winter eggs to the twigs.

8. At the date of writing (August 5), the first females on hop are still alive and breeding, having existed two months. There is, consequently, an increasing admixture of generations, from the first on hop until frost overtakes the species in all conditions and sweeps from the face of the earth all individuals alike, perpetuating in the egg state those only which reached the sexual condition on the plum.

9. Each parthenogenetic female is capable of producing, on an average, one hundred young (the stem mother probably being more prolific) at the rate of one to six, or on an average of three per day, under favorable conditions. Each generation begins to breed about the eighth day after birth, so that the issue from a single individual easily runs up in the course of the summer to trillions. The number of leaves (700 hills, each with two poles and two vines) to an acre will not much exceed a million, so that the issue from a single stem mother may blight hundreds of acres.

10. While meteorological conditions may materially affect the increase and power for injury of the species, these are far more truly predetermined and influenced by its natural enemies, many of which have been studied and will be described.

11. The slight colorational differences, as also the structural differences, including the variation in the cornides on head and basal joints of antennæ, whether upon plum or hop, are peculiarities of brood and have no specific importance whatever.

12. The exact knowledge gained simplified the protection of the hop plant from Phorodon attack. Preventive measures should consist in destroying the insect on plum in early spring where the cultivation of this fruit is desired, and the extermination of the wild trees in the woods wherever the hop interest is paramount. Also in avoiding the introduction of the pest into new hop countries in the egg state upon plum cuttings or scions. Direct treatment is simplified by the fact that the careful grower is independent of slovenly neighbors, infection from one hop yard to another not taking place. Experiments still under way have shown that there are many effective remedies, and that the ordinary kerosene emulsion diluted with twenty-five parts of water and sprayed with the cyclone nozzle, or a soap made by boiling one pound of pure potash in three pints of fish oil and three gallons of water, and this dissolved in eight gallons of water and sprayed in the same way, are thoroughly effectual remedies and leave the plant uninjured. The former costs seventy-five cents, the latter thirty cents per acre, plus the time of two men for three hours, plus appliances. The object of further experimentation now being carried on is to simplify and reduce the cost of these last to a minimum.

* Abstract of a paper read before the Society for the Promotion of Agricultural Science.

HOW TO MAKE AN INCUBATOR.

THE cuts in this issue are from the *Farm and Garden*, which gives its name also to the incubator. We call attention to the following improvements:

1. The ventilation is from the *front* (may be at side

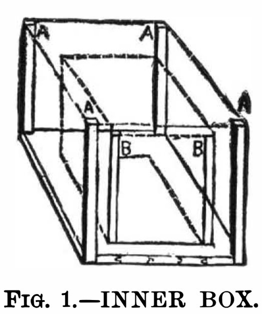


FIG. 1.—INNER BOX.

or back if preferred), which permits of controlling it, as it may be shut off with a plug, or left open, and it avoids the old method of bottom draughts.

2. The egg drawer is made a little deeper, and three *trays* placed in the drawer. This permits of changing the trays, thus having the eggs at the front, middle, and back by turns, so that they are all heated alike. Another advantage is that the eggs can be placed closer to the heat by placing strips under the trays, or they may be removed from the source of heat by taking out the strips. This is excellent in cases where the temperature is too high or too low.

3. All the dimensions are here given, and marked on the cut (Fig. 2). For instance, from bottom of incubator to bottom of egg drawer is 5 inches, then 5 more make 10, and 8 more make 18 inches—all marked, for inside box—and the same throughout.

4. The directions for operating are based on results of a number of hatches, and the operator should follow them closely. Read the whole very carefully.

5. In repeating this incubator, we do so in order to make it *plainer* than before, and the cost for *material* is about $10.

HOW TO MAKE THE INCUBATOR.

First get good boards, 1 in. thick and 1 ft. wide. Cut them 46 in. long for your floor, and have the floor 42 in. wide. Place four posts, which are 24 in. high, at each corner (Fig. 1), marked A A A A, and two posts (B B) in front, the two front posts to be 18 inches high. Make posts of 2 × 3 strips and nail them securely to the floor. Fasten the floor boards together by strips underneath, using as many as preferred. The four corner posts are for your

OUTER BOX.

This box, when finished, is 4 ft. long and 44 inches wide, outside, provided it is made of boards one inch thick. Including its top and floor, it is 26 in. high. Nail on your side boards. Let rear and front end boards cover ends of side boards. After the tank is in and the top of the *inner box* is on, cover inner box with sawdust, and nail down the top of outer box. Tongued

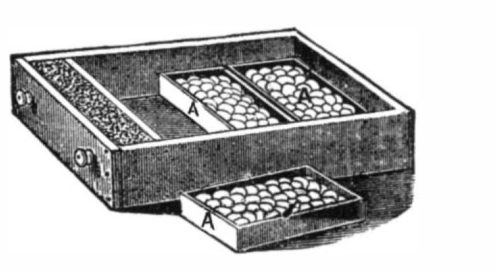


FIG. 3.—EGG DRAWER.

and grooved boards should be used for every part of the incubator except the floor, which should be of heavy boards. All the measurements given here, however, are for boards one inch thick, but three-quarter stuff may be used if desired.

INNER BOX.

This holds, or rather comprises, ventilator, egg drawer, and tank. It is 40 in. long and 32 in. wide, outside measurement, and must hold a tank 30 × 36. The side boards are nailed to the posts, B B (Fig. 1), and front boards of outer box, and fastened at the rear end by the rear boards being nailed to the ends of the side boards. Cleats are put on end and sides (on the floor), to fasten the inner box to the floor. Nail the bottoms of the side and rear end boards to the cleats.

To make the inner box, refer to Fig. 2, which has portions of the outer and inner boxes torn away, to show interior. A is the large or outer box; B is the inner box; C C are strips 1 in. wide and 1 in. thick, nailed to sides of inner box; D D are strips 1 in. wide and 1 in. thick, nailed to sides of inner box.

The strips, C C, with iron rods half an inch thick (F F F F), hold and support the tank. Let ends of iron rods extend a little into sides of inner box, to assist in supporting the weight of water. The strips, D D, are to hold the egg drawer. E is a tin tube, 1¼ inches in diameter and 2 ft. long, placed in the front part of the ventilator to admit air. Observe, however, that Fig. 2

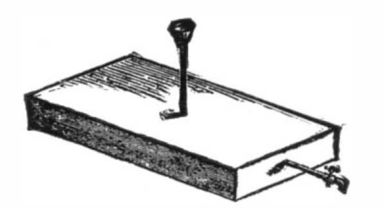


FIG. 4.—TANK.

does not show the sawdust in front, as will be explained. We will now take up the separate parts. First is the

VENTILATOR.

This is simply the bottom of the inner box, being under the egg drawer, 5 in. deep and 30 in. wide (the side boards of the inner box being its sides). The front end is boxed off, which includes the front boards and also the sawdust, thus making ventilator *inside* measurement 36 in. long. E is the tin tube for the admission of air, before mentioned. Use no sawdust in the ventilator, but paper the bottom well and close, so as to have no air enter except through the tin tube.

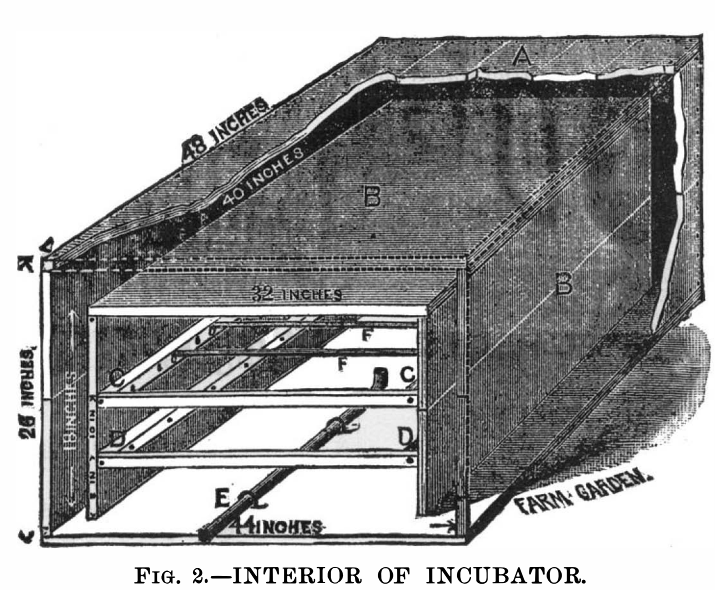


FIG. 2.—INTERIOR OF INCUBATOR.

The tin tube is open at the front on outside of incubator, and enters into ventilator.

EGG DRAWER.

The egg drawer goes *under* the tank, and rests on the strips, D D (Fig. 2). The egg drawer is 4 in. deep, outside measurement. It is 39 in. long, outside measure-

ment (which includes the boxed-off portion in front of drawer), and is 30 in. wide. Three movable trays, each 1½ in. deep, are fitted in egg drawer. Nail strips one inch wide and five-eighths of an inch thick, one inch apart, the length of the egg drawer (but not under boxed-off portion), for the bottom. Mortise ends of strips in egg drawer, so as to have the bottom smooth. Tack a piece of muslin on these strips (thin muslin is best), and tack it on the *inside* of the drawer. Now nail strips to bottoms of trays (use lath, if desired, cut to one inch width), but you need not mortise them. Simply nail them on the bottom, one inch apart, running lengthwise, and tack muslin on the bottom of the trays, *inside*, in the same way as for egg drawer. The inside of your drawer will be 3 inches deep. The sawdust in front of egg drawer (the boxed portion fits in

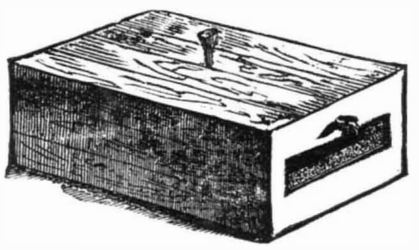


FIG. 5.—INCUBATOR READY FOR THE EGG DRAWER.

boxed front of incubator—see Fig. 5). Put a broad cap on outside of egg drawer, at front end, to exclude air.

THE TANK.

This is 30 × 36 inches, and is 7 in. deep. It is supported by the strips, C C, and rods, F F F F (Fig. 2). Being 36 in. long, it goes close up to the *back* boards of the inner box, the front being inclosed by a sliding board, secured with upright strips at each end of board one inch in diameter (so as to remove tank when necessary), which leaves a small space in *front* of the sliding board to be filled with sawdust. Have the tank tube in front only long enough to extend through the sawdust in front, and have your faucet to screw into this tube, the tube being threaded. The tube on the top of the tank should be long enough to extend through the tops of *both* boxes (outer and inner, through the sawdust), and should, therefore, be 7 inches high from top of tank, as is seen at Fig. 5. When the incubator is ready, we have Fig. 5, which shows the sawdust packing in front, by looking into the opening into which the egg drawer enters when filled with eggs.

Fig. 6 shows the incubator as if cut in half lengthwise, and displays all the positions. What is meant by the "boxed-off" portion in front is that portion filled with sawdust in front. The side boards of the

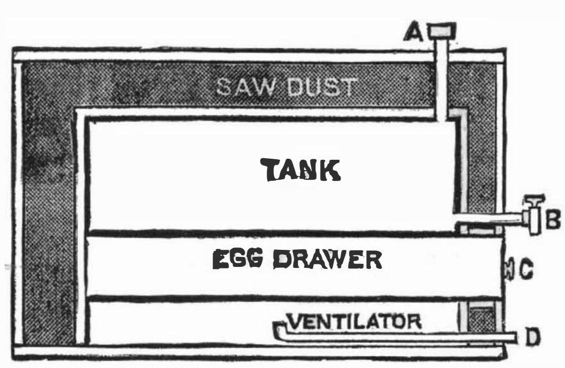


FIG. 6.—SECTIONAL VIEW OF INCUBATOR.

inner box are joined, on their front ends, to the front boards of the outer box, being also nailed to the two short middle posts. Fill in between the boxes with sawdust, and if sawdust is scarce, use chaff, oats, finely cut hay (rammed down), or anything that will answer, but sawdust or chaff is best. In Fig. 6, A is the tube on top, B the faucet in front, C the opening for the egg drawer, and D the tube to admit air into the ventilator. This tin tube should be as close to the bottom of the ventilator as possible. When making incubator, do not forget to cut holes for tubes of tank and also for air tubes to come through, and then putty around them.

DIRECTIONS FOR OPERATING.

Each tray holds about 80 eggs, laid in promiscuously, the same as in a nest, making total number for incubator 240 eggs. First fill the tank with *boiling* water, but never allow it to remain in the tube on top, as it thus increases pressure; hence, when tank is full to the top of the tube, draw off a gallon of water. Fill it 48 hours before putting eggs in, and have heat up to 115° before they are put in. As the eggs will cool down the heat, do not open the drawer for 6 hours, when the heat should be 103°, and kept as near to that degree as

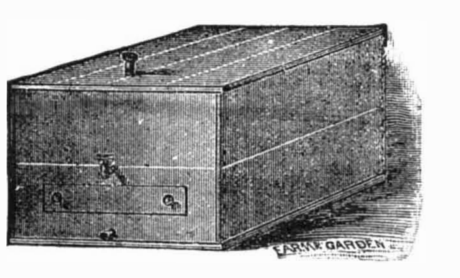


FIG. 7.—INCUBATOR COMPLETE.

possible, until the end of the hatch. It is best to run it a few days without eggs, to learn it thoroughly. Place incubator in a place where the temperature does not fall below 60°. As the heat will come up slowly, it will also cool off slowly. Should the heat be difficult to bring up, or the eggs be too cool, you can raise or lower the trays, using small strips under them. You can also stop up or open the air tube in the front opening of the ventilator whenever you desire. When the eggs are put in, the drawer will cool down some. All that is required then is to add about a bucket or so of water once or twice a day, in the morning and at night, but be careful about endeavoring to get up heat suddenly, as the heat does not rise for 5 hours after the additional bucket of water is added. The cool air comes from the ventilator pipe, passing through the muslin bottom of the egg drawer to the eggs. Avoid opening the egg drawer frequently, as it allows too much escape of heat, and be careful not to open when chicks are hatching, unless compelled, as it causes loss of heat and moisture at a critical time. *Cold draughts* on the chicks at that time are fatal. Do not oblige visitors. *Be sure your thermometer records correctly*, as half the failures are due to incorrect thermometers, and not one in twenty is correct. Place the bulb of the thermometer even with the top of the eggs, that is, when the thermometer is lying down in the drawer with the upper end slightly raised, so as to allow the mercury to rise, both the bulb and eggs should be of the same heat, as the figures record the heat in the *bulb*, and not in the tube.

Turn the eggs twice a day at regular intervals—six o'clock in the morning and six o'clock at night. Do not let them cool lower than 70°. Turn them by taking a row of eggs from the end of the tray and placing them at the other end, turning the eggs by rolling them over with your hand. By removing only one row you can roll all the rest easily. Give no moisture the first week, very little the second, and plenty the third week. Do not sprinkle the eggs. For moisture, put a wet sponge, the size of an egg (placed in a flat cup), in each tray, the second week, and two sponges in each tray the third week. Do not put in sponges until you are about to shut up the drawer, after turning. Wet the sponges by dipping in *hot* water. After the first ten days the animal heat of the chicks will partially assist in keeping the temperature. Be careful, as heat always drops when chicks are taken out. You can have a small glass door in front of egg drawer to observe thermometer, if desired. Always change position of trays when eggs are turned, putting the front one at the rear.—*Poultry Keeper.*

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