

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 solu-

tion 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

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,

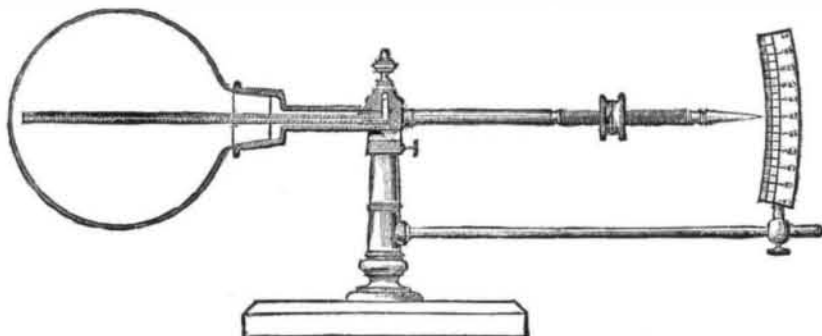


FIG. 1.

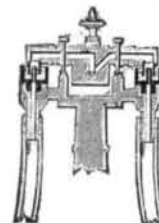


FIG. 2.

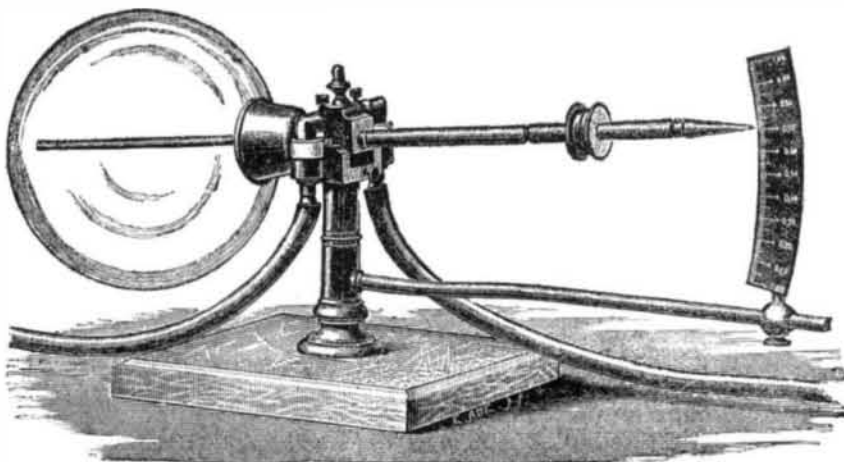


FIG. 3.

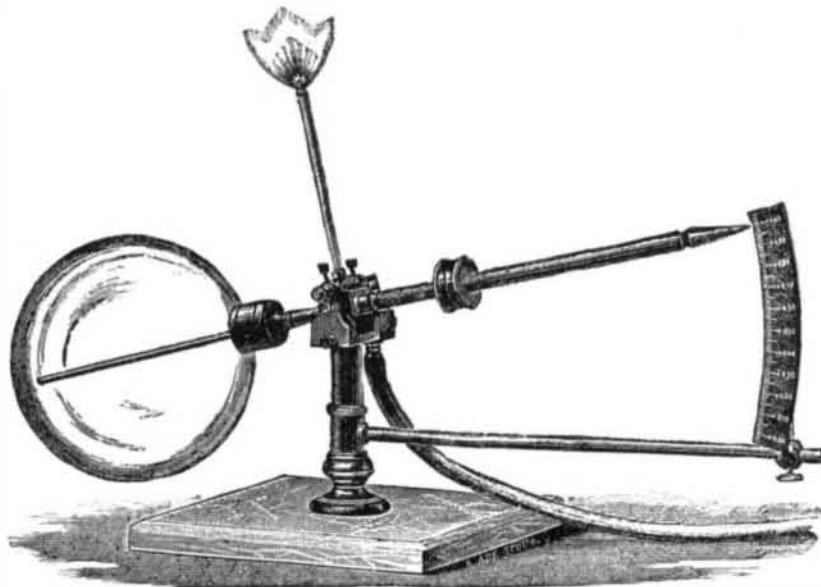


FIG. 4.

THE GAS BALANCE.

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

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

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.

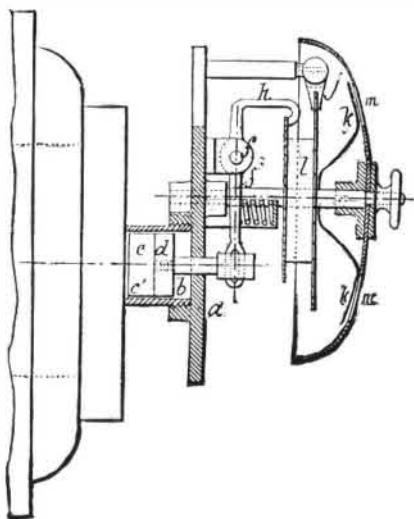
To mention but a few examples of a simple analysis, the apparatus will be found very useful for ascertaining the quantities of carbonic acid in the illuminating gas, in the saturation gases of sugar refineries and of soda manufactories, in heating, generator, and smoke gas, and also the sulphur dioxide 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 consists 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 *f*. 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

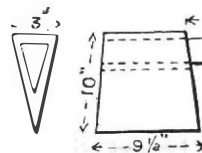
the left at the same time, and the lever, *f*, oscillates around its pivot and lifts the hook, *h*, which in turn frees the hammer, *j*, of the bell.

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.*

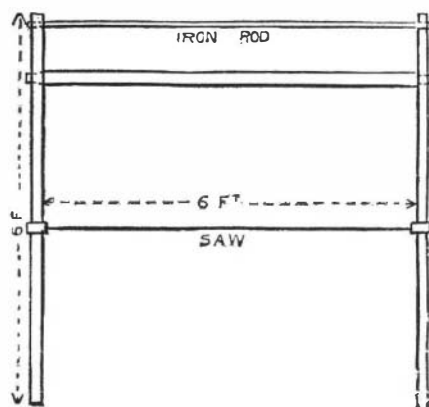
CHINESE PLANK SAWING.

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 papan," 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 other 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 hoes, 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.

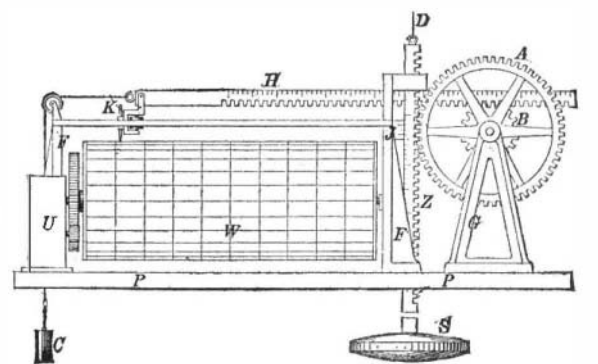
To the float, S, made of copper plate, is attached a brass rod, Z, of rectangular section, divided into teeth according to the metric system (5 mm. to every tooth), which is so guided between rollers that it can have no

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 cylinder,



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 Marienleuchte 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.