cause the applicability of such a test is modified by geological phenomena. North of the glacial limit all the products of decomposition have been planed away and deposited as drift formation over the length and breadth of the land. The rocks are therefore in general quite fresh in appearance, and possess but a slight depth of cap or worthless rock. The same classes of rock, however, in the South are covered with the rotten products resulting from long ages of atmospheric action. They may be rotten to great depths, and the removal of the worthless rock is often difficult. This is due to the circumstance that no agencies have here operated to scrape off and remove the loose material from their surfaces in recent geological time.

There are other peculiarities of decomposition regarding which too absolute rules have been laid down. Pyrites is considered to be the enemy of the quarryman and constructor, as it decomposes with ease and stains and discolors the rock. But here, too, there are features which very seriously modify the effect of this decomposing substance. Pyrites, in sharp, well defined crystals, sometimes decomposes with great difficulty. If a crystal or grain of pyrites is embodied in soft, porous, light-colored sandstones, like those which come from Ohio, its presence will with certainty soon demonstrate itself by the black spot which will form about it in the porous stone, and which will permanently disfigure and mar its beauty. If the same grain of pyrites is situated in a very hard, compact, non-absorbent stone, the constituent minerals of which are not rifted or cracked, this grain of pyrites may decompose and the products be washed away, leaving the stone untarnished.

We believe that the microscopic study of these stones is, even in such simple cases as this, necessary for a correct determination as regards the influence of decomposing agents upon the stone.

Again, some of the constituent elements of rocks are so frequently found in a decomposed condition that they are considered to be deleterious, when present in large quantity, on account of their well known tendency to decompose. For example, olivine indicates a very marked tendency to decompose, as indicated by

INSTRUMENTS FOR DRAWING CURVES.

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

V. THE CYCLOID AND TROCHOIDS.

THIS apparatus consists of a rigid frame composed of two bars, F, F, and a rack R, parallel to each other and secured to two transverse pieces T T. The outer bars, F F, serve also as guides, upon which the carriage G G slides freely. In this carriage is formed the bearing for the wheel W, which engages with the rack R, and rolls along it as the carriage moves. To the shaft of W is secured the crank A A, formed of a rigid steel rod, upon which the socket B may be clamped at any distance from the center C, by means of a binding screw, not shown. This socket B is pivoted to a block which is formed in one piece with the pen-holder P; and this block slides freely in the long slot S S. This slot is formed in a bar which runs diametrically across the light ring H H, whose center is O, the point of contact of the pitch circle of the wheel W and the pitch line of the rack R. The ring H H runs freely in grooves cut in the circumferences of four rollers, L L L L, which turn upon pivots fixed vertically in standards borne by the carriage G G, and symmetrically arranged about the center O.

Thus by varying the effective length of the crank A A, the instrument can be adjusted to draw the prolate trochoid with its loop, as when the pen is at P, the cycloid with its cusp, if the pen be placed at Q, the prolate trochoid with its wave, if the pen be fixed within the pitch circle of the wheel as at I, or the right line if the pen be made to coincide with the center C.

And the pen being fixed in the holder with its edges at right angles to the slot S S, will always run in the true direction of the curve; for the point of contact being the instantaneous axis, the central line of the slot is always normal to whatever curve the pen may be tracing; thus O P, O Q, O I, are normal to the curves above named at the points P, Q, I, respectively, and O C is perpendicular to the path of the center, at C.

This device is the companion to the one for drawing the roulette spirals, described in the preceding article of

ON THE CAUSE OF THE ACCUMULATION OF "BLACK PASTE" IN STEAM CHESTS AND CYLINDERS.

By Prof. J. E. DENTON.

THE investigation of the above phenomenon has been a subject of continuous study by the Department of Tests at the Stevens Institute during the last two years. Certain large dealers in lubricants had received, from time to time, various complaints and reports of the formation or discovery of such deposits in engines in the lubrication of which their oils were employed, and it became desirable to learn whether the lubricants were responsible for the accumulation of the foreign matter. The result of the investigation warrants the conclusion that the deposits are not attributable to any particular quality of the lubricant used, but arise from the admixture of solid matter with the lubricant, the solid matter being brought into the engine cylinder from the boiler by the steam, and precipitated from the latter by cylinder condensation.

The general course pursued in the investigation is therefore regarded as possibly of general interest to all steam users, and the following account of the matter is therefore presented by consent of the parties for whom the work has been executed. Without their persistently stimulative aid and liberal expenditure of money, such problems as the one under notice could not even approximate solution.

I. Samples of "deposits" collected from locomotive cylinders, from stationary engines of various sizes, running under various conditions, and located in various parts of the country, and from marine engines, all showed an average composition, by chemical analysis, as follows:

	Per cent.
Oil, animal and hydrocarbon, part free and part combined with lime, lead, manganese, etc., about.....	40
Iron, or iron oxide, about.....	20
Lime, magnesia, lead, silica, zinc, copper, etc., about.....	40

INSTRUMENT FOR DRAWING CURVES.

the vast accumulations of serpentine which are so frequently found to be a result of its decomposition; but the circumstances which in past time have brought about this decomposition may have been very different from those which indicate that it will decompose under the present influences. We wish to bring prominently forward that we consider that a decision as to the probable action of the agents producing decomposition in rocks should be largely dependent upon careful microscopic examination of the structure of the rock. Our experience has demonstrated that a rock of a given character, as regards ultimate composition and mineral constituents, may be easily affected by the weather if its constituent minerals, as indicated by their microscopic structure, are so fractured that they are laid open to atmospheric agencies through rifts, no matter how small, while the same stone, with the same constituents, may be eminently resistible to decomposing agencies if its constituent minerals are sound, whole, and impermeable, as indicated by the microscopic structure.

In the old world, where immense cathedrals, planned long ago, have been in the process of construction for hundreds of years, it has not been uncommon to see portions of the building fall into decay before the structure was finished, and the process of restoration often consumes large sums of money while the process of construction is yet going on. It thus very frequently happens that a variety of stones is used in the construction of the same building, because in this process of construction experience is gained indicating inapplicability of the stones used for durable structures. In this case it is experience alone which finally dictates the most suitable material; and even to this day, here in America, there is no other criterion to apply to a building stone save the test of experience, and the result is that buildings can be pointed to which, like those old, immense structures before referred to, are already crumbling while yet in the process of construction.

STRUCTURAL STRENGTH OF SEA-GOING TORPEDO BOAT No. 1.

CORRECTION.—In Table III. of the above article, published in SUPPLEMENT 704, the heading "Lines of Inclination" should read "Sines of Inclination."

this series (SCIENTIFIC AMERICAN SUPPLEMENT, No. 703) and illustrates the converse case. Here the marking point is carried by a circle rolling upon a fixed right line, while there it was carried by a right line rolling upon a fixed circle. And as in that case, so in this, it is to be understood that our purpose is merely to exhibit clearly the mechanical movements of the apparatus, which would require to be inverted and suspended above the paper were it to be actually constructed and employed for tracing these curves.

It may be of interest to note that when the crank arm is either greater or less than the radius of the wheel, the ring H H moves with a variable angular velocity, except when the crank is reduced to zero by fixing the pencil at C, in which case the ring will not turn at all. But when the pencil is fixed at Q, as in tracing the cycloid, the angular velocity of the ring is constant, and equal to half that of the wheel W. So that were a machine for shaping cycloidal cams to be constructed upon this basis, the action could be improved by the addition of suitable gearing to drive the ring at the required rate.

It may also be observed that the pen holder need not be formed in one piece with the sliding block, as above described. Instead of this, the sliding block, pivoted as before to the socket on the crank arm below, may be provided on the upper side with suitable means for clamping a supplementary block or arm capable of sliding in the line of the slot S; thus the pen holder, carried by this supplementary arm, may be set at any desired distance in the line of the slot, on either side of the crank pin.

If made in this way, the instrument will be capable of drawing not only the cycloid and trochoids, but curves at a constant normal distance from them, on either the concave or the convex side. Such parallel curves, when they lie on the concave side of the original or fundamental curve, sometimes present very curious and unlooked for features, as may be seen by reference to the SCIENTIFIC AMERICAN SUPPLEMENT, No. 420.

Upon the whole, then, this apparatus when thus modified, although capable of tracing the cycloid on only one scale, may be admitted to have a tolerably comprehensive range, in respect to the variety of forms which it can be made to delineate.

From these it was concluded that the oil and iron might be accounted for by the use of the lubricant and possible wear of cylinders, but that the forty per cent. of foreign matter must come from the boilers.

II. A large compound blowing engine at an iron works broke its piston ring through the accumulation of a hard black deposit under the rings. The same deposit was found throughout the cylinder passages and in the receiver. The oil used was the purest petroleum, yet the analysis of the deposit showed considerable animal oil. Upon investigation, it was found that the boilers took water from a stream just under a grating where there was always an abundant accumulation of all sorts of animal grease. The grease could only have reached the engine cylinders through the boilers.

The engine had not had its cylinders open for a long period, and the boilers were seldom cleaned, as the works ran night and day, and the plant was overloaded. The hypothesis that the boilers sent over foreign matter to the cylinder, which contaminated the lubricant, was, therefore, further supported by this instance. Specific knowledge was accordingly sought of the condition of the interior of the boilers in the case of some engine making a deposit.

III. Such knowledge was best available in the case of transatlantic steamships, whose boilers are examined thoroughly every voyage. Accordingly, arrangements were made with the Red Star steamship line to investigate the interior of the engines and boilers of the steamship Noordland, over a series of voyages.

This ship was using the purest quality of high grade petroleum as a cylinder lubricant. In the receiver, low pressure piston, and throughout the condenser and air pumps, there was an abundant accumulation of black deposit of the consistency of putty, which, on analysis, showed the same average composition as given above. The writer was permitted to change the oil to a mixture of petroleum and a large percentage of the finest neatfoot oil, but no marked change occurred in the amount or character of the deposit, which continued to be about one-half oily matter and the remainder a heterogeneous mixture of iron, silica, etc.

Upon examining the interior of the boilers, it was

found that during each voyage (of twelve sailing days) all surfaces within the range of water level were covered with deposits, and in some places over one inch thick, which, upon analysis, showed practically the same qualitative composition as the deposits in the cylinders. A deposit scraped from the edges of the incisions in the dry pipe, where steam enters the latter and becomes isolated from the main space of the boiler, showed a composition of half oil and half miscellaneous matter, precisely similar to the cylinder deposits. All evidence, therefore, was still consistent with the hypothesis that the miscellaneous matter in the cylinder deposits had their source in the boiler. Such matter must then go over with the steam, notwithstanding that by distillation water is ordinarily supposed to rid itself of impurities.*

IV. To settle the matter, steam was collected in glass bottles from the steam chests of the Noordland, during a voyage to Antwerp, and an analysis made of the steam thus condensed. The result was the discovery that the steam, on arriving at the engines, contained 10 grains of solid matter to the U. S. gallon, and the composition of the solid matter was about one-half oil, ten per cent, iron, and the remainder the same heterogeneous mixture of lime, silica, zinc, etc., found in the cylinder deposits; the oil being fed to the steam before the steam was collected.

The qualitative chain of evidence proving that the foreign ingredients or "dirt" in the cylinder deposits originate in the lack of cleanliness of the boiler being thus fairly complete, it remained to test the theory.

1st. By considering whether the 10 grains per gallon of solid matter could furnish as much of the latter as was represented by the total amount of deposit found throughout the engine per voyage.

2d. By learning if a clean boiler would fail to make a deposit with an oil which was known to have been used in a large number of engines which had shown deposits in the cylinder or steam chest.

V. Ten grains of solid matter to the gallon is, roundly, 10 pounds of solid matter to each 58,000 pounds of water. The engines of the Noordland used about 60,000 pounds of steam per hour. The total solid matter represented by 10 grains per gallon would therefore account for fully 10 pounds of "dirt" per hour passing through the cylinders. But it is probable that only that portion of the solid matter mixes with the oil which is contained in the steam which condenses to liquid in the cylinders. The minimum cylinder condensation of such an engine is probably about 15 per cent. of its total consumption of steam.

Hence, about $0.15 \times 10 = 1.5$ pounds of "dirt" may be supposed to be precipitated, including the oil fed to the cylinder.† This would make the cylinder deposit per voyage of 12 days

$$12 \times 24 \times 1.5 = 430 \text{ pounds.}$$

This amount is probably six times the amount ever found in the cylinders,‡ pumps, etc., but the figure shows that the solid matter in the steam is amply able to afford as much accumulation as is actually found.

VI. Regarding the second test of the theory by means of a clean boiler, the latter was found in the case of a sectional boiler using very pure water. The deposit annually in these boilers of 50 H. P. capacity averages less than a pailful of hard, insoluble chips. The engine was of the non-condensing, high speed type. Analysis of the steam condensed at the steam chest before the oil mixed with it showed one grain of solid matter per gallon, and the amount of steam did not exceed 400 pounds per hour.

Hence, the total solid matter entering with the steam per hour was

$$\frac{400}{60,000} = \frac{1}{150} \text{ pound.}$$

The oil was fed to the cylinder at the rate of $\frac{1}{10}$ pound per hour. Seven months' use produced no deposit of any kind. Now, in the case of the steamship Noordland, the solid matter passing through the steam per hour was one-half the weight of oil. Hence, in the case of the steam boiler the proportion of oil to "dirt" was three times as much as in the Noordland; consequently, if the oil itself possessed any property tending to produce the formation of deposit, the latter should have appeared more readily in the case of the steam boiler than in the case of the steamship.

The general conclusion, therefore, is that deposits of "black gum," etc., in engine cylinders are not caused by absence of any proper quality in the cylinder lubricant, but by the contamination of the latter with dirt, which may be furnished by the boiler if the latter in any way accumulates foreign matter upon its interior surfaces.—Stevens Indicator.

EDISON'S NEW PHONOGRAPH.

SINCE the epoch at which the celebrated American inventor Edison patented his first phonograph, he has not ceased to introduce into it improvements of a nature to better its operation and increase its practical utility.

In our issue of January 21, 1888, we exhibited to our readers the form of the apparatus that it seemed as if the inventor had finally decided upon, and for which, as in the beginning, innumerable applications were foreseen.

It is necessary to believe, however, that Mr. Edison did not consider his apparatus perfect, for he has continued to work on it ever since; and it seems that perfection has now been nearly reached, judging from the enthusiastic reception that the apparatus had at the Academy of Sciences at its session of April 23, when Mr. Janssen presented it in the name of Edison and of his representative, Colonel Gouraud.

The new apparatus, Fig. 1, contains several improvements, which are well indicated in Mr. Janssen's note, which we here quote nearly *in extenso*.

* Evidence that steam does not entirely free itself of the solid impurities in water is afforded in the finding of steam pipes in heating plants almost entirely plugged through the accumulation of solid matter carried along with the steam. See account of heating plant, etc., by the writer, in the *Stevens Indicator* for October, 1888.

† The wearing away of the surfaces of the cylinders should, of course, be included in the estimate of possible deposit; but on computation it is found that the most liberal allowance for wear would create a weight of iron less than one-half per cent. of the weight of oil used. So that the wearing of the surfaces is not a material factor in the problem.

‡ The deposit in the boilers is larger than this amount, but the feed water, which contained 90 grains of solid matter to the gallon, is amply able to account for the entire boiler deposit, including allowance for surface blowing.

The principal improvements introduced into the new phonograph are three in number. In the first place the single part designed to produce, under the influence of the voice or of instruments, impressions upon the cylinder, and afterward to reproduce the sounds by the action of the cylinder, has been divided into two. This division appears to me very happy and very important. It permits of much more precisely adapting the part to the special function that it has to fulfill. Thus, in the new apparatus, the inscription of the vibrating disk is made by means of a style whose point is so fashioned as to cut the quite ductile material of appropriate consistency that forms the new cylinders. There results from this action of the inscribing style a shaving of extreme delicacy, and, upon the cylinder, a furrow that interprets the most delicate motions of the disk vibrating under the action of its generator.

sounds and the preservation of the cylinders that bear the inscriptions. Thus it is possible to retard or quicken the emission of sounds, or interrupt and resume at such a point as may be desired, or to begin the entire emission over again as many times as desirable.

The phonograph seems especially qualified for reproducing sharp sounds with surprising perfection; yet I must admit that the sounds of the voice of quite low tonality have been very well reproduced. The fact must not be lost sight of that Mr. Edison, in his new instrument, has endeavored to obtain perfection in the reproduction of sounds, and not their power. So acoustic tubes should always be used for hearing the sounds well.

It is very interesting to find that the phonograph is capable not only of registering all the sounds of the musical scale and those that are introduced through the speaking of various languages, but also the sounds

FIG. 1.—EDISON'S NEW PHONOGRAPH.

Although the style has been so constructed as to produce a furrow that interprets as accurately as possible the motions of the vibrating disk, the reproducing style and disk have, on the contrary, been contrived for the reception of their vibrating motions from such furrow without alteration; and Mr. Edison has so well attained this end that it is possible to reproduce the speech inscribed an almost unlimited number of times and without perceptible alteration.

It is precisely these points that I have just spoken of that have received the recent improvements to which I alluded in the beginning. I do not believe myself authorized to enter into any more details in regard to them.

The replacing of the tinfoil by a plastic substance which can be cut with great precision and without requiring any appreciable stress is also very happy.

The third very important improvement regards the motions. In the old apparatus, it was the inscribing cylinder that moved, but in the new one it is the small device that carries the disks and styles. The motion is given by electricity.

A ball regulator provided with a brake permits of obtaining variable velocities and, consequently, a more or less rapid emission of the sounds. But in all cases, the apparatus is so perfectly constructed that the sliding motion of the styles and the rotary motion of the cylinder can be rapidly put in accordance, which latter should be very perfect for a proper emission of the

of an entire orchestra presented simultaneously for inscription.

I am persuaded that, aside from the uses that the new instrument will be put to, and which will increase beyond anything that we can now foresee, the phonograph will become the starting point of important studies in acoustics and molecular mechanics. It is, therefore, a splendid problem that Mr. Edison has solved, and all the friends of progress and science owe him a tribute of admiration and gratitude.

In September, 1888, the new phonograph was already improved enough to allow Mr. Janssen to send Mr. Edison the following "phonogram" from the meeting of the British Association:

"The problem of artificially reproducing the human voice is one of the most astonishing ones that man has ever proposed to himself. The genius of Mr. Edison gives us the solution of it, and his name will be blessed by all those who will be able to hear again the loved voices of those whom they have lost. It is the first French voice that, under this so new a form, has traversed the Atlantic."

This sending of a French phonogram to America followed closely on the phonogram sent from America by Edison to Col. Gouraud, then at London. In this letter, one heard Edison speaking, coughing, laughing, and finishing his letter by expressing the pleasure that he would have in hearing his representative (Gouraud), instead of tiring himself with reading his bad writing.

FIG. 2.—EDISON LISTENING TO THE FIRST PHONOGRAM SENT FROM ENGLAND.