had boiled off at —186 deg. from the liquid mixture of ozone and oxygen, the thermometer rose 60 deg. without any gas being evolved. The determination of the density of his ozone, which contained a little oxygen, gave the value 1.3698, which corresponds to a molecular weight of 43.8. This showed conclusively, Ladenburg thought, that the molecule of ozone is O_3. If, for instance, it were O_4, there would be an error in his results of over 50 per cent, and the conclusion would follow that his ozone contained 60 per cent of oxygen, for which there was not the slightest evidence.

The determination of iodine liberated from potassium iodide was made merely to ascertain the percentage of ozone in his mixture, which was found to be 84.4 per cent. This value was then used in correcting the density found to that of pure ozone, and 1.469 was the result obtained, which corresponds to a molecular weight of 47.

Quite recently Brunck (Ber., xxxiii., 1832), in an article on the quantitative determination of ozone, referred again to the apparently inadequate proof of Ladenburg that ozone has the molecular weight 48. This reference called forth another reply from Ladenburg (Ber., xxxiii., 2282), in which he used substantially the same argument which he used against Staedel and Gröger, and further he criticises some of the results of Brunck regarding the liberation of iodine from potassium iodide in acid solution. Brunck (Ber., xxxiii., 2999) answered these criticisms in a later paper.—American Chemical Journal, xxv., No. 5.

ERYSIMIN.

This is a glucoside recently isolated from the seeds of the Cruciferous plant, *Erysimum aureum*. The discoverers, Schlagdenhauffen and Reeb, state that it is an amorphous pale yellow compound, soluble in any proportion in water and alcohol, but insoluble in ether, chloroform, benzol, and carbon disulphide. It is slightly hygroscopic, melts at 190 degrees C., and has the formula $C_4H_7O_2$. Potassium myronate is not present in the seeds. Erysimin is a powerful heart poison.—Pharm Centralh., 42, 94.

ENGRAVING MACHINE.

Nearly ten years ago, says Engineering, we published an account of an engraving machine, made by Messrs. Taylor, Taylor & Hobson, of Stoughton Street Works, Leicester. Since that time very great improvements have been made in the machine, which is now used by leading brass and general engravers; by engineers and makers of hardware; in making stamps, dies, and original stamp models for printing; molds for glass, rubber, soaps, etc., and for engraving seals. It will, therefore, interest our readers to know what form the machine has taken after the various improvements which have been made in it. This they will see from the perspective view given in Fig. 1, while they will gather the details of construction from the remaining figures.

As regards the general principle, there is no novelty; it is in the method of carrying the principle into effect that the new features are to be sought. The engraving is done with a rotary cutter, the shape of which varies according to the character of the letter or of the work which is to be cut. This cutter is not stationary, but can be moved to and fro to follow the outline of the letters or other device, while at the same time it is kept in rotation by a gut band. The movement of the cutter is determined by a style which the operator moves over an enlarged copy. Between the style and the cutter there is interposed a pantograph by which the motion is reduced, the proportion of the arms of the pantograph being such that the work may be one-third, or any less proportion, of the copy. By removing the pantograph, work can be executed of the same size as the copy itself.

Referring to the engravings, Fig. 1 shows a general view of the machine, Fig. 2 shows a table for attachment of circular work, and Fig. 3 a plant of the pantograph. In this latter the copy-holder can be seen. Upon it can be clamped the copy, which may either be a specially prepared plate, or else standard metal copy types, fixed in grooves, and arranged to spell any desired wording, the spaces being provided for by blanks. The style is fixed in the end of the long arm, *L*, and stands above the copy. The members of the pantograph are *L*, *J*, *F*, and *B*, the cutter frame slider, *H*, being clamped to the bar, *F*, on which there is engraved a scale by which the bars can be set to give the desired degree of reduction from the copy. For this purpose the bolts of the sliders, *D* and *E*, are loosened, and the sliders are set so that their index edges coincide with the marks indicating the desired scale of reduction. Tightening pulleys, *A* and *C*, are provided to keep the band taut, in spite of the movement of the cutter spindle to and fro as it follows the outlines of the letters.

Figs. 4 and 5 show the cutter spindle and the means of feeding it to its work. The spindle, *S*, has a pulley or wharve at its lower end, the pulley being recessed so that the center pressure of the band falls within the lower bearing of the spindle. This bearing is conical, while the upper bearing is a deeply recessed "center," which can be easily set to take up all shake, and yet to leave the spindle quite free to revolve. The cutter spindle is fed down to give the required depth of cut by means of the milled wheel, *W*. This can be done in two ways. The stop rod shown in Fig. 4 can be set, and the nut in which the screw, *T*, revolves fed down on to it, or the adjustment may be made by the engraved scale round the nut. The screw, *T*, is bored through, and within it there is a spindle, the spindle and the screw being clamped together by a washer and nuts in such a way that there is sufficient friction to turn the screw when the spindle is rotated, but yet not enough to prevent the spindle slipping when the screw comes against a stop. The screw has only a small range of motion, as it has a small projecting pin whose traverse is determined by two vertical pins (Fig. 4). When the graduated scale is set to zero, as in Fig. 4, the cutter may be moved up and down by the milled wheel, *W*, and its position fixed by the stop-rod, as already explained. Instead of feeding the cutter in this way to a fixed stop, the graduated scale may be used to cause the cutter to penetrate any constant distance, measured from the surface of the work. The divisions of the scale indicate hundredths of an inch. The scale is set to the required depth; the nuts at the

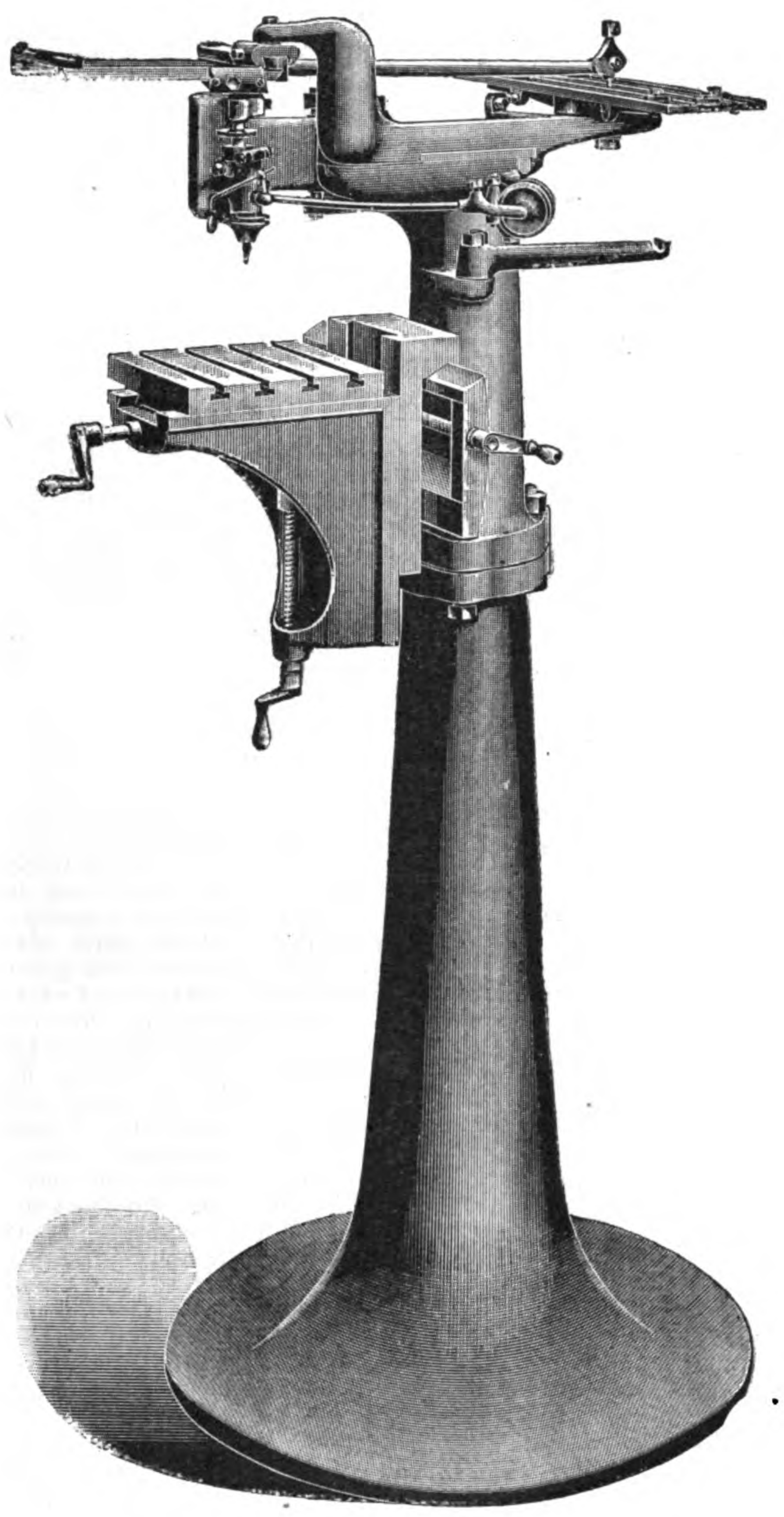
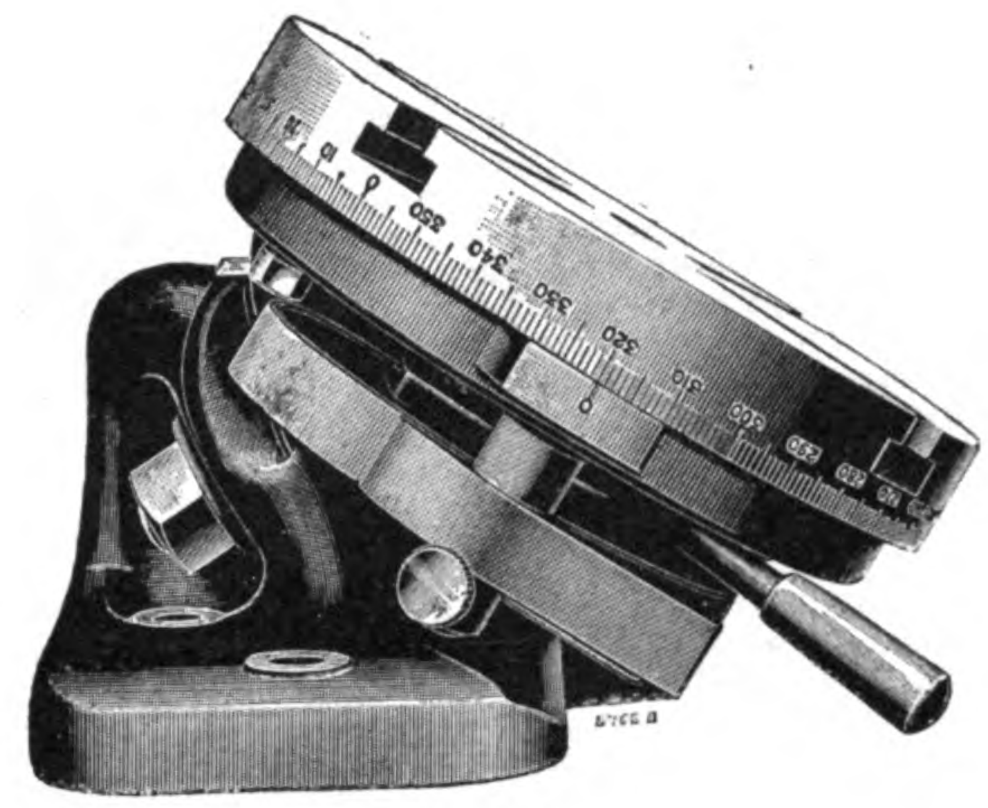


FIG 1.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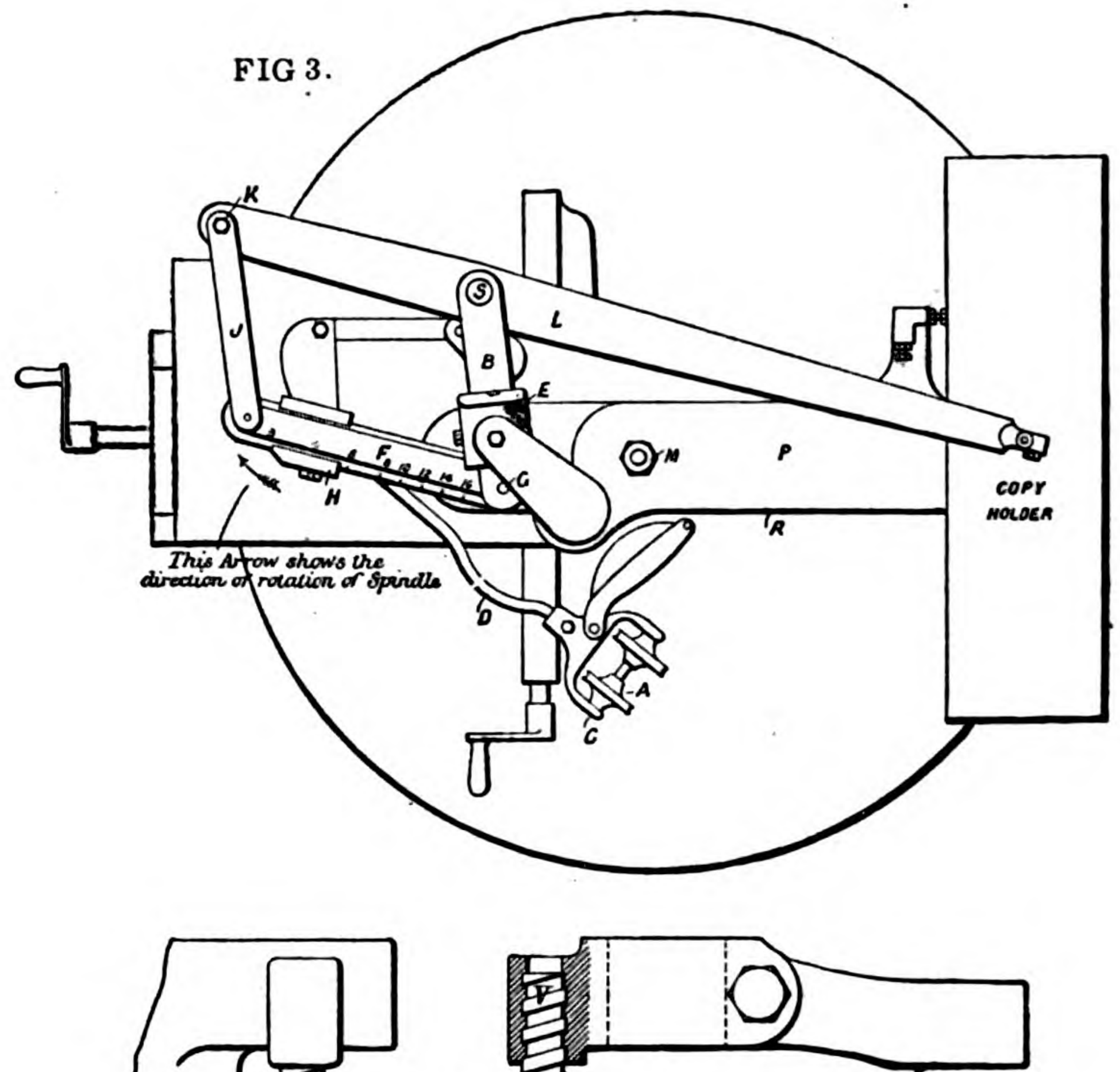
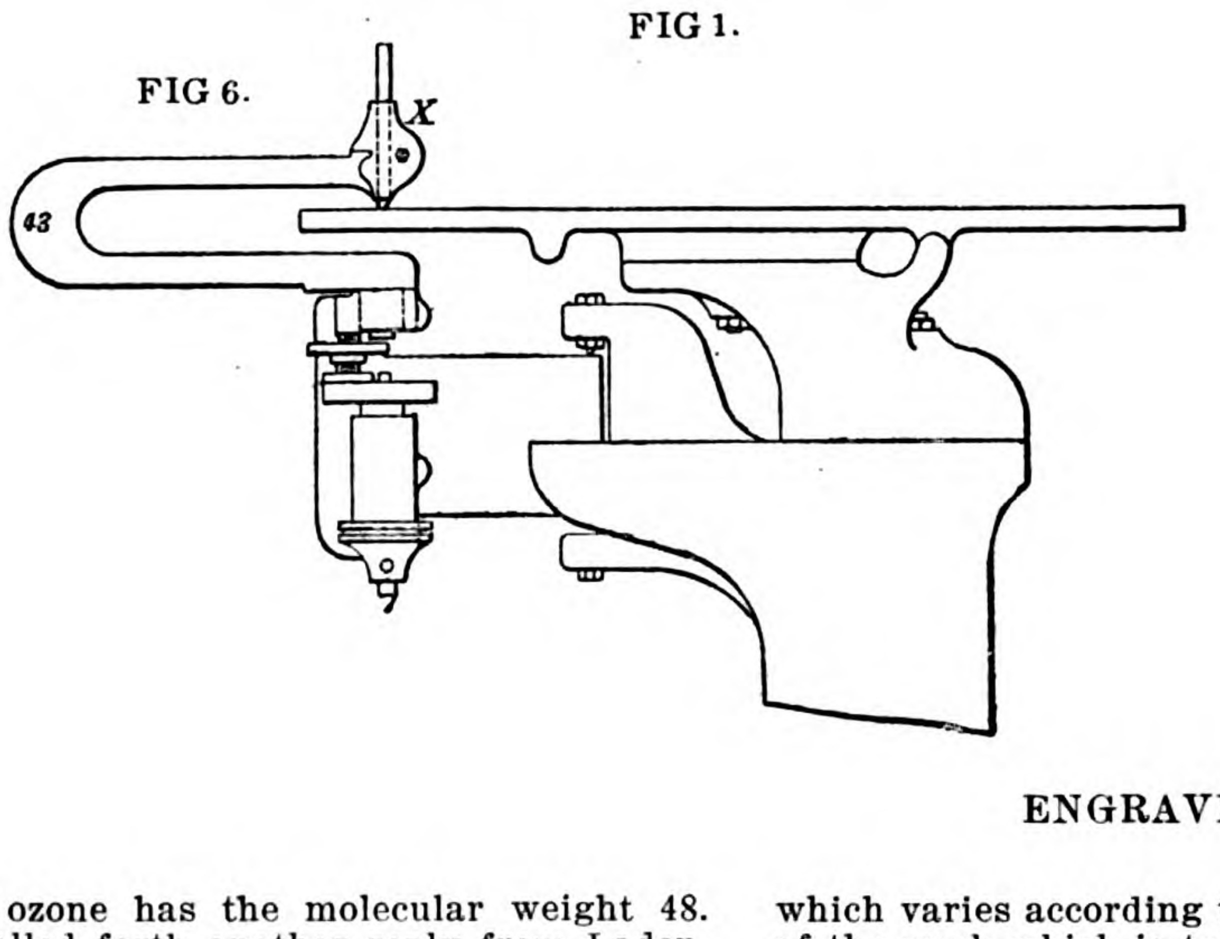




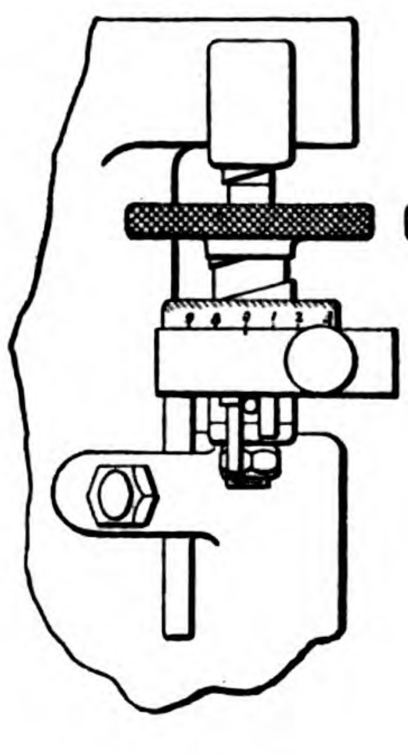


FIG 4.

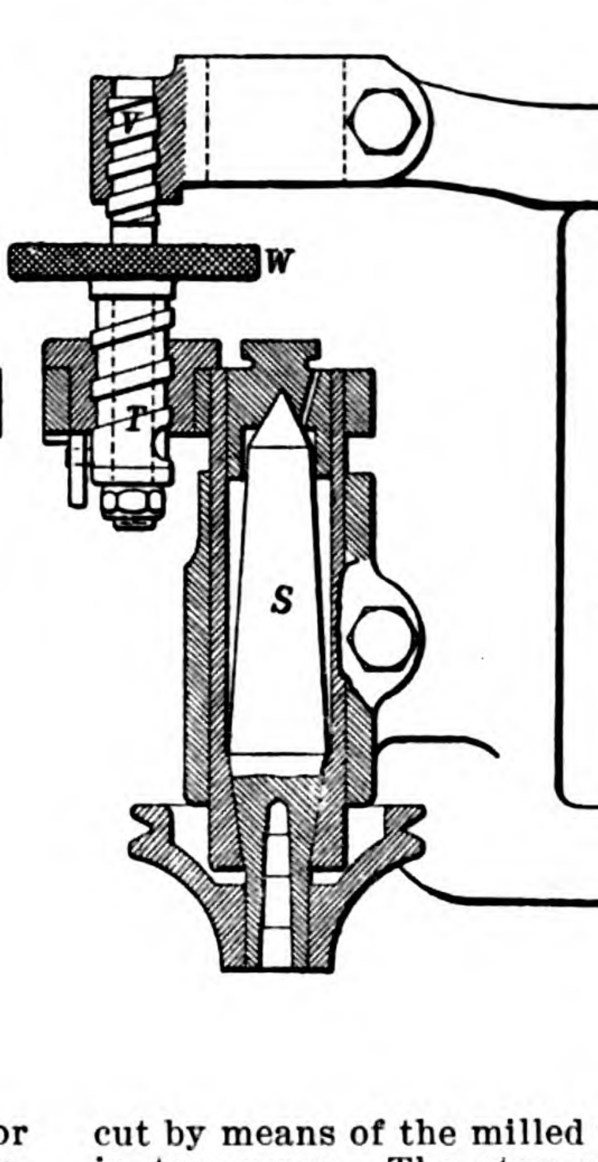


FIG 5.

ENGRAVING MACHINE.

bottom of the spindle are tightened to make the spindle turn stiffly in the screw, *T*. The wheel, *W*, is then turned until the cutter just touches the surface of the work; then the wheel is turned backward until the pin projecting from the nut meets the stop-pin. This moves the cutter to the required depth.

Fig. 6 shows the pantograph removed, and the cutter spindle moved directly, the style being directly over a full-sized copy.

Figs. 7 to 9 show three forms of cutter, and Figs. 10 to 13 the methods of grinding them, Fig. 12 being an enlarged view to illustrate the backing off which affects the cutting edges. The grinding of the cutter is done by an emery, whose spindle (Fig. 13) fits in the cutter spindle (Fig. 5) when the cutter is removed. A grinding attachment (Figs. 1, 10, and 11) is provided for holding the cutter in relation to the emery wheel, each cutter being placed for grinding in a spindle (Fig. 10), which lies in two bearings in the attachment, *Z*. By aid of this attachment grinding becomes a perfectly easy operation, and cutters such as Figs. 7 to 9 can be kept in perfect condition with very little trouble.

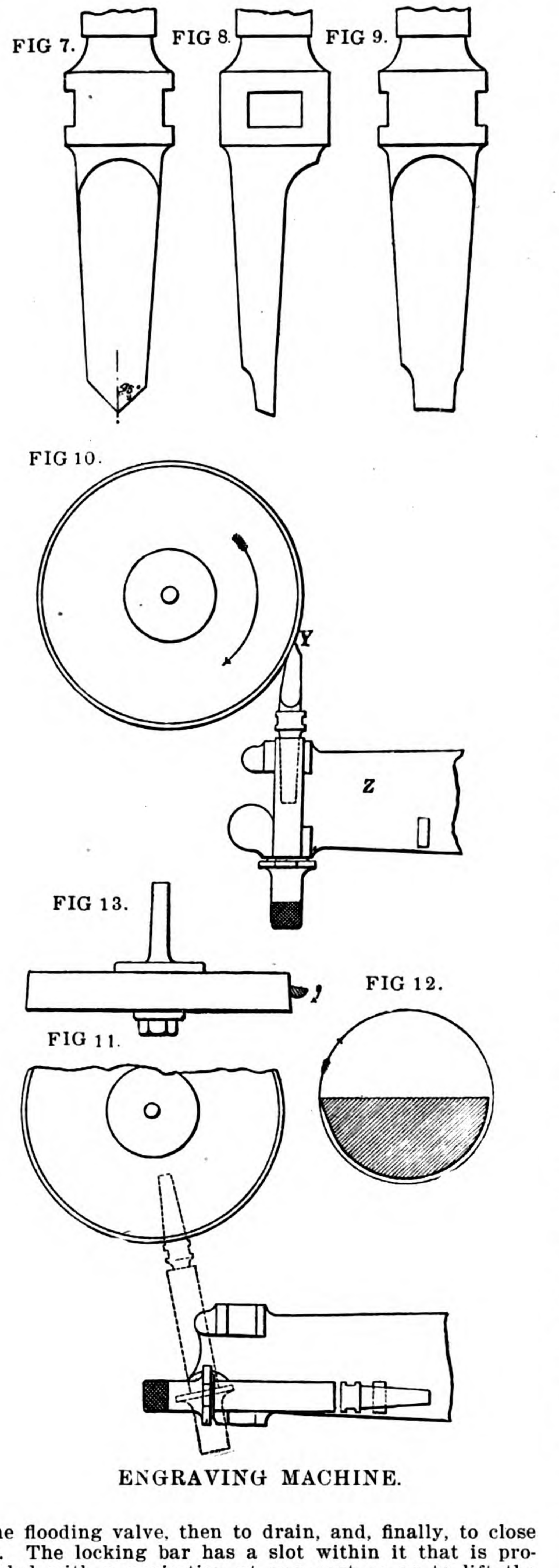
The circular attachment (Fig. 2) is intended to hold circular work, in the form of disks, cones, or cylinders, and to revolve it so as to present successive portions to the action of the engraving cutter. For this class of work it is necessary to bring the copy letters in turn to zero over the center hole of the copy-holder. The circular attachment is bolted to the slide-rest table, with the planed edge of its base close against the face of the vertical slide. In this position, on all reductions of the pantograph, the cutter is in line with the center of a circular disk, or above the axis of any cylinder held on the circular attachment, when the style is at the zero of the copy-holder. The spacing of letters on circular work may be decided by means of the paper index bands, on which lines may be ruled, and brought successively to coincide with the edge of the spring pawl; and for permanent work the paper band and its holder should be replaced by a circular disk of brass, 1-10 inch thick, and 4 inches in diameter, the edge of which may be provided with suitable notches to engage with the spring pawl. Like the faceplate of any lathe, this attachment can be provided with suitable chucks or holders for special work.

We have seen this instrument in operation and have also seen a large variety of work which it has done, and can testify to the ease and rapidity with which it is turned out, and also to its high quality. There are many purposes for which it is useful to engineers, especially in the cheap production of "directions" to be attached to cocks and the like, telling their uses, and the way in which they are to be manipulated. The machine will produce both lettering and designs either sunk or in relief, on metals and other materials.

INTERLOCKING GEAR FOR SUPERHEATER VALVES.

In connection with the use of superheaters upon steam boilers there is an element of care required upon the part of the fireman or attendant regarding the manner in which the valves connected with the superheater and the steam pipe main are operated.

In most superheaters it is necessary, when steam is being raised and the main stop valve of course closed, to admit water into the superheater tubes to prevent their being burnt. It is also necessary that this water shall be drained off from the superheater before the main steam valve is opened, otherwise there is a risk that the water which has not been completely evaporated into steam within the superheater will be forced out into the main steam pipe under the pressure of the steam in the boiler drum. It is evident from the illustration how this may occur, since the superheater receives its steam at the top, and delivers it from the bottom into the main steam pipe through the pipes shown dotted in the end elevation. To insure that this condition shall not arise, Lovell & Co., of 56 Chancery Lane, London, have patented an interlocking gear, and have fitted it to the boilers of the Reading Electric Supply Company, Limited. Our illustrations show the application of the gear to a Babcock & Wilcox boiler, its object being to prevent the main steam valve being opened while water is either in the superheater or while the drain cock is open for draining the water out of it. The simplest form of application is that in which a circular rack or ratchet is cast upon the underside of the main stop valve wheel. The flooding and draining valve hand wheel has connected to it a rod, which by a bell-crank lever moves a locking bar sliding in an inclosed casing, so as to raise the weighted end of a pivoted pawl, which engages and disengages with the ratchet on the stop-valve wheel. In the draining position of the combined flooding and draining valve the pawl is in contact with the teeth on the hand wheel, and this position is maintained during the whole of the movement of the hand wheel on the draining valve, except that when the draining valve is closed after it has moved in the direction, first to open



ENGRAVING MACHINE.

the flooding valve, then to drain, and, finally, to close it. The locking bar has a slot within it that is provided with a projection at one part so as to lift the pawl out of contact with the ratchet, the weighted end of the pawl sliding on the top of the locking-bar groove while the pawl is out of contact. The stop-valve wheel is free to be turned in the direction to close the valve at any time, but cannot be turned to open the valve except when the pawl is out of contact, the pawl being only out of contact when the flooding valve wheel is carried to its closed position. To prevent the flooding valve, or three-way cock generally used, from being moved in the wrong direction a ratchet and pawl is arranged in connection with the valve spindle, and to prevent the pawl on the hand wheel of the stop valve from being tampered with, it is pivoted and mounted in an inclosed casing, as shown.—The Engineer.

A CENTURY OF CIVIL ENGINEERING.*

The century which has just passed, the nineteenth of the Christian era, is distinguished from any of the preceding hundred-year periods in the world's history by the advances made in the co-operation of investigators in numerous branches of science in the formulation of doctrines regarding the nature and co-ordination of natural phenomena, which stand the test of experiment and calculation, thus leading to a nearer approximation to the understanding of the laws which govern such phenomena, and so to the development into a profession of the "Art of directing the great sources of power in Nature for the use and convenience of Man," which Art is entitled Civil Engineering. This definition is itself one of the most noteworthy products of the Nineteenth Century, and a study of the sequence of events and reasoning which led to its formulation is not without interest.

Ever since man became endowed with consciousness and the power of reasoning, he has been striving to solve the problems of the physical world around him in which he perceived matter in motion, which was evidenced to his senses by sight and touch, by sound and taste and smell, but which was devoid of sentience, so far as he could discover. He observed at once that by its different manifestations his physical comfort was materially affected, and it did not take long for him to learn that certain sequences of sensation, of one sort or another, followed certain manifestations occurring singly or in combination, and then that the order of many such manifestations could be controlled by him at will, while that of multitudes of others could not be so controlled at first, their methods and causes not being appreciable by his unassisted senses.

But until about three hundred years ago there does not seem to have been any systematic and well-directed effort to investigate the reasons why material changes occurred naturally, or how certain changes could be artificially produced with certainty.

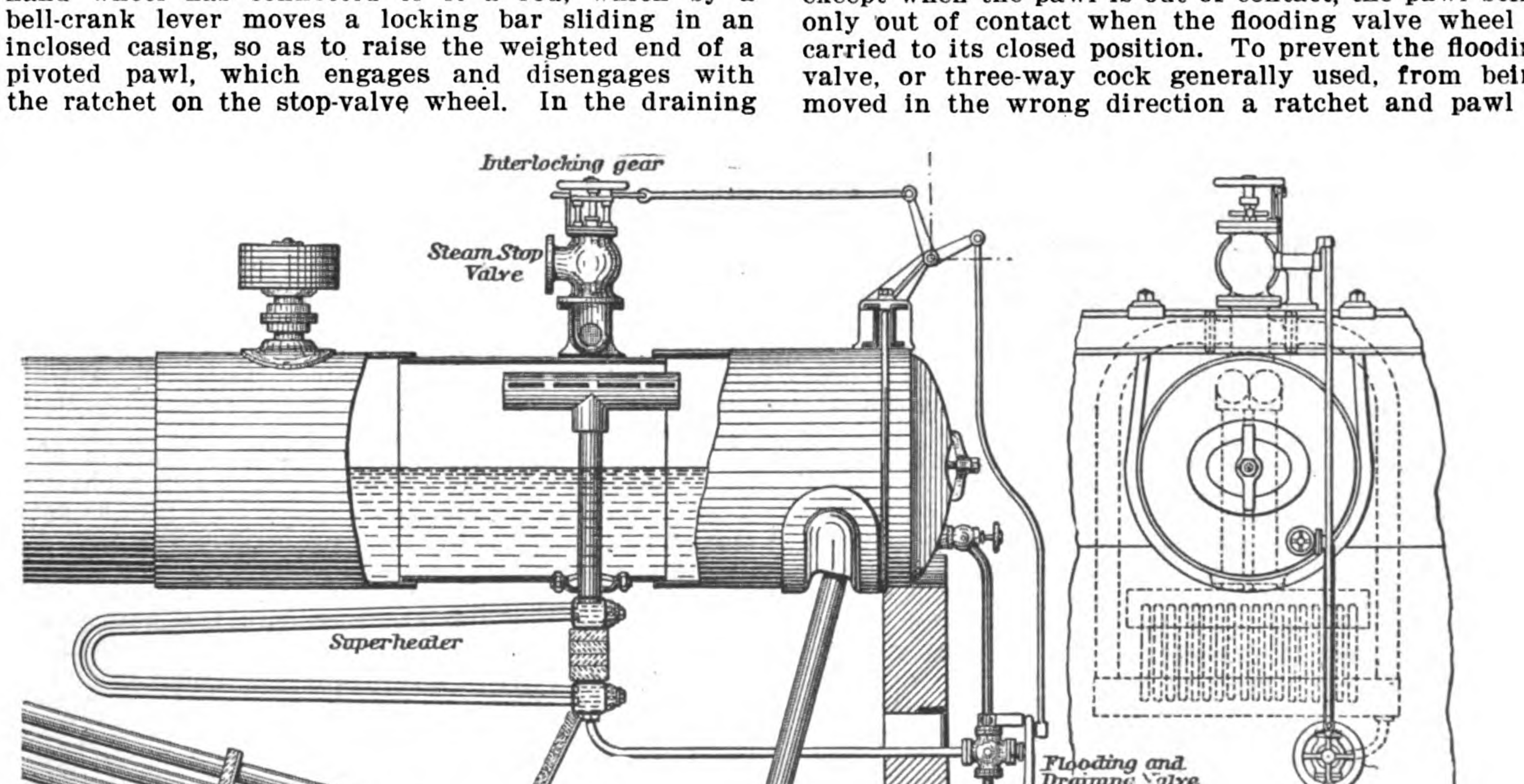
To discover the sequence of natural events is first of all an empirical task: facts must be observed systematically, and recorded, and then their combinations reasoned upon. Hypotheses can then be formed as to the probable effects of slightly different collocations and sequences of events, and these subjected to experiment and computation. An hypothesis cannot be established as a scientific fact until it has been verified by observation and also proved to be in accordance with mathematical laws. Tennyson's apothegm, that "knowledge comes, but wisdom lingers," is profoundly true.

Now, up to the beginning of the seventeenth century of the Christian era, there had been no organized physical experimentation, on a comprehensive scale, and intelligent reasoning therefrom. The speculations as to the laws of nature which had been made from time to time had been purely efforts of the imagination, and were unsustained by either practical demonstration or analytical reasoning. Various hypotheses had been framed, on insufficient or incorrect premises, and some of them had been so near the truth as actually to delay the progress of the truth, by the appearance of exactness in the reasoning from them, up to a certain point.

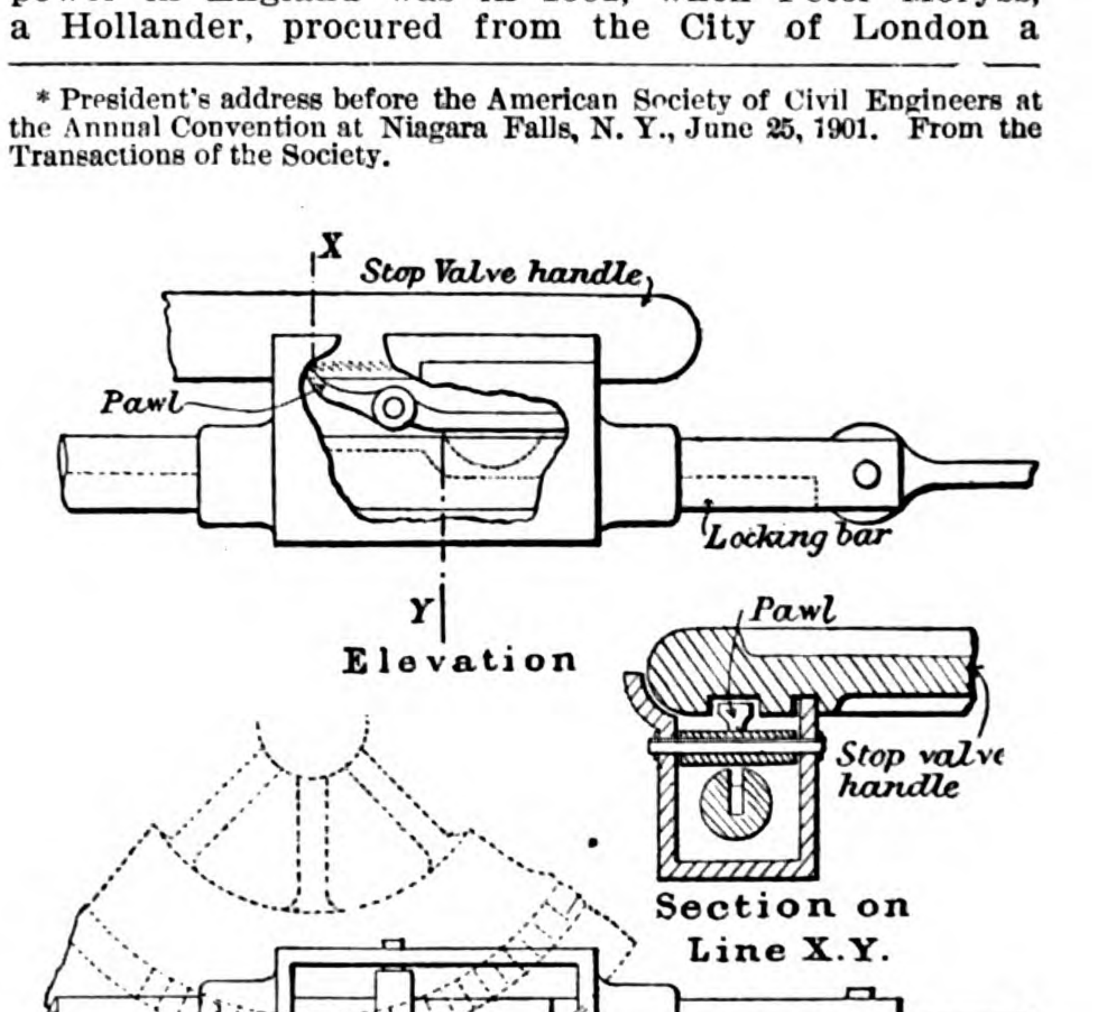
Really, the civil engineer had been practising his art and directing the forces of nature for the use and convenience of man, but without any conception of what those forces were, or how they acted, or of why he did anything, or what the result of it would be, unless he had done the same thing before in the same way. He did not know that the earth moved, and he had no idea why or at what rate a stone fell to the earth, or water ran down hill. He had no measure of heat or light, and used no power but that which the muscles of an animal produced. And yet he had built the Pyramids, the Parthenon and the Pantheon; had constructed aqueducts, canals and sewers; had regulated and maintained the rivers of China for thousands of years; and had just been recognized, on account of his labors in protecting the lowlands of Holland and the shores of Italian rivers from the encroachments of the water, as holding a distinct rank among the workers of the world.

Of the application of the forces of nature to aiding his labors, he seems to have been ignorant, except by the use of a flowing stream to turn a wheel. The earliest recorded application of this mode of producing power in England was in 1582, when Peter Moryss, a Hollander, procured from the City of London a

* President's address before the American Society of Civil Engineers at the Annual Convention at Niagara Falls, N. Y., June 25, 1901. From the Transactions of the Society.



THE LOVELL INTERLOCKING GEAR.



DETAILS OF RATCHET ARRANGEMENT.

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OBJECTS AND METHODS OF INVESTIGATING CERTAIN PHYSICAL PROPERTIES OF SOILS.*

By LYMAN J. BRIGGS, Assistant Chief and Physicist, Division of Soils.

INTRODUCTION.

THE physical properties of soils are recognized by plant physiologists to be of the greatest importance in plant economy. Even in the consideration of climatic conditions, it is now generally considered that for most economic plants the meteorological conditions of the soil hold equal rank with atmospheric conditions. A high temperature in the soil under favorable conditions promotes extensive root development; a high atmospheric temperature under equally favorable conditions favors a heavy growth of foliage. A deficiency in water content of either air or soil is attended with distress on the part of the plant. Finally, the leafy portion of the plant and the root system have been shown to be correlated in so many other ways that even without the experimental proofs mentioned above the great influence of soil conditions becomes at once apparent.

The peculiar characteristics displayed by many soils in their relation to plant life can thus be traced, in many instances, directly to certain physical properties of the soil. In the term "physical properties" as applied to soils, we here include also those properties which, in the case of the atmosphere above the soil, are commonly separated into a group known as "climatic conditions." In this broader definition we thus include the two more important soil conditions influenced by climate, namely, the temperature and the moisture content.

In considering the physical characteristics of the soil we must include also the soil atmosphere. By this term we designate the gases contained in the interstitial spaces of the soil, which are thus more or less separated from and to some extent independent of the atmosphere above. This soil atmosphere, particularly when inclosed to some extent by soil moisture, has been shown by King to be capable of modifying somewhat through barometric or temperature changes the distribution of water in the soil.

We thus see that, from a physical standpoint, the soil under field conditions may be divided into three parts, as follows: (1) The soil proper, consisting of the soil grains of various sizes, grouped in different ways, and made up of insoluble or difficultly soluble minerals; (2) the soil moisture, covering the soil grains, and containing in solution a varying amount of the soluble soil constituents; and, (3) the soil atmosphere, differing from air in composition to some extent, and usually saturated with water vapor.

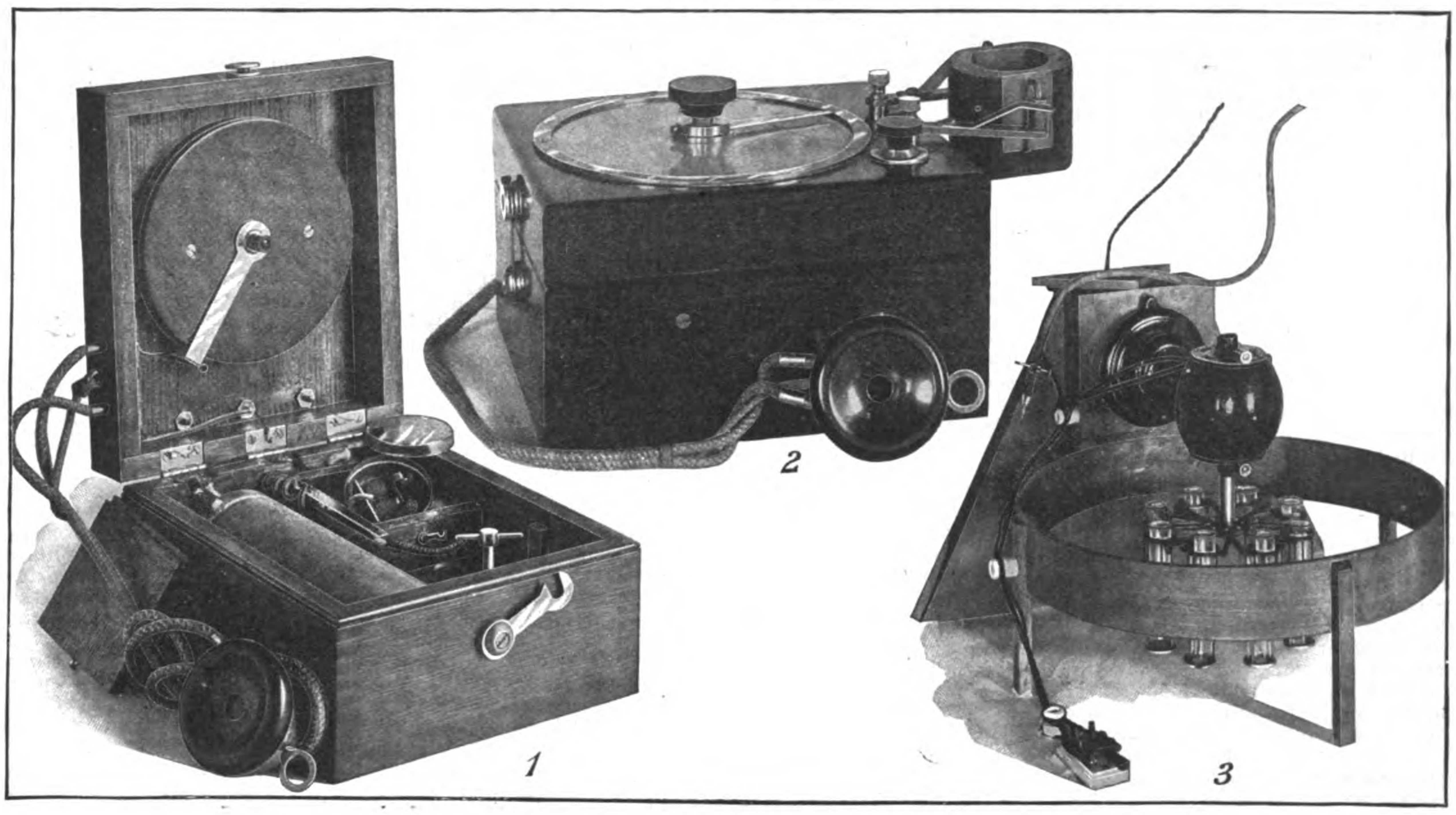

FIG. 1.—APPARATUS FOR INVESTIGATING PHYSICAL PROPERTIES OF SOILS.

1. Interior of soil hygrometer, used in investigating the water content of soils in the field; 2, electrical apparatus, used in determining the soluble salt content of soils and irrigation waters; 3, centrifugal apparatus, used in the mechanical analysis of soils.

PHYSICAL PROPERTIES PECULIAR TO THE SOIL GRAINS.

Soil Texture.—The two more important physical properties of a soil considered from the standpoint of the first class are texture and structure. Following previous usage of these words, we shall define "texture" to represent the relative sizes of the soil grains, while "structure" will be taken to represent the arrangement of these grains under field conditions. These terms at the present time have only a relative meaning, that is to say, there is no fixed scale for measuring or expressing either texture or structure, such as we have for temperature. In the case of structure we can at present only say that one soil has a closer or a more open structure than another. In a similar manner we say that one soil has a finer texture than another. A more specific statement of texture can, however, be made by the use of the results obtained by mechanical analysis.

The mechanical analysis of a soil consists in separating the soil grains into groups according to size, and in determining the relative amounts of the different groups, which together constitute the soil. Such an examination gives the most reliable means at present available for the comparison and classification of soils, since it is practically free from personal bias and errors of judgment.

In some cases a mechanical analysis fails to give proper indication of important and distinctive characteristics, since it deals only with the size of the grains and not with their arrangement or other physical properties. Beyond question, however, plant development is greatly influenced by the texture of the soil. Whether the texture has a direct influence or whether the effect is due entirely to the change in the water content and other physical properties is not definitely known, and for the present is of secondary importance. The unmistakable relation between the texture of the soil and the character of the crop grown is the important point. This relation makes possible the classification and mapping of soils and the correlation of soils of widely separated areas.*

The great importance of a thorough knowledge of the texture of soils is well illustrated in the recent work of the department relating to the growing of tobacco in the Connecticut Valley. It was observed by Professor Whitney that certain soil areas of the Connecticut Valley were practically identical as regards texture and water content with certain areas in Florida upon which the finest of cigar wrappers are being grown from Sumatra seed. Experiments were accordingly made on one of the Connecticut areas, using the same seed and methods of cultivation and curing employed in Florida, with the most satisfactory results. Should the more extensive experiments now in progress support the earlier work,

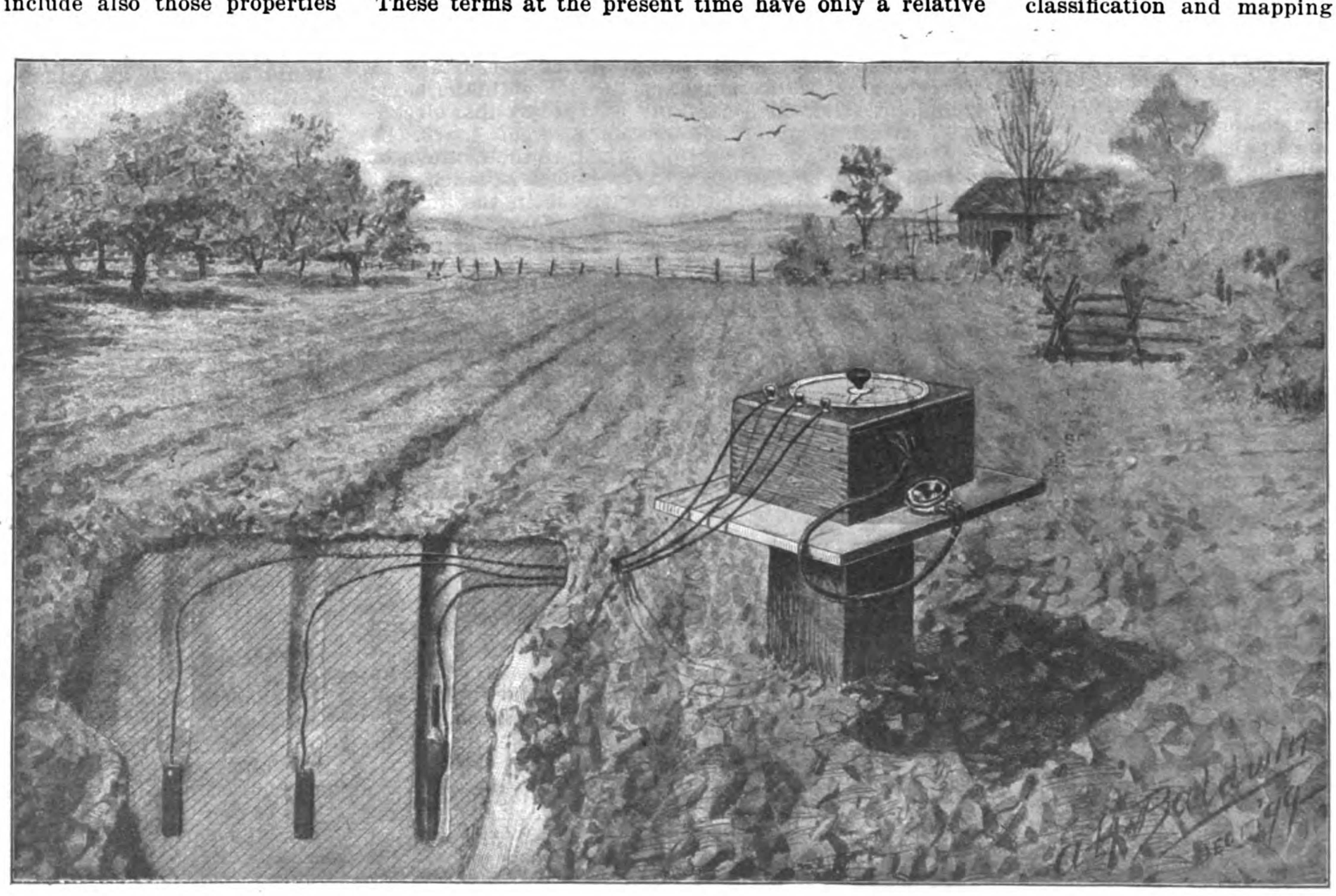

FIG. 2.—SOIL HYGROMETER AS USED IN THE FIELD, WITH SECTIONAL VIEW OF THE SOIL, TO SHOW CARBON ELECTRODES AND TEMPERATURE CELL.

* From the Yearbook, United States Department of Agriculture, 1900.

* Striking examples of the relation between the texture of the soil and the character of the product may be found in "Tobacco Soils of the United States," by Prof. Milton Whitney, Bulletin No. 11, Division of Soils, 1897.

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