rotating disk, produced forcible sounds in a flask at the other side.

A red-hot poker, placed in the position previously occupied by the coal, produced strong sounds. Maintaining the flask in position behind the rotating disk, amusing alternations of sound and silence accompanied the alternate introduction and removal of the poker.

The temperature of the iron was then lowered till its heat just ceased to be visible. The intermittent invisible rays produced audible sounds.

The temperature was gradually lowered, being accompanied by a gradual and continuous diminution of the sound. When it ceased to be audible the temperature of the poker was found to be below that of boiling water.

As might be expected from the foregoing experiments, an incandescent platinum spiral, with or without the mirror, produced musical sounds. When the battery power was reduced from ten cells to three, the sounds, though enfeebled, were still distinct.

My neglect of aqueous vapor had led me for a time astray in 1859, but before publishing my results I had discovered my error. On the present occasion this omnipresent substance had also to be reckoned with. Fourteen flasks of various sizes, with their bottoms covered with a little sulphuric acid, were closed with ordinary corks and permitted to remain in the laboratory from the 23d of December to the 4th of January. Tested on the latter day with the intermittent beam, half of them emitted feeble sounds, but half were silent. The sounds were undoubtedly due, not to a dry air, but to traces of aqueous vapor.

An ordinary bottle, containing sulphuric acid for laboratory purposes, being connected with the ear and placed in the intermittent beam, emitted a faint, but distinct, musical sound. This bottle had been opened two or three times during the day, its dryness being thus vitiated by the mixture of a small quantity of common air. A second similar bottle, in which sulphuric acid had stood undisturbed for some days, was placed in the beam; the dry air above the liquid proved absolutely silent.

On the evening of January the 7th Professor Dewar handed me four flasks treated in the following manner: Into one was poured a small quantity of strong sulphuric acid; into another a small quantity of Nordhausen sulphuric acid; in a third were placed some fragments of fused chloride of calcium; while the fourth contained a small quantity of phosphoric anhydride. They were closed with well-fitting India-rubber stoppers, and permitted to remain undisturbed throughout the night. Tested after twelve hours, each of them emitted a feeble sound, the flask last mentioned being the strongest. Tested again six hours later, the sound had disappeared from three of the flasks, that containing the phosphoric anhydride alone remaining musical.

Breathing into a flask partially filled with sulphuric acid instantly restores the sounding power, which continues for a considerable time. The wetting of the interior surface of the flask with the sulphuric acid always enfeebles and sometimes destroys the sound.

A bulb, less than a cubic inch in volume, and containing a little water, lowered to the temperature of melting ice, produces very distinct sounds. Warming the water in the flame of a spirit lamp, the sound becomes greatly augmented in strength. At the boiling temperature the sound emitted by this small bulb* is of extraordinary intensity.

These results are in accord with those obtained by me nearly nineteen years ago, both in reference to air and to aqueous vapor. They are in utter discordance with those obtained by other experimenters, who have ascribed a high absorption to air and none to aqueous vapor.

The action of aqueous vapor being thus revealed, the necessity of thoroughly drying the flasks, when testing other substances, becomes obvious. The following plan has been found effective: Each flask is first heated in the flame of a spirit lamp till every visible trace of internal moisture has disappeared, and it is afterward raised to a temperature of about 400° C. While the flask is still hot, a glass tube is introduced into it, and air freed from carbonic acid by caustic potash, and from aqueous vapor by sulphuric acid, is urged through the flask until it is cool. Connected with the ear tube, and exposed immediately to the intermittent beam, the attention of the ear, if I may use the term, is converged upon the flask. When the experiment is carefully made, dry air proves as incompetent to produce sound as to absorb radiant heat.

In 1868 I determined the absorptions of a great number of liquids whose vapors I did not examine. My experiments having amply proved the parallelism of liquid and vaporous absorption, I held undoubtedly twelve years ago that the vapor of cyanide of ethyl and of acetic acid would prove powerfully absorbent. This conclusion is now easily tested. A small quantity of either of these substances, placed in a bulb a cubic inch in volume, warmed, and exposed to the intermittent beam, emits a sound of extraordinary power.

I also tried to extract sounds from perfumes, which I had proved in 1861 to be absorbers of radiant heat. I limit myself here to the vapors of patchouli and cassia, the former exercising a measured absorption of 30 and the latter an absorption of 109. Placed in dried flasks and slightly warmed, sounds were obtained from both these substances, but the sound of cassia was much louder than that of patchouli.

Many years ago I had proved tetrachloride of carbon to be highly diathermanous. Its sounding power is as feeble as its absorbent power.

In relation to colliery explosions, the deportment of marsh gas was of special interest. Professor Dewar was good enough to furnish me with a pure sample of this gas. The sounds produced by it, when exposed to the intermittent beam, were very powerful.

Chloride of methyl, a liquid which boils at the ordinary temperature of the air, was poured into a small flask, and permitted to displace the air within it. Exposed to the intermittent beam, its sound was similar in power to that of marsh gas.

The specific gravity of marsh gas being about half that of air, it might be expected that the flask containing it, when left open and erect, would soon get rid of its contents. This, however, is not the case. After a considerable interval the film of this gas clinging to the interior surface of the flask was able to produce sounds of great power.

A small quantity of liquid bromine being poured into a well-dried flask, the brown vapor rapidly diffused itself in the air above the liquid. Placed in the intermittent beam, a somewhat forcible sound was produced. This might seem to militate against my former experiments, which assigned a very low absorptive power to bromine vapor. But my former experiments on this vapor were conducted with obscure

heat; whereas, in the present instance, I had to deal with the radiation from incandescent lime, whose heat is, in part, luminous. Now the color of the bromine vapor proves it to be an energetic absorber of the luminous rays; and to them, when suddenly converted into thermometric heat in the body of the vapor, I thought the sounds might be due.

Between the flask containing the bromine and the rotating disk I therefore placed an empty glass cell; the sounds continued. I then filled the cell with transparent bisulphide of carbon; the sounds still continued. For the transparent bisulphide I then substituted the same liquid saturated with dissolved iodine. This solution cut off the light while allowing the rays of heat free transmission; the sounds were immediately stilled.

Iodine vaporized by heat in a small flask yielded a forcible sound, which was not sensibly affected by the interposition of transparent bisulphide of carbon, but which was completely quelled by the iodine solution. It might indeed have been foreseen that the rays transmitted by the iodine as a liquid would also be transmitted by its vapor, and thus fail to be converted into sound.*

To complete the argument: While the flask containing the bromine vapor was sounding in the intermittent beam, a strong solution of alum was interposed between it and the rotating disk. There was no sensible abatement of the sounds with either bromine or iodine vapor.

In these experiments the rays from the lime light was converged to a point a little beyond the rotating disk. In the next experiment they were rendered parallel by the mirror, and afterward rendered convergent by a lens of ice. At the focus of the ice lens the sounds were extracted from both bromine and iodine vapor. Sounds were also produced after the beam had been sent through the alum solution and the ice less conjointly.

With a very rude arrangement I have been able to hear the sounds of the more active vapors at a distance of one hundred feet from the source of rays.

Several vapors other than those mentioned in this abstract have been examined, and sounds obtained from all of them. The vapors of all compound liquids will, I doubt not, be found sonorous in the intermittent beam. And, as I question whether there is an absolutely diathermanous substance in nature, I think it probable that even the vapors of elementary bodies, including the elementary gases, when more strictly examined, will be found capable of producing sounds.

ON SOME PHYSICAL PHENOMENA.

By W. J. MILLAR, C. E.

In studying our physical surroundings we have certain conditions or manifestations brought prominently before us, and to these we give the names of force, matter, motion, space, and time. Taking these as enumerated, we have:

1. *Force*.—To arrive at an adequate conception of force is beyond our power, but we are all more or less familiar with many of its manifestations; thus, when by muscular action we bring about some change in the condition of the objects around us we are conscious of an exertion on our part which arises from the resistance offered to our operations. The exertion rendered necessary to overcome this resistance gives us an idea of force, and we say that we have to exert force to oppose the resistance offered.

Again, if we watch a stone which has been thrown upward, as it descends again to the earth we see the action of force. To send the stone upward required an exertion on our part, because of the weight or tendency of the body to fall. The stone in its descent was urged towards the earth by the very resistance or weight which we had opposed in giving it ascending motion, and in this falling tendency we see the action of a different form of force than what obtained in the first case, where the exertion was a muscular action of the arm. The resistance overcome was really another form of force, to which we give the name of gravitation. When a bullet is driven from a gun by the firing of a charge of powder, we know that this is due to the sudden formation of gases whose expansive power drives out the movable obstacle or bullet which assists in hemming them in, and we speak of this action as an explosive force.

In short, we may define force to be that which tends to produce change in the condition of matter.

2. *Matter*.—Matter has been defined as that which is obvious to the senses—substance—what we might call the structural characteristics of the universe. The various conditions of matter are apparent as we look around—the rocks and minerals of our globe, and the liquids upon its surface, with the all-encompassing envelope of air, are to us at once illustrations of matter.

Matter in itself has no power to change its condition. Such change can only come about through the action of force. An illustration of this will be found in the case of the falling stone; without the intervention of some agent, whereby force is exerted, the stone would have remained at rest. The quantity of matter in a body is said to be the mass of the body.

3. *Motion*.—From what has already been said it will be seen that motion is a condition of matter when acted upon by force. This condition is very constantly brought before us, whether in the movement of the falling stone, the dread rush of the cannon ball, or in the grander movement of the planetary bodies in their orbits around the sun. Besides these greater movements of matter we have what is known as molecular motion such as in the matter of gases, the small particles of which are supposed to be in very rapid motion.

4. *Space*.—It is obvious that in order to have the movements spoken of, the bodies, or portions of matter under consideration, must be separated, there must be a distance between them for this condition to have effect, and this separation we recognize as space. Thus when the projectile has reached the end of its flight, we speak of the space which it has passed over, and as we pass station after station in an express railway train, we feel that the motion is constantly carrying us onward from point to point, and at the end of the journey we speak of the distance traveled or the space passed over. In this idea of space we have only one dimension or length for our measure. A more extended idea of space, however, arises when we consider the motion of the cannon ball in detail, for here, besides the movement in its line of flight, we have another movement towards the earth; the ball is under the influence of two forces, one the explosive action of the powder, and the other that of gravitation. The resultant action of these two forces produces a curved path. The body may thus be said to be moving in two directions at the same time; a more simple illustration of space measured by two dimensions is that of a thin sheet of

paper whose boundaries are the dimensions which we name length and breadth. When, however, we apply this method to substances of a different form, such as a book or a box, we find that we require to indicate a third dimension to complete our definition of such an object. In such a case we must employ three dimensions, viz., what is called length, breadth, and thickness. We have thus distance, extension, and volume—the latter being our ultimate conception of space.

5. *Time*.—Our usual idea of time is duration, and is a relation of the past and present, a something which, constantly changing, yet links actions which are remote with others which are near. In this way we set ourselves to adopt measures for these relations, and these measures serve for fixing definite points in this succession or flow of events which we call time. Time may well be considered as flowing onwards; as a stream whose current is bearing us onward. To note more correctly this flowing current we have devised instruments, such as clocks and chronometers, whose motions are intended to be uniform, and which in this way measure out quantities of time. These time-measures again have to be regulated by the periodic motion of the heavenly bodies, so that as near an approach as possible to a true record of the flow of time may be made.

Time, like space in its entirety, is beyond our conception; individually we are only cognizant of limited portions of both, and even when we look backward along the stream of events until we reach the first dim life portraits of history, we have only got but as it were a scale of historic time suitable for measuring recent periods of the world's history, but which sinks into insignificance with the vaster periods of geological time, the records of which on the rock-bound volume of the earth's crust are all too dim and indistinct to give us a definite measure for our guidance.

By means of correct time-measures we arrive at some idea of space; thus, if we measure time, as by a clock or watch, in hours, minutes, and seconds, we may speak of passing from one point to another in such a time, but if we pass over the same distance in less time the separation seems to us less, and thus if this change became very rapid we might speak of distance being annihilated.

We can measure space by time if we consider three points, two of which lie at different distances from the third. We find that a longer time is required to reach the one than to reach the other, and we might say that one point was an hour distant, while the other was two hours distant. Here we have change of position estimated by time; but as this change of position implies motion, our measurement is not complete until we know something of the relation of some measured quantity of space with a known quantity of time, which latter relation is known as velocity; or

$$s = vt, \text{ and } v = \frac{s}{t}$$

where s = space in feet,
 t = time in seconds,
and v = velocity in feet per second.

6. *Velocity*, then, signifies the rate at which change of position is made. Thus, when we speak of passing over so many feet of space in a second of time, we call this rate of change the velocity of the moving body during the second. Here, then, we have two motions as it were, the motion of the body in space whereby it changes its position, but during this operation some other motion is going on, namely, the flow of time. Thus the body may move through 1 ft. of space in one second of time, and again it might move through 2 ft. of space in the same time. If the space, on the other hand, gets less and less, whilst the time remains the same, we gradually arrive at a point where the velocity, becoming zero, or nothing, we have a cessation of motion in space, and we say the body is at rest. If we travel by a carriage over a certain distance during a certain time, we have changed our position in space and also changed our position in time. If, however, we remain at rest for the same period of time we have not altered our position in space, but simply that in time. Time then bears us onward with a steady flow, and is unaffected by motions in space.

7. *Momentum*.—Having now considered matter and force by themselves, we come now to a consideration of matter under the action of force and having acquired velocity, and here we may revert to the original illustration of the falling stone. The stone or portion of matter, if supported at a height, would produce by its weight, or tendency to the earth's surface, a pressure upon the support, and if this pressure be effectually resisted by the support of the hand or otherwise, the body would be kept in this position and no motion would ensue. If, however, we remove the support, the stone, through the action of the now unbalanced force, will begin to fall, and will do so at an ever increasing velocity until brought to rest. During the fall the stone was impelled downward, and the impulse so induced is measured by the time during which the force acts. If we increase the size of the body we find that we have to exert more force to keep it from falling, so that for a body of double the size or mass we require twice the supporting force, and for a body treble the size thrice the supporting force, and so on. The momentum of a body is the product of the mass and the velocity. A body when falling freely in Britain attains at the end of the first second a velocity of about 32.2 ft. per second, and in gravitation results the ex-

pression for momentum is Wv —where W = weight of body,

v = velocity in feet per second, and $g = 32.2$, and it is usual to state the relation of momentum to impulse by the equation

$Ft = \frac{Wv}{g}$, F being the force acting, and t the time of action in seconds on the body.

8. *Energy*.—This term is used to denote the capacity for overcoming resistance or doing work, work being an action whereby a material change is produced. Thus, when we raise the stone from above to a higher position we overcome the resistance due to its gravity, or tendency to fall to the earth's surface, and this resistance is overcome through a certain space, equivalent to mechanical work performed. The energy, therefore, which we have expended is equal to the work performed, and is measured by the weight multiplied by the height through which the body has been raised, and this energy is stored for the time in the body by virtue of the position it has now attained. If the body be allowed to fall, and return to the point from which it started, it will communicate this stored up energy to any obstacle which brings it to rest. The energy of position is sometimes called potential energy, and the energy of motion, actual or kinetic energy.

* In such bulbs even bisulphide of carbon vapor may be so nursed as to produce sounds of considerable strength.

* I intentionally use this phraseology.

It will be seen from these illustrations that these are interchangeable, whatever is lost by the one being gained by the other. If the stone be of the weight of one pound, and be lifted through 10 ft., we have in this new position ten foot pounds of potential energy. If now it is allowed to fall and stopped at one-half of the height, or 5 ft., it has now in virtue of its position only five foot pounds of potential energy, but it has, in striking the obstacle which brought it to rest, given out the other five foot pounds of energy as actual energy of motion, hence the sum of the potential and actual energies remains constant. Although various transformations of energy are constantly taking place, yet the sum of all the energy of the universe remains constant—a principle known as the conservation of energy.

In a steam engine the energy of combustion due to the combination of the carbon of the coal and the oxygen of the air appears as heat, which is thus a form of energy. The heat through the medium of the water in the boiler produces steam, which communicates motion to the machinery. The potential energy of the gunpowder in a loaded gun becomes changed into the kinetic energy of the projectile through the chemical affinity of the constituents of the powder upon ignition. And the dull and apparently inert mass becomes suddenly changed into a large volume of gaseous matter whose elastic force propels the bullet.

In a railway train moving with a uniform speed the energy of the steam in the engine is expended in overcoming the frictional, tractive, and other resistances; if by the action of the brakes or through a collision the train be brought to rest, the actual or kinetic energy of the moving mass of the train will be mainly changed into heat of friction and in overcoming the resistances opposed in breaking up the parts in contact.

In many ways we may observe this mutual relation of heat and mechanical work, and it has been proved experimentally that 772 foot-pounds of work has to be expended in order to raise the temperature of one pound of water at 39 deg. Fahr. through one degree; the number 772 is thus known as the mechanical equivalent of heat.

From various considerations it would appear that the energy of the universe is tending to the condition of heat, and that consequently there may come a period in which all matter will be at a uniform temperature with a consequent cessation of visible motion—to this principle the term dissipation of energy has been given.—*Engineering.*

THE HARMONIC ANALYZER.

In February, 1876, Sir William Thomson submitted to the Royal Society a proposal for an integrating machine which should produce mechanically the harmonic constituents of meteorological, tidal, and other curves, thus obviating the large amount of work involved in their calculation by the ordinary methods. The machine thus proposed was to consist primarily of a series (connected by suitable mechanical

by a rack and pinion, carried five forks acting on the spheres for the purpose of moving them to and fro; and there was also fitted to this bar a pointer for tracing the curve to be analyzed.

The curve was passed over a cylinder placed between the first pair of integrators, and turned by a handle controlled by the left hand of the operator, whose right hand governed at the same time the pointer just referred to as fixed to the horizontal bar. At the ends of the cylinder were cranks at right angles to one another, and a similar pair fitted to an upright between the third and fourth disks were set in motion by means of toothed wheels connected with a horizontal shaft at the rear of the machine; one end of this shaft was geared to a toothed wheel fixed to the record cylinder, by which it was turned, while at its other extremity it carried a large wheel with oblique teeth working into a crown wheel, and so, giving motion to the fifth disk, recording the mean. Each of these four cranks gave a simple, harmonic angular motion to one of the four disks by means of a slide and crosshead, carrying a rack working into a sector attached to the rim of the disk. The angular velocity of the second pair of cranks was double that of the first, so that the machine was fitted for analyzing meteorological curves and producing the constants in Bessel's formula:

$$E = a + a_1 \cos. \theta + b_1 \sin. \theta + a_2 \cos. 2\theta + b_2 \sin. 2\theta + \text{etc.},$$

And it was therefore handed over to the Meteorological Office, where, under the superintendence of Mr. R. H. Scott, F.R.S., its practical working was tested upon the curves of temperature and barometric pressure supplied by the self-recording instruments at the observatories of the Meteorological Council, and with very satisfactory results.

The Council of the Meteorological Office having thus satisfied themselves of its practical value, eventually requested Mr. R. W. Munro, of Gray's Inn road, to construct a larger machine containing seven disks—one for the mean and three pairs for the first three terms of the expansion—in which they introduced several mechanical improvements.

This has now been completed, and is shown in the accompanying engraving. In principle it is, of course, precisely similar to its predecessor—differing from it only in constructive details intended to secure stability and accuracy in its movements. Instead of being largely made of wood, as was the case with the model, it is entirely of metal; the cast-iron frames carrying the disks being secured to a firm iron bed supported by two substantial uprights; the disks themselves are of gun-metal, and the spheres of steel, carefully turned and nickel-plated, to prevent rusting; the horizontal bar carrying the forks for moving the spheres is also of steel and plated, and is carried above the disks upon five iron uprights or guides. The forks are provided with adjusting screws allowing of very accurate centering of the spheres upon the disks, and adjusting screws are likewise provided for the frames carrying the recording cylinders, by which their parallelism to the faces of the disks can be rigidly se-

wheels are skew cut to further lessen the risk of error from backlash.

The height of the machine is 3 feet 8 inches, and the length of the steel bar, which is rather longer than the bed of the machine, 9 feet. The machine is now upon its trial at the Meteorological Office, and, notwithstanding the weight and solidity of some of its parts, the whole is so nicely balanced and fitted that it works with the utmost ease and smoothness, and in the range and accuracy of its work it will without doubt prove greatly superior to its cruder progenitors. Its novelty and the success which has attended its preliminary trials have attracted to it considerable attention from scientific men interested in such machines, and at the same time the very careful workmanship and finish bestowed upon it, and the ingenuity displayed in the adaptation of means to ends, reflects the greatest credit upon its constructor, Mr. R. W. Munro.—*Engineering.*

THE JORDAN BAROMETER.

It is impossible to foresee the result of the perfecting of any scientific instrument. It is rarely the case that such an instrument is—like the spiders among *insecta* and their allies—born in the form which it will maintain through life. Such, however, was the case with the weather-glass of Pascal. The best mercurial barometers of the present day are in principle, and almost in detail, identical with the tube which that great genius carried up the Puy de Dome for his memorable experiment. The great defect of the mercurial barometer is the narrow limit of its movement. A difference of ten per cent. in the atmospheric pressure, which is about the maximum to be obtained at any fixed point on the surface of the earth, only causes a difference of three inches in height of the column of mercury, and it is difficult to read the barometer more closely than to the tenth of an inch. The ball-like, or the cup-like, form of the top of the mercury gives some indication as to the actually upward or downward tendency of the barometric movement; but the desirability of a more visible display of the force of atmospheric pressure is undeniable.

Extreme delicacy, no doubt, is obtained by the use of an aneroid, furnished with vernier and magnifying glass. But the aneroid is better suited for observations involving change of place than for those made successively on the same spot. Like the old-fashioned wheel barometer, the aneroid usually requires a tap, to see that the needle is freely moving; and this is but a clumsy means of making a delicate observation. Years ago we remember, in the window of an optician in Liverpool, an inclined barometer. The upper three inches or four inches of vertical tube were replaced by five feet or six feet of inclined tube, so that by placing the graduation at right angles to the latter, the intervals of change were magnified from twelve to fifteen times. We are not aware how the ingenious modification acted. Those of our readers who were at the meeting of the British Association in Birm-

SIR WILLIAM THOMSON'S HARMONIC ANALYZER.

means) of his brother Professor James Thomson's integrators, in which the motion of a disk is conveyed through the medium of a loose sphere sufficiently heavy to give the necessary frictional adhesion to a cylinder fixed in front of the disk parallel to its face. The annexed Figs. 2 and 3 will make the arrangement clear, the plane of the disk, D, being inclined at an angle of 45 deg. to a perpendicular plane passing through the axis of the cylinder, C; the ball, B, rests both upon the face of the disk and the surface of the cylinder, free to move to and fro, the points of rolling contact of the ball with the disk and cylinder describing straight lines, respectively passing through the center of the disk and parallel to the axis of the cylinder. In the integration of $y dx$ the distance from the center of the disk of that point upon its face on which the ball rests in its longitudinal motion represents y ; while the angular space turned through by the disk from some initial position represents x . The circumference of the recording cylinder is divided into equal divisions, say from 0 to 100, by which the angular space through which it turns can easily be read off, and this reading, multiplied by a suitable numerical factor, expresses the integral in terms of any required unit.

Professor James Thomson has pointed out that an element of imperfection common to previous integrating instruments, and "which cannot but prevent our contemplating them with full satisfaction," is to be found in "the sliding action which the edge-wheel or roller is required to take in conjunction with its rolling action," and for the arrangement just described he claims the merit of working by pure rolling contact, instead of by a combination of rolling and slipping.

A model of Sir William's proposed machine was subsequently constructed and exhibited to the Royal Society in 1878. Five of the integrators were placed side by side, so that the centers of all the disks were in one line, and the axes of all the cylinders in a line parallel to it. A long wooden rod, supported above the integrators by guides, and worked

cured. The spheres are not touched by the forks themselves, but by the flat faces of two screws passing through their lower extremities, and in this way a ready means of preventing looseness or tightness of the spheres in the forks is provided.

Each recording cylinder has attached to it a counter for registering the number of its complete revolutions, and to secure a maximum of freedom in their movements the spindles of the cylinders, as well as the slides carrying the racks for giving motion to the disks, and the horizontal steel bar, are all made to run upon friction rollers; the slides have in addition counterpoises attached to them to prevent error from backlash.

The motion of the shaft at the rear of the machine is communicated to the second and third pairs of cranks through sets of toothed wheels so arranged that they may, if desired, be changed for others of different ratios to the cylinder carrying the curves, and in this way the terms of other orders of the expansion may be obtained, should they be required, with the same instrument merely going over the curves afresh, and using wheels of the proper ratios in place of those used for the first, second, and third pairs of terms.

The cylinders over which the curves have to pass is provided with an ingenious arrangement by which it can be expanded or contracted to alter its circumferential measurement, so that within certain limits variations in the length of the time ordinates of the curves can be very readily allowed for. To effect this, the cylinder (see Figs. 4, 5, and 6) is made in three sections, each provided with an eccentric movement; of course, except when these are at their normal positions the "cylinder" is not cylindrical, but still, even when moved to their extreme limits, the deviation is not so large as to cause any inconvenience in its use. Adjustments are also supplied to the pointers, of which two are used at once, to meet the peculiarities of the curves submitted to analysis; and throughout the machine all racks and toothed

ham, some fourteen years ago, may remember that one of the lions of the place was a water barometer, erected in the house of an amateur, which seemed almost to breathe like a living being. A water barometer was made by Professor Daniell for the Royal Society in 1830. The indications given by this instrument (the movement being about twelve times as great as that of the mercurial column) are very distinct. But the variation of temperature exerts such an influence on the vapor rising from the water within the tube as to interfere with the accuracy of the instrument. In fact, it is not a barometer, pure and simple, but a combination of barometer and thermometer.

Mr. Jordan, of the Museum of Practical Geology in Jermyn street, has met, and, it seems safe to say has overcome this defect in the water barometer. He has substituted for water, pure glycerine, the specific gravity of which is 1.26—or only one fourth more than that of water, and glycerine possesses the unusual advantage of combining perfect fluidity with a boiling point of 440° Fahr., and a correspondingly low freezing point. Thus, it raises no vapor to be affected by heat in the top of the tube, nor will it be injuriously affected by frost. The only defect of the substance is the readiness with which it absorbs water from the atmosphere. This has been met by Mr. Jordan, by the ingenious device of giving the glycerine a waterproof coat or, in other words, floating a layer of petroleum on the surface of the glycerine in the cistern. Thus, a barometer of extreme delicacy, and as little liable to get out of order as the mercurial barometer itself, has been placed at the service of science.

One of these barometers has been constructed at Kew Observatory; a second at the Museum of Practical Geology in Jermyn street; a third at the South Kensington Museum; and a fourth at the office of the *Times* newspaper. This journal has commenced the publication of two hours' reading of the instrument, plotted on the natural scale. The un-