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ON THE ABSOLUTE VACUUM AS A NON-CONDUCTOR OF ELECTRICITY, AND THE IMPORTANT BEARING OF THE FACT UPON ELECTRIC THEORIES.*

BY DR. P. H. VANDER WEYDE.

* A paper read before the N. Y. Electrical Society.

The historical exhibition which I furnished at the American Institute Fair of 1887 contained several series which for want of space could not be separately shown, as would have been desirable, if space had permitted. In fact, everything was to a great degree mixed up for the reason referred to.

Among these series, electricity in vacuo formed a prominent and important feature, and because this is a subject so little understood, and even misunderstood, by the majority of electricians, and is also neglected in the text books, I felt induced to take this for my subject, when I was requested to address the society.

An additional reason was that it is of some practical importance, not so much in regard to its mechanical applications, as for the understanding and explanation of a great number of natural phenomena.

I will treat the subject historically, and therefore begin by calling your attention to the experiments of Nollet, recorded in this little book, published in Paris, 1753, and illustrated with carefully engraved figures. His experiments consisted in passing a current of static electricity through glass flasks, from which a large portion of the air had been previously removed by the air pump. He found that the electric current passed as a luminous stream which was very bright when the room was darkened, while luminous pencils were thrown off toward the sides of the flask, if they were touched by the fingers, or any other conductor of electricity.

Some thirty years later a variation of this experiment was contrived, consisting of a strong glass tube of about two or three inches diameter and three or more feet long, provided with brass caps at each end, which could be conveniently attached to the air pump and exhausted. As the exhaustion proceeded, the rarefied air in the tube became a conductor of electricity, while this conductivity appeared to improve in proportion as the air was more exhausted. At last a regular stream of electricity was seen to pass through the tube, which stream resembled strikingly the luminous coloured streams seen in the aurora borealis, wherefore such a tube was called the "aurora tube," and under that name is found in most philosophical collections.

This apparatus was exhibited at the fair, the exhibit consisting of an old historical air pump, made about 1780, with the aurora tube screwed on the top of it. A few other smaller devices of a similar nature were less conspicuous, and about them I wish only to remark that, when using an ordinary air pump, it appeared that the conductivity of the air increased in proportion to the amount of exhaustion ; hence the impression became prevalent that if we could only obtain a perfect vacuum we would have the best of all conductors, and this idea is, unfortunately, even at the present day, shared by several prominent electricians who have not had the opportunity to keep themselves posted in regard to the discoveries made during the last few years, especially those made by Crookes, Gassiot, Spottiswoode, Gordon and others.

I must not omit to mention that before the latter discoveries Geissler, in Germany, began to furnish investigators with a great variety of glass tubes of various fanciful shapes, made of different kinds of glass and filled with various gases and vapours, exhausted by the air pump or by being heated, and then sealed up by the blow pipe, while platinum or aluminum wires were inserted at the extreme ends, so as to conduct the electric current through the rarefied gases inside. As those tubes exhibit a series of striking and beautiful phenomena, they became very popular, and no physical collection is considered complete without a set of such tubes. They give occasion to exhibit the aurora phenomena, and similar ones of the same character without the trouble of continually working the air pump.

I had two sets of such tubes on exhibition at the fair ; one was extra large, the tubes being three and four feet long, and another set of tubes as many inches in length, and which I shall have the pleasure to exhibit to you to-night, being much easier and safer to transport than large tubes.

I will now proceed to make a statement of the facts as they are. They are startling and difficult to explain without the knowledge of the new conceptions of Prof. Crookes regarding the nature of matter in the four different conditions, in which it presents itself to us.

The facts referred to are : The atmosphere in its ordinary condition is a very good non-conductor of electricity, provided it is perfectly dry and under a pressure equal to a mercurial barometric column of 760 millimetres or higher.

It is an important consideration, that if the air in which we live were a good conductor of electricity, man could never have become acquainted with electrical phenomena, as then static electricity could never have been collected, studied and experimented with ; as this form of electricity was the key to the other different forms, the latter would never have been discovered.

When rarefied by the air pump to a quarter of the normal pressure, the insulting qualities of air are not so good, and when reduced to a pressure of 10 or 20 millimetres it is a good conductor and exhibits the phenomena referred to before. As this is about the limit attainable by an ordinary air pump, it is very natural that experimenters became possessed of the idea stated above, that the conductivity of the air would keep on increasing as the exhaustion proceeded, but after the Sprengel mercurial air pump was invented, by which the air can be exhausted to a thousandth of a millimetre of mercurial pressure (which is about equivalent to one-millionth part of ordinary atmospheric pressure), it was found that the capacity of the air to show the auroral phenomena in the usual way ceased.

The electric current then behaves in a very different manner, as it radiates in straight lines and cannot turn corners, so that when the tubes are bent it gives occasion to very striking and novel phenomena, which were first brought forward by Prof. Crookes in the tubes which are known by his name.

The difference between the Geissler tubes and the Crookes tubes is, that in the first the vacuum is very imperfect. In the Crookes tubes it is about a thousand times better, while if we succeed in making the vacuum a million times better, the conductivity of the air ceases absolutely. To accomplish this we must aid the function of the Sprengel air pump by some chemical device which will remove the laet remnant of air. It then becomes an absolute non-conductor, which ordinary atmospheric air is not, because it is possible to pass currents of high tension in the form of an electric spark through the densest and dryest air. In the absolute vacuum, however, it is impossible to pass, over the space of a quarter inch, a spark which, when leaping through the air, will be six or more inches long.

I exhibit here such a tube, in which the two platinum wires are brought together within a distance of scarcely a quarter inch. In this tube a vacuum did exist so perfect that it was impossible to pass a spark through, which through air would leap over a distance of more than six inches. I found that the spark would rather pass over the outside of the tube for that distance than go through the interior. In order to satisfy myself that no trace of electricity passed through the interior space of an quarter inch, I connected one of the platinum wires with a Leyden jar, wound a brass chain half way around the middle part of the tube, and connected this brass chain with the ground, in order to prevent any electricity from reaching the Leyden jar through the air along the outside, but I was not able to obtain the least trace of a charge in the Leyden jar. Later I increased the strength of the current more and more, until at last something happened in the tube which destroyed the vacuum ; something volatilised, covering the sides of the glass interior with a blackish deposit, which may perhaps be platinum black, a thing which may not be impossible, if we consider that the electric discharge furnishes us the highest temperature which we can possibly produce by any means.

For more than 20 years I have preached this non-conductibility of a perfect vacuum, as it was proved by experiments with the Ruhmkorff coil, by de la Rive and Du Moncel. The latter describes the experiments in his book "Sur l'appareil d'induction de Ruhmkorff," published in Paris about 25 years ago.

It has not a little surprised me that the priority of this discovery is so remote as I found it to be, and that so important a fact as that of the non-conducting power of a perfect vacuum has been overlooked and ignored for nearly a century after it was proved by experiment. I found in the *Philosophical Transactions* for 1785, page 272, vol. 75, the extract of a paper read by Morgan before the Royal Society, and which I published eight years ago in the *Practical American*, which I edited at the time. The paper referred to states that a mercurial gauge 15 inches long, filled with pure mercury which was boiled in the glass until all air was expelled, was coated with tin-foil 5 inches down from its sealed end, and was inverted into the mercury in a little trough, through a perforation in its brass cap ; the air over the mercury in the trough was then exhausted when the mercury in the gauge fell down more or less in proportion to this exhaustion, but had always a perfect vacuum over it. If then the tin-foil coating the upper end of the tube was connected with the conductor of an electric machine, not the smallest ray of light nor the slightest charge could be produced in this exhausted gauge ; but if the mercury had been imperfectly boiled, coloured luminous phenomena were seen. The same was the case when the sealed end of a perfectly exhausted tube became cracked so that a little air had access. At first the electric charge passed with a yellow or green light; more air made the colour a beautiful green, then blue, from blue to indigo ; more air still, voilet and purple, until the medium became so dense as to no longer conduct electricity. The writer closes with the observation :—"I think there can be little doubt, from the above experiments, of the non-conductive power of a perfect vacuum, This seems to prove that there is a limit even in the rarefication of air, which sets bounds to its conducting power ; or, in other words, that the particles of air may be so far separated from each other as no longer to be able to transmit electricity ; that if they are brought to within a certain distance of each other, their conducting power begins, and continually increases, till their approach also arrives at the limit."

It is also a fact, known for more than a century by expert barometer makers, that the luminosity which shows itself in the dark in its vacuum, when a barometer is moved up or down in order to cause the mercurial column to oscillate in the same way, is only seen when the mercury has been boiled in the tube to a moderate degree ; when the vacuum is made too perfect it shows itself feebly, or not at all, the same as is the case when the vacuum is contaminated with watery vapours.

So much for facts ; now for the theory which explains them, and for which we are indebted to Prof. Crookes. It gives us an inside view of the nature of matter in the conditions in which it presents itself to us, and is based on the theory of Dalton, that all matter consists of an immense number of infinitesimal particles, called atoms, which are indestructible, and in continual motion, which latter is also indestructible.

Astronomy teaches that in the planetary system we find a condition of things which is far beyond our ordinary conception based on our experience about things falling under the daily, immediate observation of our senses. First, the distances at which the celestial objects are placed are immense in proportion to their size, stupendous as it appears to us. Secondly, they are in a continuous motion, which is indestructible. Every planetary system is to us a perfect "perpetuum mobile."

Modern chemistry teaches the same doctrine in regard to ultimate atoms, which constitute that which we call matter. First, the distances of these atoms are also very large, in proportion to their size, which is infinitesimally small beyond our conception ; secondly, these small particles or atoms are also in a continuous everlasting motion, as indestructible as is the motion of the planetary bodies.

As a concise statement of the modern philosophical conceptions in regard to this subject, we say that, as the chemists of the past century proved, that apparent destruction of matter was only a transmutation of form, so the physicists of the present century have proved that apparent destruction of motion is also merely a transmutation of form, a change in the mode of motion; mass motion changed into molecular motion, which revals itself as heat, light, or electricity, or, *vice versa*, any of the latter forces into one another or into mass motion. Of this transformation the steam engine and the modern dynamo are forcible illustrations.

The great Swedish chemist Berzelius more than half a century ago expressed similar views, when he declared that the heat and light we see in an electric discharge, say, in a stroke of lightning, is not the electricity itself; he states most explicitly that the restoration of the electrical equilibrium, which when destroyed gives rise to what we call electrical phenomena, causes the evolution of sudden light and heat in the bodies through whose medium this restoration of equilibrium takes place, which light and heat then radiates and diffuses itself according to the ordinary well known laws of radiation and convection.

Crookes, in order to explain the peculiar behaviour of electric discharges through his highly exhausted tubes, teaches the doctrine that our conception of three states of matters, solid, liquid and gaseous, is incomplete; he says that there is a fourth condition, which he calls radiant matter. He teaches as follows:—

In solid bodies the atoms are in a state of rest; that is to say, as far as their relative position is concerned, but each atom oscillates to a greater or lesser degree. If the amplitude of the oscillation is small, we call the body cold; if the amplitude of the oscillation is large, we call the body hot; and in so far, Crookes's theory agrees with what Tyndall has popularised is his well known work, entitled, "Heat as a Mode of Motion."

When the amplitude of the oscillations becomes so great that the atoms turn over and commence to rotate around their centres, the body reaches its melting point and becomes a liquid. Therefore, in liquids the atoms are not rigidly fixed to certain positions, but can freely roll over one another, and this constitutes the difference between solids and liquids.

When the velocity of the rotation becomes greater and greater, we say that the liquid is becoming hotter, and when from some cause or other this motion is still further increased, a new set of phenomena begins. The atoms are projected into space, and in place of rotating they are propelled from the liquid, and also repel one another, and as millions upon millions exist in the small space of a cubic inch, collisions take place by billions, and the body enters in what we call the "gaseous" condition.

Here we have entered a field for the conception of which very few are prepared. We are as little prepared for it as our ancestors were when Galileo and Copernicus, and later, Herschel, revealed to mankind the immensity of the universe. When at school, studying astronomy, we obtained some kind of conception of the infinitely large.

We are not yet educated to the conception of the infinitely small, which is a new revelation, which is as difficult to grasp with our finite mind as it is to grasp the infinitely large. In considerating the latter, we speak of distances so great that our common measures are utterly inadequate, and we must have recourse to larger standards of measures, such as the velocity of light connected with the time it takes to reach us from the most distant stars, which, in some cases, has been proved to be ten thousand years.

In considering the motion of the atoms of gaseous matter, we enter the other extreme of the conception of great and small. It appears that the number of atoms in one cubic inch of the common air we breathe is represented by a series of more than twenty figures, which particles or atoms are in constant continual collision to the number of ten million per second, while the velocity is so great that, if moving in a straight line, they would pass through a space of eleven thousand feet in a single second, thus surpassing the velocity of sound ten times. This is the nature of the third or gaseous condition.

The fourth condition, attained by the Sprengel air pump, is called by Crookes radiant matter. It is reached when the exhaustion proceeds so far that there are so few atoms left as to make the collisions exceptional; then the atoms will move in straight lines, and encountering no mutual hindrance to their motion, they will follow the laws of electric repulsion and *radiate* from the point charged with electricity; hence matter in this condition is called "radiant matter.

Now we come to tho most interesting feature of our consideration, namely, the chemical device referred to above, and intended to remove this last trace of air; recourse is had to the strong chemical affinity of potash for carbonic acid. The exhausted tube is filled with carbonic acid gas and again exhausted, and this process repeated in order to make sure that no atmospheric gas is left, but only very rarefied carbonic acid gas. A recess is connected with the tube during the operation, in which recess is placed a small stick of pure caustic potash. This recess is heated by a spirit lamp, so as to drive out the carbonic acid which the potash may contain, and then the vacuum is again made. The last remant of carbonic acid which the air pump cannot remove is then absorbed by the potash, when this is allowed to cool down. In this way the absolute vacuum is produced, through which no electric current can be made to pass.

The bearing of this fact is of the utmost importance in regard to our conception of the nature of electricity. It is generally admitted that the theory of the existence of a caloric fluid is erroneous, and that heat is merely a peculiar mode of motion as referred to above, and this view is adopted, notwithstanding there is no experiment known serving to demonstrate that heat cannot be transmitted through a space absolutely devoid of all matter. Heat and light will both pass through a vacuum perfect enough to obstruct absolutely the passage of electricity. If there were such a thing as an electric fluid, it surely would pass through any empty space, and we are therefore driven to the conclusion that the presence of matter is as absolute a condition for the transmission of electricity as the presence of air is an absolute condition for the transmission of sound; and there is as little necessity to accept the hypothesis of the existence of an electric fluid as there is for the hypothesis of a sonorous or caloric fluid.

Air being the ordinary vehicle by which sonorous vibrations are transmitted, a proper degree of exhaustion will arrest this transmission, and any common air pump can be made to prove that sound is with difficulty transmitted through a partial vacuum, and not at all when the vacuum is somewhat nearer to perfection. This experiment is acknowledged to be intended for a demonstration that the air molecules are the media for transmitting sound; that without such a medium there can be no sound, and that there exists no peculiar sonorous imponderable fluid which pervades the air, and should be the cause of sound transmission. When now we see that more highly rarefied air behaves toward electricity in exactly the same way as the lesser rarefied air behaves toward sound, namely, that at a certain degree of rarefaction the transmission becomes more imperfect, and at a certain point stops entirely, we are driven to the conclusion that electricity as well as sound is merely a peculiar form of motion of ponderable matter.

The conventional method of calling electricity a fluid must be understood to be only for the sake of convenience in explaining the phenomena presented. An argument in favour of this custom is that electric currents behave like water in two respects, namely, moving under greater or smaller pressure and in greater or smaller quantities.

What in water is called pressure or head is in electricity called electromotive force, and as hydraulic pressure can overcome great mechanical resistances so electromotive force can overcome great electrical resistances.

It is measured by a standard unit, which is properly called after the illustrious Italian who first invented an apparatus which multiplied the small electromotive force of a galvanic couple, the column of Volta. The quantity of electricity discharged through a channel is measured by another standard, also very appropriately named after the great French investigator, Ampère, who discovered the laws governing the mutual action and reaction of currents of great quantity.

That rarefied air is by no means so good a conductor as assumed by many, is proved by the fact that it requires a considerable electromotive force to pass it through. Machines producing static electricity, either by friction or induction, give that high electromotive force, while a single large galvanic cell or better still, a thermo-electric couple, offers the other extreme, viz., a large quantity of very low electromotive force utterly incapable of being transmitted through any kind of vacuum.

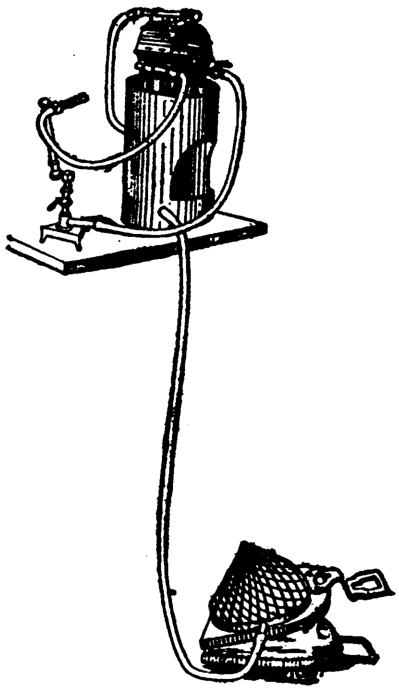
I referred in the beginning of this paper to the application of the knowledge recently obtained in regard to the behaviour of electricity in rarefied air and in vacuo for the purpose of explaining certain natural phenomena. These phenomena are principally the aurora borealis and australis, and especially those which are related to the immense enigmas which from time to time appear in the heavens, the comets, which alarm the ignorant. On a future occasion I hope to have the satisfaction to show you that all the peculiarities presented in both cases may be satisfactorily accounted for by the lately discovered facts to which I have called your attention to-night.

THE "MIDGET" COMBINED GAS BLAST FURNACE AND BLOW-PIPE.

The illustration accompanying this article represents one of the numerous practical inventions in the construction of furnaces, devised by the inventor of the improved petroleum furnace above described. The object sought in this improvement is to secure, within the least possible space, and with the least expenditure of time, the highest heating effect, and with no greater expenditure of power than is required to operate a blow-pipe. The furnace will be found to answer for the successful operating of muffle work, crucible work, and the blow-pipe.

The entire apparatus, including blow-pipe, bellows, stand and furnace, does not occupy more than ten inches of space, and can be carried conveniently in a small hand satchel.

By reference to the engraving, a series of stop-cocks will be seen both to the right and left, and one at the rear. They are intended to supply any desired quantity of gas and air, and to admit pre-determined volumes of gases and vapours



"MIDGET" BLAST FURNACE.

either in combination with one another or separate, and in any desired proportions, either into the combustion chamber or into the muffle. Thus, when it is desirable to effect the rapid oxidation of any substance, a current of oxygen may be passed into the muffle; or, when it is important to prevent oxidation, a current of reducing gases is injected into the muffle; and, in like manner, any desired gas or vapour may be forced into the muffle to produce any desired chemical effects on substances placed therein.

To the chemist it presents facilities whereby he may call into action the effects of heat of any desired temperature, covering the whole range of analytical work, conveniently submitting the substances operated on to the action of various gases and vapours with a degree of precision not heretofore attainable.

The operations being reduced to such a minature scale, it becomes very easy to operate it by foot or hand power, as the smallest motor will give an abundant air supply, and thus make it automatic at a trifling expense, as compared with the same advantages heretofore possible to obtain.

Either gas or the vapour of gasolene will yield equally good results. Two gallons of gasolene will give about four days' service. From 3,000° to 4,000° of heat may be obtained in from six to ten minutes, heating a muffle 2½ inches long by 1¼ inches in diameter.—*Manufacturer and Builder.*

A German photographer, Anshuetz, of Lissa, after some years' experimenting in photographing the flight of cannon balls, has at last succeeded in obtaining photographs of the trajectory of balls moving at a velocity of 1,300 feet per second, with an exposure of only the ten-thousandth part of a second.

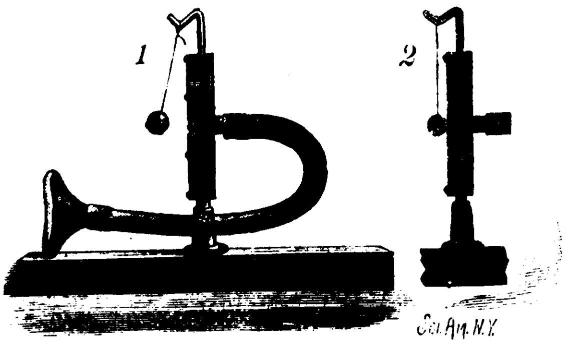
VIBRATIONS OF DIAPHRAGMS

BY GEO. M. HOPKINS.

The telephone and phonograph show conclusively that the human voice is able to set certain bodies in active vibration. These vibrations may be detected by touch, but they are not discernible by the unaided eye. It has been shown that the force which produces them is able to perform a considerable amount of work. A telephone diaphragm is able to vibrate sufficiently to transmit speech, even when heavily weighted. A diaphragm, when placed in a horizontal position and damped by a five pound weight suspended from its centre, transmitted speech equally as well as one not so damped, the only difference being a considerable loss in the volume of sound.

Mr. Edison, some years since, devised a piece of apparatus known as the motophone, in which a diaphragm vibrated by the voice, was made to rotate a wheel at a high velocity. In the phonograph the cutting stylus, which is moved by the diaphragm, exhibits, when in action, something of the power of the voice, and the engraving on the cylinder of the phonograph shows the complex character of the vibrations of the diaphragm, but on so small a scale as to be difficult of observation.

The use of the apparatus shown in the annexed engravings is, first, to show by means of the lantern that the telephone diaphragm vibrates, and, second, to exhibit by the same means the character of the vibrations.



EXPERIMENT SHOWING THE VIBRATION OF A DIAPHRAGM.

In Fig. 1 is shown a telephone diaphragm arranged upon a standard and adapted for projection. This apparatus is shown in section in Fig. 2. To the top of the diaphragm cell is secured a hook which supports a small metallic ball opposite the centre of the diaphragm by means of a fine silk thread. The ball hangs normally in contact with the diaphragm, but when sounds are uttered in the tube attached to the cell, the diaphragm is vibrated, its motion being made manifest by the repeated repulsion of the ball.

In Fig. 3 is shown an instrument for tracing upon a smoked glass a record of the movements of the diaphragm. A wooden frame is supported by a standard secured to the base board. The face of the wooden frame is grooved to receive the smoked glass plate, which is held in the groove by four spring clips, so that it may be moved up or down after each tracing, preparatory to making a new one. In one edge of the frame are inserted two parallel rods, which are further supported by a standard attached to the base. The standards are made adjustable to adapt the instrument to lanterns of different heights. The arm which supports the diaphragm cell is provided with a sleeve which slides freely on the upper rod, and it is furnished at its lower end with a fork which partly embraces the lower rod. By this arrangement, the diaphragm cell is truly guided while the tracing is being made, and at the same time the construction allows of tilting the cell whenever it is desirable to remove the tracing point from the surface of the glass. The diaphragm cell consists of two chambered recessed disks fastened together with screws, and clamping between them a thin iron diaphragm. The upper disk is apertured and provided with a flexible tube terminating in a mouthpiece. To the centre of the diaphragm is attached a stud, which is pivoted to the tracing lever, the lever being fulcrumed in a rigid arm projecting downward from the cell. The free end of the tracing lever carries a fine cambric needle, which lightly touches the surface of the smoked glass when the cell is in the position shown. The tracing lever is made of a thin bar of aluminum, which can spring laterally, but which is very rigid in the direction of its motion.

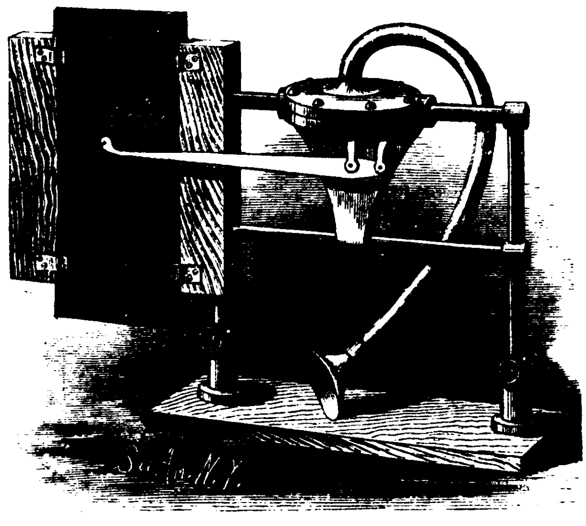


FIG. 3.—PHONOGRAPHIC RECORDER.

When used, the apparatus is placed with reference to the lantern so that the opening of the wooden frame will come within the cone of light in front of the condenser. The smoked glass is focused on the screen, the diaphragm cell is placed near the wooden frame and held in one hand, while the mouthpiece at the end of the flexible tube is held at the mouth by the other hand. Now, while a sound is made in the mouthpiece, the diaphragm cell is quickly but steadily drawn along, so as to cause the tracing needle to traverse the smoked glass. A sinuous line will be formed upon the glass, which will be characteristic of the sound uttered, and this line will appear upon the screen as it is formed. By tilting the diaphragm cell, and moving the smoked glass, and then returning the cell to the point of starting, the operation may be repeated. It will thus be seen that, by means of this instrument, a sound may be produced and analyzed at the same moment.—*Scientific American.*

There are 15,000 photographic establishments in the United States, furnishing employment to about 50,000 people. Less than 50 years ago there was not a photographic camera in the world.

THE BIRTH OF PRINTING.

Of all inventions, probably none has exercised a greater influence upon modern civilization than that of printing. While it has been the mother and preserver of many other inventions which have changed the face of society, it has also afforded facilities for the intercourse of mind with mind—of living men with each other as well as with the thinkers of past generations—which have evoked an extraordinary degree of mental activity, and exercised a powerful influence on the development of modern history.

Although letters were diligently cultivated long before the invention of printing, and many valuable books existed in manuscript, and seminaries of learning flourished in all civilized countries, knowledge was for the most part confined to a comparatively small number of persons. The manuscripts which contained the treasured thoughts of the ancient poets, scholars and men of science, were so scarce and dear that they were frequently sold for double or treble their weight in gold. In some cases they were considered so precious that they were conveyed by deed, like landed estate. In the thirteenth century, a manuscript copy of the "Romance of the Rose" was sold at Paris for over £33 sterling; a copy of the Bible cost from £40 to £60 for the writing only, for it took an expert copyist about ten months' labor to make one. Such being the case, it will be obvious that books were then, for the most part, the luxury of the rich, and comparatively inaccessible to the great body of the people.*

Even the most advanced minds could exercise but little influence on their age. They were able to address themselves to only a very limited number of their fellow-men, and in most cases their influence died with them. The results of study, investigation and experience remaining unrecorded, knowledge was for the most part transmitted orally, and often inaccurately. Thus many arts and inventions discovered by individuals became lost to the race, and a point of social stagnation was arrived at, beyond which further progress seemed improbable.

This state of things was entirely changed by the introduction of printing. It gave a new birth to letters; it enabled books to be perpetually renovated and multiplied at a comparatively moderate cost, and to diffuse the light which they contained over a much larger number of minds. It gave a greatly increased power to the individual and to society, by facilitating the intercourse of educated men of all countries with each other. Active thinkers were no longer restricted by the limits of their town or parish, or even of their nation or epoch; and the knowledge that their printed words would have an effect where their spoken words did not reach, could not fail to stimulate the highest order of minds into action. The permanency of invention and discovery was thus secured; the most advanced point of one generation became the starting point of the next, and the results of the labors of one age were carried forward into all the ages that succeeded.

The invention of printing, like most others, struggled slowly and securely into life. The wooden blocks, or tablets, of Laurence Coster were superseded by separate types of the same material. Gutenberg, of Mentz, next used large types cut in metal, from which the impressions were taken. And finally, Gutenberg's associate, Schœffer, cut the characters in a matrix, after which the types were cast, and thus completed the art as it now remains.

*It must be borne in mind that money in the thirteenth century was worth, by comparison, twelve times what it is now.

It is a remarkable circumstance, that the first book which Gutenberg undertook to print with his cut metal types was a folio edition of the Bible in the Latin vulgate, consisting of 641 leaves. When the immense labor involved in carrying out such a work is considered—the cutting by hand, with imperfect tools, of each separate type required for the setting of a folio page, and the difficulties to be overcome with respect to vellum, paper, ink and press work, one cannot but feel astonished at the boldness of the undertaking; nor can it be a matter of surprise that the execution of the work occupied Gutenberg and his associates a period of from seven to eight years.

We do not, however, suppose that Gutenberg and his associates were induced to execute this first printed Bible through any more lofty motive than that of earning a considerable sum of money by the enterprise. They were, doubtless, tempted by the immense prices for which manuscript copies of the Bible then sold, and they merely sought to produce, by one set of operations, a number of duplicates, in imitation of the written character, which they hoped to be able to sell at the manuscript prices.

But as neither Gutenberg nor Schœffer were rich men, and as the work involved great labor and expense while in progress, they found it necessary to invite some capitalist to jo in them, and hence their communication of the secret to John Faust, ths wealthy goldsmith of Mentz, who agreed to join them in their venture, and supply them with the necessary means for carrying out the undertaking.

The first edition of the printed Bible having been disposed of without the secret having been revealed, Faust and Shœffer brought out a second edition in 1462, which they again offered for sale at the manuscript prices. Faust carried a number of copies to Paris to dispose of, and sold several of them for 500 to 600 crowns, then price the paid for manuscript. But great was the astonishment of the Parisian copyists when Faust anxious to dispose of the remainder, lowered his price to 60, and then to 30 crowns. The copies sold, having been compared with each other, were found to be exactly uniform. It was immediately inferred that these Bibles must have been produced by magic, as such an extraordinary uniformity was considered entirely beyond the reach of human contrivance. Information was forthwith given to the police against Faust as a magician. His lodgings were searched, when a number of Bibles were found there complete. The red ink with which they were embellished was supposed to be his blood. It was seriously believed that he was in league with the devil; and he was carried off to prison, from which he was only delivered upon making a full revelation of his secret.

Several other books, of less importance, were printed by Gutenberg and Schœffer at Mentz—two editions of the Psalter, a Catholicon, a Codex Psalmorum, and an edition of Cicero's offices; but they were printed in such small numbers, and were sold at such high prices, that, like the manuscripts which they superceded, they were only purchasable by kings, nobles, collegiate bodies, and rich ecclesiastical establishments. It was only after the lapse of many years, when the manufacture of paper had become improved, and Schœffer had invented his method of cutting the characters in a matrix and casting the type in quantity, that books could be printed in such forms as to be accessible to the great body of the people.—*Smiles' "The Huguenots."*

STOVES.—It is now just about 50 years since stoves—cooking and heating—first began to be generally used. That was when Americans began to make stoves for the home market.

A MACHINE TO SUPERSEDE TYPESETTING.

Prior to January 1st, there had been issued from the U. S. Patent Office upward of 160 patents relating to typesetting and type-distributing machines. All such devices, with many others known only in foreign countries, have thus far, however, met with but little favor among printers, and they have not been employed in practical work to a sufficient extent to have any appreciable effect in this most important branch of the printing business. Printing presses have been improved almost beyond comparison with those of the earlier days of the craft—when only about 200 impressions were obtainable per hour from small forms, as against more than 20,000 copies now made per hour of our largest newspapers ; but the typesetting part of the making of books and newspapers has remained substantially where it was left by the earliest users of movable types.

The accompanying illustration represents the latest, and in many respects the most remarkable, of the numerous machines which inventors and mechanics have from time to time devised in their long-continued efforts to find some practical means by which to supersede or cut short the tedious work of typesetting. It is known as the Linotype machine, from the nature of its product, but would probably by more generally designated as the "Tribune" machine, from the fact that it has been in practical use in the New York *Tribune* office for more than two years, where it now does substantially all the work formerly done by the compositors of that paper.

It is not, strictly speaking, a typesetting machine, but forms type bars, each of the length, width, and height of a line of type, and the exact counterpart of that which a compositor would set up, except that each line is formed of one entire piece of metal, instead of as many different pieces as there are characters, spaces, etc. A representation of such type bar or slug is given in one of the small views. The key-board, in front of which the operator sits, has 107 keys, each marked for a capital or lower case character of a fount of type, or the figures, points, or compound letters used in connection therewith, many of the letters most frequently used having several keys. The operative parts are carried by a rigid metal frame, all portions of which are stationary. The "copy" is placed upon a convenient holder just above the key-board, and above and behind the copyholder is a series of vertical tubes, one to correspond with each key, forming the magazine in which the matrices representing type are held. The keys are pivoted in a supporting frame carried by a bar attached to the magazine tubes, and each has a vertical slot or opening for the passage of a matrix, which drops by gravity as the key is depressed, another type at the same time descending from the magazine tube to take the place of the one discharged, and bearing upon the upper edge of the key. This slotted oscillating key thus serves as an escapement, receiving the matrices one at a time from the tube, and delivering them through the corresponding openings beneath, the delivery being instantaneous as the operator touches each key.

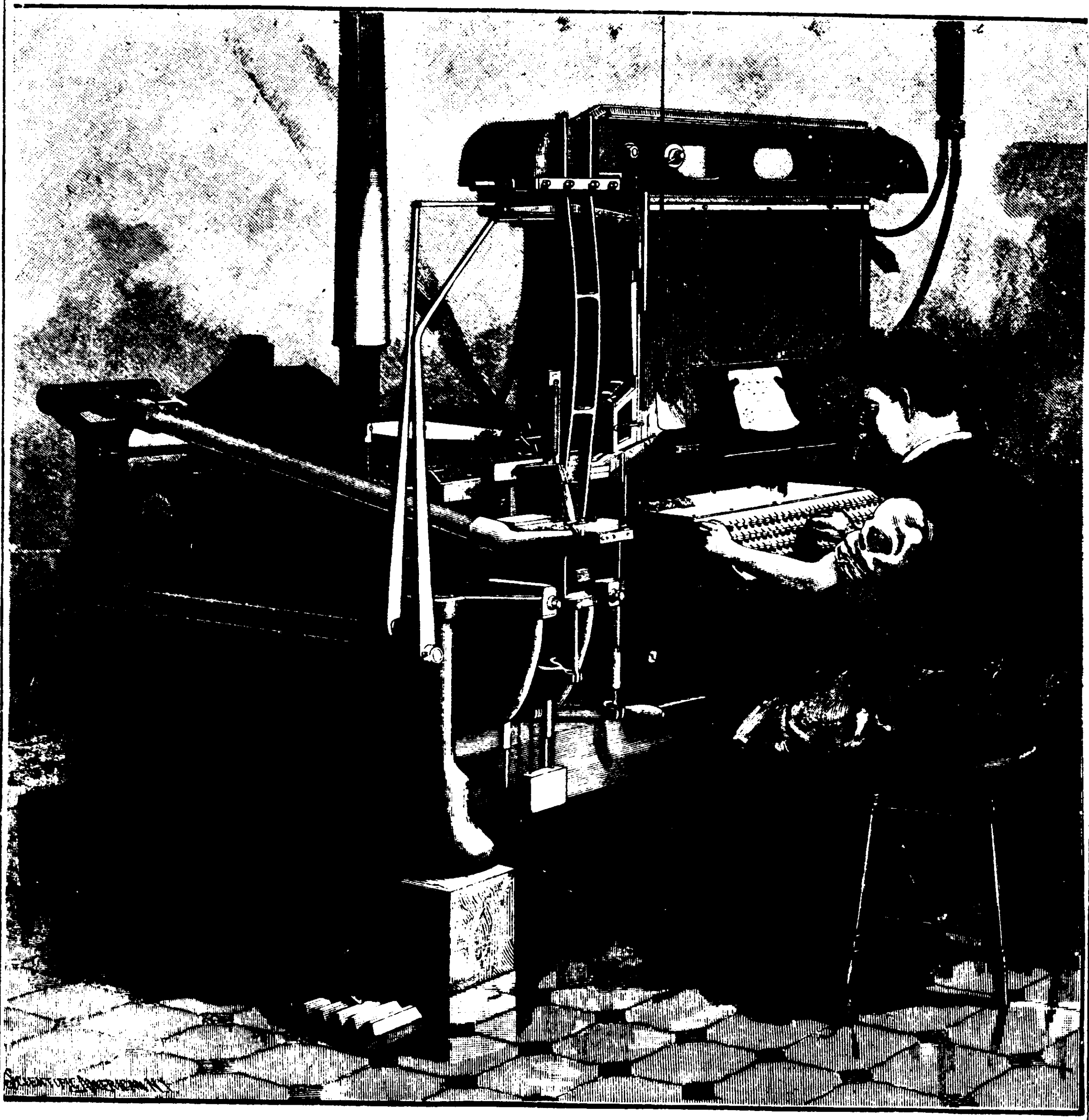
The matrices, of which one is shown herewith, each consist of a thin plate of brass, an inch and a quarter long, about three-fourths of an inch wide, and of a thickness minutely defined by that of the letter produced on each, all matrices bearing the same letter being exact duplicates of each other. Each matrix has suspending shoulders differing on the matrices representing the respective characters, and secondary shoulders or notches differing in width on the different matrices, these special distinctions being necessary to insure the correct automatic distribution of the matrices to the magazine tubes after they have been used. A side view of one of the matrices is also shown at A, in the sectional figure, where it forms part of a line as held up for casting.

The magazine in which these matrices are held is composed of a series of independent vertical tubes, each internally of suitable size to receive its particular matrix, and drawn from sheet metal to make a smooth, seamless, and perfectly true conductor, through which the matrix will pass without danger of stoppage. The upper end of each tube is slightly enlarged or flared, to permit the free entry of the matrices, and any tube can be removed independently of the others.

To receive the matrices, as they are delivered one at a time below the magazine, and conduct them to the point at which they are assembled or composed to form lines, a horizontal guide or channel is provided, with rails on which the shoulders of the matrices are supported, the matrices fitting loosely in such channel, and being maintained therein in substantially upright position. The matrices are advanced through this guide or channel to the point of assemblage by means of a blast of air directed longitudinally through the channel, from the lowermost of the two tubes seen to be connected with the machine at the right of the operator, the other tube being connected with the casting mechanism, to assist in cooling the mould. By this means the delivery of each matrix is effected so promptly that its motion can hardly be seen, the click of the matrix coming to its place in the line being formed seeming to be almost simultaneous with the touching of each key, little fingers or followers at the same time continually pushing forward the characters until the line is completed, or approximately so.

This brings us to one of the most interesting features of the machine, that of the justification of the lines, the difficulty of mechanically effecting which has heretofore been one of the principal obstacles in all such machines. In this machine the operation is simple, the justification is perfect, and takes no time. The matrices, as they are pneumatically delivered and loosely held in horizontal position on their guides, have their sides in which the letters are cut plainly in view of the operator, who can then replace any letter which may have been erroneously used, and also see when his line is so nearly full that it will not hold another word, or whether some word possibly had better be divided, or how much more space will be needed to make the line full, according to the predetermined measurement. The usual spaces between the words, etc., as ordinarily inserted by the compositor, are already in place, having been inserted in the same way as the matrices, by the use of a "space key," but the spaces here used differ from the matrices, and consist of longitudinally tapered or wedge-shaped bars, three or four inches long, with their larger ends hanging down below the bottoms of the line of matrices. These space bars now do all the further work of spacing, being caused to rise automatically by means of a vertically reciprocating plate acting against their lower ends, until the line has been expanded to the full limits allowed by the clamps which determine its length. In this way the increased space between the words is evenly divided, and "uneven spacing" is simply impossible, no attention to the matter being required on the part of the operator, who is already touching the keys for the formation of the next line.

The line of matrices thus completed is received by a head opposite the end of the stationary type guide, there being immediately below and behind the head a mould, in the form of a vertical disk, having a mould chamber or slot extended horizontally through it of a form and size identical with that of the required type bar. This portion of the machine will be better understood by reference to the sectional view, where B represents the disk mould, A the line of matrices as held up

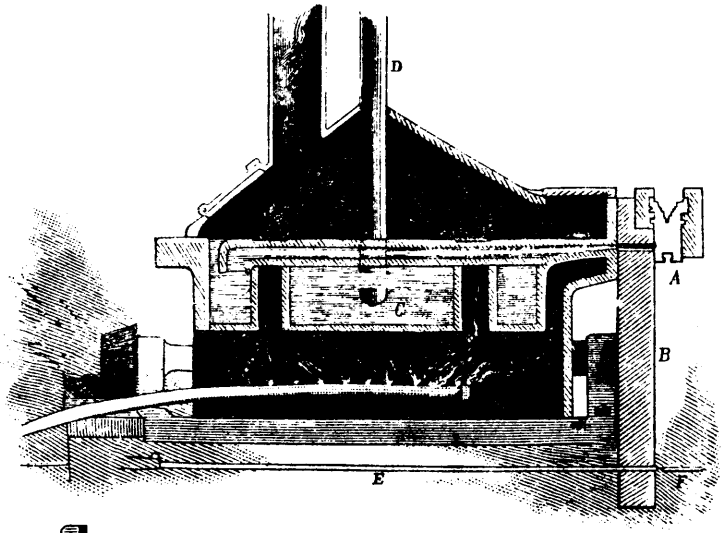


SETTING TYPE BY MACHINERY, AS CONDUCTED AT THE NEW YORK "TRIBUNE" OFFICE.

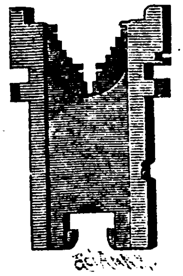
thereto, C the reservoir of melted metal in its gas-heated chamber, D a plunger acting as a force pump to force the metal into the mould, and E an ejector bar which has forced out the type bar, F. For the purpose of forcing the line of matrices tightly against the mould, their characters registering with the mould proper, an outside clamping head is employed to bear against the outer edge of the line, while supplemental clamps or jaws assist to hold the line firmly and in exact adjustment. To avoid overheating of the mould when rapidly operated, it is made with transverse openings adapted for communication with the blast nozzle, although no difficulty is ordinarily experienced on this account.

There are, as is well known, a great variety of type metals, according to the sizes of type and its uses, ordinary type for newspaper work being mainly composed of 6 parts lead and 2 of antimony. The addition of a little bismuth, however, carries down the melting point, and also produces a softer metal, as more commonly used for stereotypes. Such an alloy, composed of 9 parts lead, 2 of antimony, and 2 of bismuth, readily melts at about or a little over 300° F. The thin type bar made by the machine, therefore, readily cools sufficiently for ejection during the revolution of the mould disk, the type bars being thence carried to a galley attached to the machine to the left of the operator, where the bars are assembled in the order of their production in the form of a column ready for use.

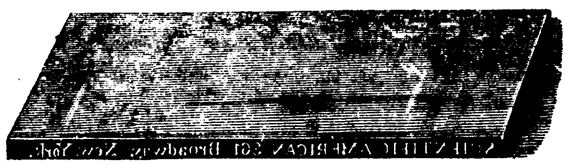
Not only is all this work done automatically, but the matrices, after the type bar has been formed, are automatically withdrawn from their position against the mould disk and



FURNACE FOR MELTING METAL.



MATRIX.



TYPE BAR.

lifted by a carrier to the distributing mechanism, at the top of the magazine, whence they are distributed to their several tubes. This distributing mechanism consists essentially of an endless chain or belt, arranged to travel horizontally above distributing rails, the belt carrying a series of blocks armed with adjustable forks or fingers to act between the matrices and push them forward. The rails are parallel and sufficiently separated to admit of the matrices being carried in an upright position between them, and the inner edge of each rail has a lip designed to engage the shoulders of the matrices and hold them in suspension, the lip being divided transversely into a number of sections to engage matrices having different shoulders, whereby each matrix will be sustained upon the rails until it is carried to the point at which it is to be released to drop into its proper tube in the magazine. Connected with the distributing rails are wires from a battery, by means of which a matrix forced or dropping out of place will cause the closing of a circuit and the stoppage of the carrier belt; the particular matrix causing the stoppage is always immediately in front of the operator, with whom it is only the work of a moment to replace the matrix, or remove it entirely if it happens to be defective.

How far this machine may be considered a practical success for general uses, in the way of superseding typesetting by hand in the old way, it is perhaps too early to give a definite answer. It is obvious that it is not adapted for work requiring different varieties of type, as small capitals, italics, accented letters, etc., although we understand the machine is now being made to use small capitals, as well as the other characters usually employed in Roman text. But there is a large class of work, especially that required for newspapers in general, in regard to which this objection would not be very material. The actual performance of the machine at present, and for many months past, on such plain work, is about equal to that of three ordinary compositors, and it requires but a short time for an operator to attain an efficiency which will enable him steadily to maintain this speed, as compared with hand work. This, at least, has been the experience on the New York *Tribune*, where only thirty machines are ordinarily kept running for a day's work of eight hours each to get out a ten-page edition of the daily, which would require the services of about ninety men in the old way of working. The absolute saving of all distribution, which is equivalent to about one-quarter of the work of composition, is of itself a most important factor in the economy of the machine, while "standing matter," in the form of these type bars, can be kept for an unlimited time, and in any amount, without inconveniencing the office. To correct an error a new line has to be made, but this is done so quickly that the entire work of correcting is said not to be increased. When a considerable number of the machines are employed, the more or less constant services of a machinist or repairer would undoubtedly be necessary, but the machine, as it is, appears to be a wonderfully perfect piece of mechanism, almost endowed with intelligence, and we are informed that one machinist easily does all the repairing needed on the forty machines now in use in the *Tribune* office. The machines are not for sale, as we understand, so that the question of their cost cannot be answered, but they are to be leased, those using them to pay a fixed sum on the execution of the lease and a quarterly rent besides.—*Scientific American.*

THE LIMITATION OF AMERICAN PATENTS BY FOREIGN PATENTS.

The late decision of the Supreme Court of the United States in regard to the limitation of the life of an American patent by the shortest term of the foreign patent for the same invention is attracting a great deal of attention from manufacturers and patent owners. The press has made not a little unfavorable criticism.

The decision reverses an unbroken line of decisions by circuit courts on this very matter. The nine men who owe their appointments to the Supreme Court of the United States to personal and political favor are gaining for themselves no very enviable reputation for their remarkable decisions in patent cases. The surprising decision by the (them) majority of that court sustaining the validity of the notorious Bell Telephone patent shocked the country. The individual opinions of four (only three left now) men, as in the telephone case, or of nine men (the whole court) are worth no more than are the opinions of three or four—or of nine other men competent to form a judgment in such matters. As a matter of fact these decisions have no binding force except in regard to the parties to the particular case litigated.

An Act of Congress provides that the life of an American patent shall be limited by the shortest term of any foreign patent for the same invention in force at the time the American patent is granted. In this particular case when the inventor had taken out his American patent, he already had taken out a Canadian patent for five years. At the expiration of the first term of five years—the inventor had his election to pay a second government fee and have his Canadian patent extended a further time of five years—thus making its life ten years; and at the end of the second term of ten years, the patentee had the further right to pay a third government fee and have his patent extended for a third term—making the life fifteen years in all—or the inventor could have taken out his Canadian patent for the full term of fifteen years in the first instance—if he had so elected. In the case under review by the Supreme Court the owner of the patent elected to take his patent out for the term of five years in the first instance; so far as the world knew the patent only had a life of five years—because no one knew what the intention of the patent owner might be at the end of the first term of five years as to taking out his patent for a second term of five years. So the invariable decisions of the circuit courts, heretofore, have been that, in such cases as this, the life of the American patent must be limited to the shortest term of any foreign patent in existence when the American patent is granted; and that if the patentee elected at the expiration of that shortest term to take out his patent for another short term—such election and such subsequent extension of his patent would have no subsequent effect on the life of the American patent—which already was fixed by law when the American patent was granted.

But the Supreme Court of the United States now comes forward and reverses all their former decisions—and decides (so it would seem) that the life of the American patent is not a fixed and definite term when it is granted, but is shorter or longer just as the whim may seize upon the American patentee in regard to taking out a second or third foreign patent. We say that this seems to be the effect of the decision of the Supreme Court. Certainly this was the issue before that court. But upon a careful re-reading of that decision it seems to be the opinion of the ablest patent lawyers that it is difficult to state precisely what the Supreme Court did decide, and this is not the first time that the decision in patent cases of the United States Supreme Court has landed the careful and attentive reader in the clouds. What the manufacturers in this country desire above all other things is certainty, precision and exactness in patents granted and in patent law.—*American Engineer.*

CHANGES IN THE ENGLISH PATENT LAW.

The total number of applications for patents in England was larger in the year just completed than ever before, being 19,070, as compared with 18,051 in 1887, or more than three times as numerous as in any year before the passing of the patent act in 1883. That this upward tendency indicates a real amount of industrial progress it would be impossible to deny, though there is, combined with the rise in numbers, a slight fall in the average value of the inventions, as indicated by the smaller proportion which pass beyond the earliest stage. Very little more than half the applications become completed patents, and the percentage has been gradually though slowly declining as the total numbers have increased. Judging from the experience of the previous law, not a quarter of these completed patents will outlast the first period of four years. Under the old system about 30 per cent were not completed, and of those that were completed about 70 per cent dropped at the end of the first stage (then three years).

The principal event during the past year of importance to patentees has been the passing of the patents, designs, and trade marks act, 1888. This is an amending act on the principal act of 1883, and is the result of the recommendations of the Board of Trade Committee on the Patent Office, which, after sitting for two years, reported in January, 1888. This act, which has just been printed, and came into force with the year, establishes for the first time a register of patent agents. The rules by which the practice of patent agents will in future be regulated are to be made and issued by the Board of Trade, the act only providing that from next July no unregistered person shall be allowed to describe himself as a patent agent. The proposal, when it was before the House, met with a certain amount of criticism from the technical papers, but was accepted.

Another provision of importance is the abolition of what are known as "notices of interference." It has hitherto (since the passing of the 1883 act) been the practice for the office to send notice to an applicant of any subsequent application received at the office which appeared to interfere with his, in order to give him an opportunity of opposing the granting of a patent. This provision has never worked satisfactorily, the officials not having been able to make up their minds as to what constituted a "similar invention," and has therefore probably been of little practical value to patentees. The idea of informing inventors that others were on the same track was an excellent one, and the exercise of a little judgment on the part of the officials would have made it useful, and enabled it to have been carried out to the great benefit of the public. As, however, they were incapable of turning the rule to the advantage of inventors, it was perhaps as well that it should be dropped.

The remainder of the act refers principally to designs and trade marks. There is a new definition of a trade mark which does not appear much easier to construe than the old, and there are other modifications of procedure, the result of experience in the working of the act of 1883.—*London Times.*

A screw, which is half nail, is a new invention. Its holding power in white pine, they say, is 333 pounds against the 298 pounds of the present screw.

WRIGHT AND MOORE'S TYPE PRINTING TELEGRAPH.

The object of this apparatus is to enable the printed records which, in the ordinary form of printer, are made on a continuous tape or band, to be effected on a sheet of any desired width, after the manner of the ordinary type writer. The advantages of such an arrangement are so obvious that they do not require discussion. Messrs. Wright and Moore's invention is not the first of its kind; as far as we can learn, three other printing machines of the same type have been patented—two in America and one in England—the latter by Mr. Higgins, of the Exchange Telegraph Company. The American machines are those of Messrs. Anders, of Boston, and Van Hoevenburg, of New York. Neither Mr. Anders nor Mr. Van Hoevenburg ever carried their machines into practical use. It is probable that they never reached a stage beyond that of being filed in the Patent Office. Mr. Higgin's machine is constructed for *two* line wires, and is very similar in its main points to that of Van Hoevenburg. Judging from his specifications, and from a description published in the *Electrician*, Mr. Higgins has made no attempt to attain to any rapidity of transmission. The use of two wires also seems to a great extent to place any instrument beyond the pale of commercial possibility nowadays.

We think, therefore, that Messrs. Wright and Moore's invention, which employs but one wire, is by far the most satisfactory arrangement yet devised for the object in view. Its construction is free from complication, and, as a necessary consequence, its action is certain and entirely satisfactory.

In perfecting their "column" printer (as the inventors term it), which is shown in general view by fig. 1, Messrs. Wright and Moore have aimed at the attainment of such simplicity as would necessitate little or no departure from methods at present employed in working the tape machine.

To obtain ease and speed of working, two clockwork trains have been introduced, one to revolve the type-wheel, the other to feed the paper upward at the end of each line, at the same time returning the type-wheel to its initial position.

The paper-feeding and type-wheel returning clockwork is released by the action of what may be termed an auxiliary magnet, which is of about two ohms' resistance. To the armature of this magnet are attached two releasing fingers, of peculiar construction, which act upon a pin attached to a pinion at the last position in the train. On charging this magnet sufficiently to attract its armature, the fingers are *merely moved into proper position*, the paper not being fed until the current ceases and the armature is withdrawn by means of a spring. This arrangement, we believe, is entirely new.

The mode of feeding the type-wheel laterally, which is effected by means of two racks, one movable, the other stationary, is also new in connection with printing telegraphs, as far as we are aware, and is a most efficient arrangement.

Step by step printing telegraphs have been constructed with and without clockwork for years, but no great speed of transmission has ever been attained with the non-clockwork instruments. On the other hand, with clockwork, 125 to 160 revolutions of the type-wheel per minute is not uncommon. At 150 revolutions a skilled operator can transmit from 35 to 40 words a minute, practically equalling the Morse, to say nothing of other obvious advantages. Both the "Gold and Stock" and "Commercial" Companies of New York are at present running their "stock tapes" at high speeds—the former at 150 revolutions, the latter at 120 revolutions.

Fair power, about half an ampère of current, and fast working trains with heavy weights are employed for this purpose, but the results are highly satisfactory, and fully compensate for the expenditure of current and cost of perfected mechanism. Indeed, the old American stock machine, similar to that at present in use by the Exchange Company of London, was found to be entirely inadequate to the requirements of a busy day on the Exchange, and the American companies were forced into the adoption of high-speed machines. Clockwork, together with skilfully devised polarized magnets, replaced the sluggish neutral-magnet driven instrument which had outlived its usefulness.

While devising and constructing the column printer all these facts have been kept in view. The inventors have sought to give the *magnets* as little work to do as possible. The clockwork trains, which do the bulk of the work, are *released* by the magnets, the latter acting with an ease and freedom not even attained in the ordinary tape machines. This being the case, it is not unreasonable to assume that the new machine will be quite as fast as the best tape machine, and when the result—a printed page—is taken into consideration, comparison ceases.

We should add that one of the merits of the new machine is the construction of the escapement. In it the faults of the ordinary escapement have been removed, with the result that we get lightness, speed, and comparative *silence* in a greater degree than is attained in any other machine in use. Absence of noise is in itself a very high recommendation.

We come now to the description of the mechanism of the apparatus :—

Fig. 2 is a front elevation, and fig. 3 a side elevation of the mechanism. Fig. 4 shows details of the parts for moving the paper a distance, and bringing the type-wheel back to its starting point when a new line is to be commenced.

A, B, are two barrels, each driven by a cord and weight. The barrel, A, by a train of spur gear wheels drives a spindle, C, on which the type-wheel is mounted. The barrel, B, by another train of wheels, drives a roller, D, over which the paper to be printed on is led.

On the spindle, C, are two escapement wheels, C^1, into which a pallet, E^1, actuated by an electromagnet, E, with armatures polarized by the permanent magnet, F, is made to engage alternately.

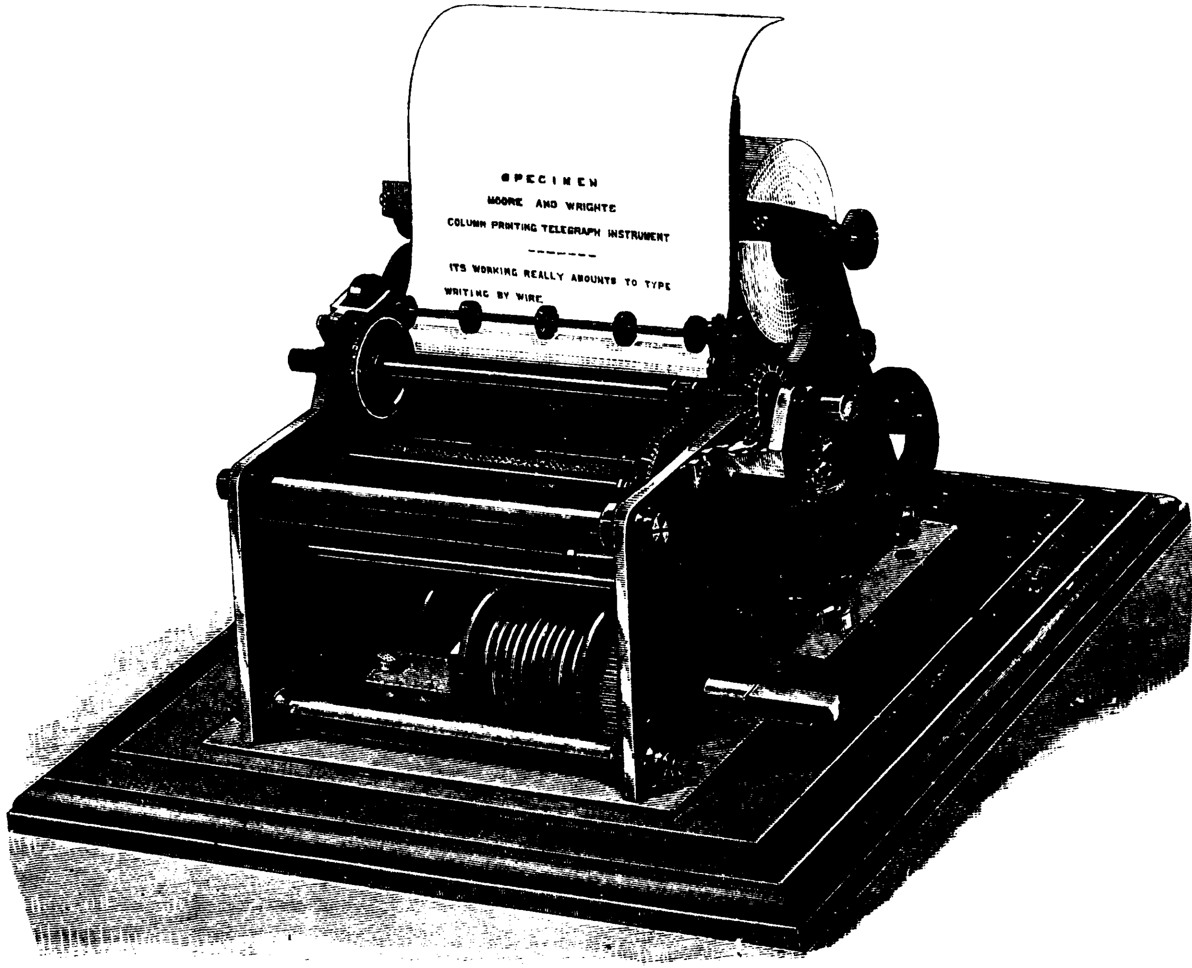
When a current of one polarity is sent through the electromagnet the armatures move in one direction, and when a current of the opposite polarity is sent they are moved in the opposite direction.

To rock the armatures, alternate currents are sent through the electromagnet by the transmitting instrument, which may be of any ordinary construction.

The paper to be printed on is led from the roll, H, round the roller, D, and this roller, after the completion of each line, is allowed to be partly rotated as explained further on, to move the paper a distance equal to the distance required between the lines of printing.

Normally the roller, D, is, as usual, a slight distance off from the circumference of the type-wheel, I, and each time that the printing of a letter is to take place, the roller is moved towards the type-wheel, and the paper where it passes around the roller is thereby forced against the type which is opposite to it. This is done by the roller, D, being rocked at each movement of the printing or impression lever, J. One arm of this lever carries the armature of an electromagnet, K, and is drawn by a spring, K^1, up to an adjustable stop, K^2.

The alternate currents which pass through the driving coil also pass through the coils of the magnet, K, but are not of



sufficient duration to cause this magnet to draw its armature towards itself until when a letter is to be printed a current of longer duration passes, as is well understood.

The type-wheel, I, is carried by a sleeve, which can be slid endwise along the spindle, G, but turns with it. The sleeve can be moved along the spindle by a fork, which embraces it, and which extends from a carriage, M, which can be slid along a fixed guide rod, N

The carriage, M, carries two pawls, O (one behind the other), which engage with ratchet teeth cut on the edge of two bars, one behind the other, and the front one of which, P, can be seen in fig. 2. The hinder toothed bar or rack is fixed.

Each time that the armature carried by the lever, J, is drawn to the magnet, K, the ratchet bar, P, is moved a distance endwise, and the pawl, O, which rests on the rack teeth instead of resting on the tooth, it was previously resting against, rests upon the next tooth and when the printing lever returns to its original position, the ratchet bar is shifted in the opposite direction by a spring (not shown in the fig.); it then drives back the pawl and the carriage, M, with it, thereby shifting the type-wheel sideways ; as it is shifted sideways, the hinder pawl slips over the hinder rack, and drops into the next tooth of the rack, so that the slide is prevented from moving back.

In this way the carriage can be traversed step by step from one side of the machine to the other. When it arrives at the end of its traverse, it is brought back to its starting position by a cord, which passes from it to the circumference of a spring barrel. To allow the cord to draw it back, both pawls are simultaneously lifted and withdrawn from the rack teeth of the bars.

This is done whenever the printing lever is moved at the time when a blank space on the circumference of the type-wheel is towards the paper, and when a special key of the transmitting instrument, which causes the current strength to be increased, is depressed.

The movements are effected in the following manner :—In circuit with the line is an electromagnet, K^3, whose armature, *k* (see also fig. 4), is held back by a retractable spring, *s* (attached to the pin, *c*), whose tension is such that it cannot be overcome except by a considerable increase in the normal current strength. To the armature are fixed two blades or stops, *a* and *b* (fig. 4), one of which, *b*, is movable, and is kept pressed in the position shown by a spring. A pin, *c* (fig. 2), fixed to and projecting at right angles to the axle of a pinion, *p*, which is in gear with the clockwork driven by the barrel, B (fig. 3), normally presses against the movable blade, *b*, and keeps it back in the same plane with the fixed blade, *a*. When the armature, *k*, is attracted, and the blades moved, the pin *c*, slips from blade *b* to blade *a*, and blade *b* jumps forward

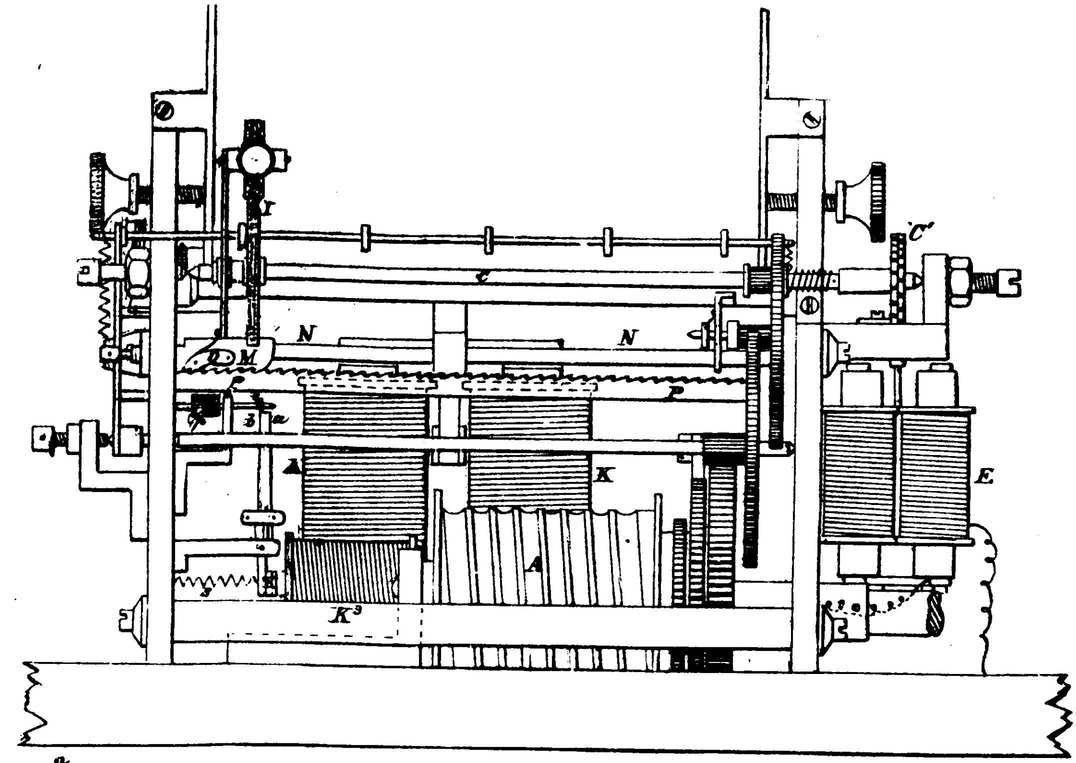


Fig. 2.

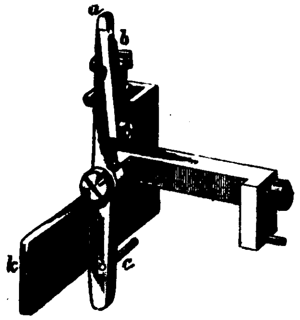
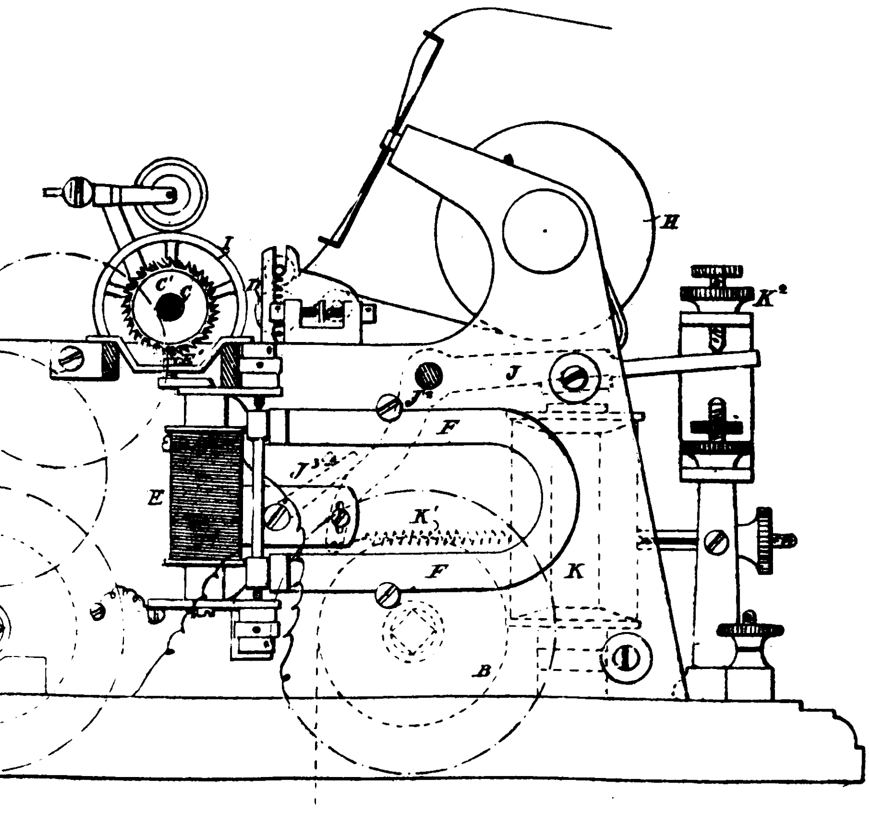


Fig. 4.



WRIGHT & MOORE'S TYPE PRINTING TELEGRAPH.

under the influence of the spring pressing against it. When the armature is drawn back, the blades are again shifted sideways, but in the opposite direction ; the pin, *e*, on the pinion axis then comes at the back of the movable blade, and there being nothing in the way of the pin, the pinion to which it is fixed turns until the pin comes on to the face of the blade, and brings it back into its original position ; thus the further rotation of the pinion is prevented. When the train of wheels connected to the pinion is thus allowed to turn, it revolves the paper roller, D (fig. 3), and shifts the paper the distance that is required to be between the lines. At the same time it turns a notched or cam wheel, and one of the projections upon the cam wheel acts against a lever, and rocks it on its centre. This movement of the lever causes a bar to be lifted which is parallel with and by the side of the two ratchet bars, P, by which the type-wheel is traversed sidewise step-by-step along its axis, as before explained. When the bar is lifted it lifts both of the pawls which engage with these ratchet racks, and the type-wheel is drawn back into the position for beginning a new line, the bar being held up by a spring catch until the type-wheel has been brought into this position ; the slide which moves the type-wheel then comes against and liberates the catch, and the bar is drawn downwards by the action of a spring. The means for bringing the type-wheels to "unison" is the well-known arrangement devised by Smith many years ago.—*Electrical Review.*

PRINTING OF PHOTOGRAPHS IN COLORS.

Mr. Fred. E. Ives lately read before the Franklin Institute a paper on heliochromy, which was an addition to a communication made to the Institute last February, and in which he explained his method of producing photographs in natural colors.

According to the *Ledger* report, Mr. Ives said : "I assumed that we might counterfeit all the colors of nature in a photographic picture by making each ray of simple select automatically, in the operation of the picture-making process, such a type color or mixture of type colors as will counterfeit it to the eye, and showed how this can be accomplished by means of photographic plates made sensitive to all colors, and exposed through compound light filters, which are suitably adjusted by experiment upon the spectrum itself."

He quoted from a recently published work on color to show that his plan of operation was in accordance with what is now recognized as the true theory of the nature of light and color sensation. Continuing, he said : "Although I originally worked out my process on the simple plan of making each primary ray of spectrum color select from and combine three pigment colors to counterfeit it, it becomes evident that in accomplishing this I might have produced one negative by the action of solar rays nearly in proportion as they excite the 'red nerve fibrills' of the eye, another in proportion as they excite the 'green fibriis,' and another in proportion as they excite the 'blue fibrils.' I did not do this at once, but after experimenting with several sets of reproduction pigments, adjusting color screens so that I could make the process counterfeit the spectrum with either set of pigments. I finally adopted reproduction colors which call for negatives of the spectrum showing curves of intensity approximating to the curves in Maxwell's diagram, illustrating the action of the spectrum upon the different sets of nerve fibrils. These colors are certain shades of red, green, and blue light, or their complementary colors in pigments, which approximate to Prussian blue, magenta red and aniline yellow, the first two of so light a shade that it is necessary to superimpose one upon the other to obtain a full violent, the blue upon the yellow to obtain green, and the magenta upon yellow to obtain red.

Concluding, he said : "Admitting the theoretical soundness of my mode of procedure, which I believe I have fairly demonstrated, there remains only the question of practicability and commercial value to be considered. The process is practicable if the same operations repeated in the same manner can be relied upon to produce pictures which counterfeit the light and shade and color of all objects. Three subjects which I shall show to-night, a delicate oil painting, a brilliant Prang chromo, and a beautiful sea shell, were made with the same light, same camera, same preparation of sensitive plates, same set of colored screens, same relative exposures, and same development. They show a very great variety of colors, mostly compound in the painting and chromo, but pure spectrum colors in the sea shell, yet the colors of all are alike faithfully counterfeited to the eye."

The pictures thrown upon the screen by Mr. Ives seemed to fully confirm his claims as to the efficiency of his mode of reproducing the colors in a picture or in nature.

Mr. Ives also exhibited a camera contrived by himself, in which the lenses and color screens are adjusted so as to produce simultaneously the three negatives required by the above mentioned heliochromic process.

A CURIOUS LITTLE DISCOVERY.—A correspondent of the *Electrical Review* says : "I have made a curious little discovery, which may interest your readers. It first occurred on a railway train. I happened to hold against the inside surface of the window-glass a daily paper which had been cut by a saw tooth cutter, leaving a ragged edge on which some of the bits were loose. When I removed the newspaper, some of the bits remained clinging to the glass. It was curious, and I began to investigate with larger pieces. All would stick to the glass when laid against it. I took different kinds of paper then, but the results were the same. Since then I have repeated the experiment a great number of times on different railways, and always found the glass apparently electrified. It cannot be capillary attraction, as the most porous kind of paper, if light, would stick just the same. I have had pieces of newspaper two inches square hold firmly. And a strange thing too, the phenomena appears as certainly in rainy weather, even when the window-panes are streaming outside. It seems to require a clean window for good results. One evening I tested seven windows in one car, and had them all spotted with bits of paper, and my fellow-travelers eyed me with suspicion as a result. Now, why does the paper stick ? Is it the friction of the air outside ? Hardly, because after a five-minute stop, fresh paper will stick just as effectually. Is it due to the heat of the finger in applying the paper ? No, because a lead pencil or a cork will do instead of the finger. Is it capillary attraction ? I think not. I will be glad to have some of your readers investigate and report. Perhaps a pocket electroscope would help.

There are several reasons why a fire burns so brightly in frosty weather. First, the air being cold is denser, and the heated air and gases from the fire are comparatively more buoyant. Consequently there is a greater draught. Then the air, being denser, contains more oxygen in an equal volume, and that gas being quickly supplied, the combustion is fiercer and more perfect. In frosty weather, too, the atmosphere is comparatively free from moisture, which of course has a tendency to damp a fire.

THE TEMPERING OF STEEL.

Perhaps all may not be aware of that peculiar trait in the character of steel which enables an adept to render it, at his will, as pliant or as obdurate as he pleases. When heated to a sufficient degree of redness (not one scintilla more, or it will be burnt), and then cooled as suddenly as possible, it will have attained it maximum degree of hardness. Othello's exclammation, "I have a sword of Spain, the ice brook's temper," bore reference to a celebrated method of hardening blades in Toledo, by plunging them while red hot into a stream of icy cold water. If, on the contrary, the heated steel be forced, by artificial means, to cool very gradually, it becomes as soft as it can be made to be. Between these two extremes any degree of hardness or softness can be obtained by tempering. Suppose a piece of steel to have been thoroughly hardened, afterwards re-heated to a certain degree, and suffered to cool gradually, it will have been softened precisely to the degree to which it has been re-heated. The adept knows exactly the degree of softness it has acquired by watching the changing colour of the metal under heat. First, it will become of a pale yellow or straw colour; this will deepen gradually into orange; then by a beautiful gradation of tint, into a rich purple; thence in to a deep blue; from that again into pale a blue; after which the colour will fade away entirely, and the metal become white again; the next stage being red hot. Any reader can test this for himself by laying a needle upon a hot poker. If the heating be arrested at any one of these stages, the steel will be of a temper corresponding to that stage. No subsequent re-heating will alter this temper, though repeated again and again, provided it stops short of the point to which it has proceeded before; thus a piece of steel which has been tempered to a purple, may be afterwards brightened and brought to a purple again without injury; but if it be heated till it becomes blue, its temper will have been reduced to that extent.—From *Cassell's Technical Educator* for March.

VOCAL MUSIC AS A PREVENTATIVE OF PHTHISIS.

A suggestive paper by Dr. C. E. Busey, of Lynchburg, was lately read before the Medical Society of Virginia. He stated as a well-known fact that those nations which were given to the cultivation of vocal music were strong, vigorous races, with broad, expansive chests. If an hour was daily devoted in our public schools to the development of vocal music, there would not be the sad spectacle of the drooping, withered, hollow-chested, round-shouldered children. There was too great a tendency to sacrifice physical health upon the altar of learning. Vocal music was a gymnastic exercise of the lungs by development of the lung tissue itself. The lungs in improved breeds of cattle, which naturally took little exercise and were domiciled much of the time, were considerably reduced in size when compared with those of animals running at liberty; and so it was with the human race, which led inactive lives from civilization.

Phthisis generally began at the apices of the lungs, because these parts were more inactive, and because the bronchial tubes were so arranged that they carried the inspired air with greater facility to the bases than to the apices. During inactivity a person would ordinarily breathe about 480 inches of air in a minute. If he walked at the rate of six miles an hour, he would breathe 3,260 cubic inches. In singing, this increased more than in walking, as to sing well required all the capacity of the lungs. The instructor of vocal music, in addition to his musical education, should understand the anatomy and physiology of the respiratory organs.—*N. Y. Med. Jour.*

SIMPLE EXPERIMENTS IN PHYSICS.

BY GEO. M. HOPKINS.

The experiment illustrated in Fig. 1 shows the great elasticity of certain solid bodies, and the almost total want of elasticity in other solid bodies. This experiment is introduced here mainly on account of its adaptability to projection with a lantern. A thick plate of glass, a small slab of marble, or better a bar of tempered steel, is supported so that its upper surface appears in the field of the lantern. A small glass ball, or a ⅜ or ½ inch hardened, ground, and polished steel ball, such as is made by the Simonds Manufacturing Company for ball bearings, is dropped upon the glass or steel from a measured height within the field of the lantern. The impact compresses the ball and the plate. At the instant following the stopping of the ball, the ball and the plate, by their own elasticity, return to their normal condition, and the force stored by the impact is given out instantaneously, forcing the ball back toward the point of starting. If undisturbed, the ball will fall and rebound again and again, losing a little of its force each time until it finally comes to rest.

By substituting a lead plate for the glass or steel plate, or by substituting a lead ball for the glass or steel one, it is found that the force acquired by the ball in its descent is expended mainly in changing the form of the plate or ball, and that as the inelastic nature of the material prevents it regaining its former shape, there can be no rebound, as in the other case.

The property of elasticity is also shown by the collision balls illustrated in Fig. 2. This well known experiment is adapted to the lantern, and shows well on the screen. Six of the steel balls already referred to, or six small glass balls or marbles are required. Each ball is provided with a small metallic eye, which is attached by means of cement or fusible metal used as a solder. Five of the balls are suspended from the two wire supports by fine silk threads, so that they all hang in line and touch each other very lightly. The sixth ball is suspended by a wire, which is bent down between the supports to receive a thread which extends through an eye attached to the supports, and serves to draw back the sixth ball. The thread by which the ball is moved is not noticeable, as it is partly or wholly concealed by the supports. By drawing back this ball in the manner indicated, and then allowing it to fall, its impact will slightly flatten the ball with which it comes into contact, and each ball in turn transmits its momentum to the next, and so on through the entire series. The last of the series is thrown out as indicated in dotted lines, and upon its return its impact produces the same result as that already described, but the effects are in a reverse order.

In Fig. 3 is shown a method of forming magnetic curves for projection, in which the iron particles slowly arrange themselves under the influence of the magnet, giving the appearance of crystallization. In a closed cell is placed a quantity of glycerine, into which is introduced a quantity of fine iron filings. In the top of the cell are inserted two soft iron pole pieces, arranged to receive the poles of a permanent magnet. The glycerine is thoroughly agitated, so as to distribute the filings as evenly as possible throughout the cell. The cell is then placed in the lantern, and the magnet applied to the pole pieces. The iron particles will be drawn slowly toward the pole pieces, arranging themselves in symmetric curves.

In Fig. 4 is shown apparatus for the projection of the static discharge. It consists of a stand having two vulcanite columns,

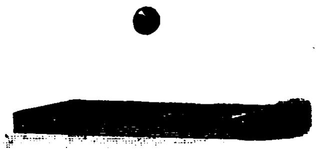


FIG. 1.—ELASTICITY OF SOLID BODIES.

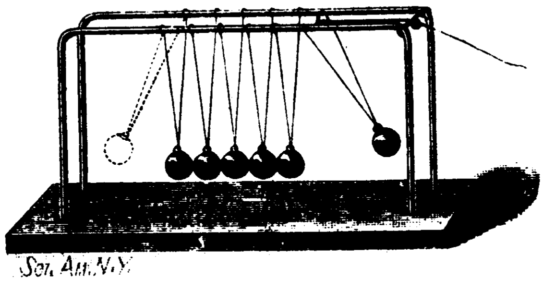


FIG. 2.—COLLISION BALLS.

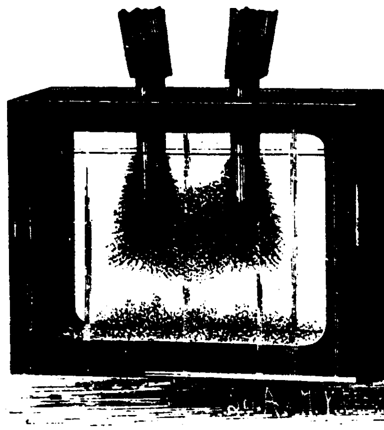


FIG. 3.—MAGNETIC FIELD..

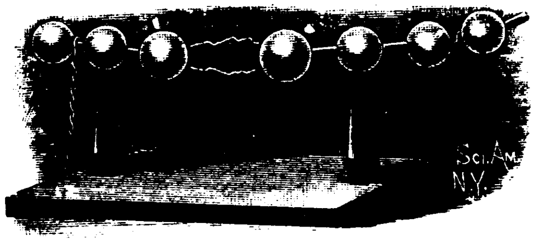


FIG. 4.—PROJECTION OF ELECTRIC SPARK.

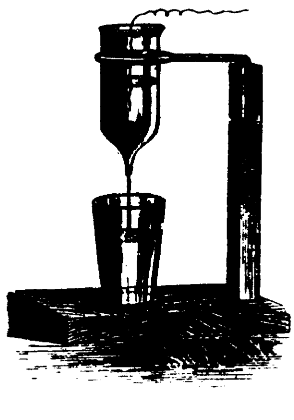


FIG. 5.—ELECTRICAL REPULSION.

in the upper ends of which are inserted adjustable brass rods, provided with brass balls at opposite ends. The adjacent balls are adjusted to the striking distance and focused on the screen. The light for projection should be only strong enough to show an image of the balls. When the conductors of a static machine or induction coil are connected with the brass rods, the path of the spark will appear as a brilliant white line on the screen. The discharge of a Leyden jar is still more brilliant.

The apparatus shown in Fig. 5 is designed to show upon the screen the experiment known as the electric fountain. A small glass vessel provided with a capillary tubulure at the bottom is supported above a tumbler. The vessel is filled with water and the capillary aperture allows the water to drop slowly when acted upon by gravity only, but when the water is electrified by connection with a static machine or induction coil, it issues in a fine stream, the change in the character of the discharge being caused by the mutual repulsion of the particles of water.

In all these experiments an erecting prism is required.—*Scientific American.*

THE CONSTRUCTION OF MILLS.

The Boston Manufacturers' Mutual Fire Insurance Co., in a recent report on paper and pulp mills, makes several very excellent suggestions relating to the construction of mill buildings in general. We give from this report an illustration showing the section of a mill representing two floors and roof. We quote as follows :

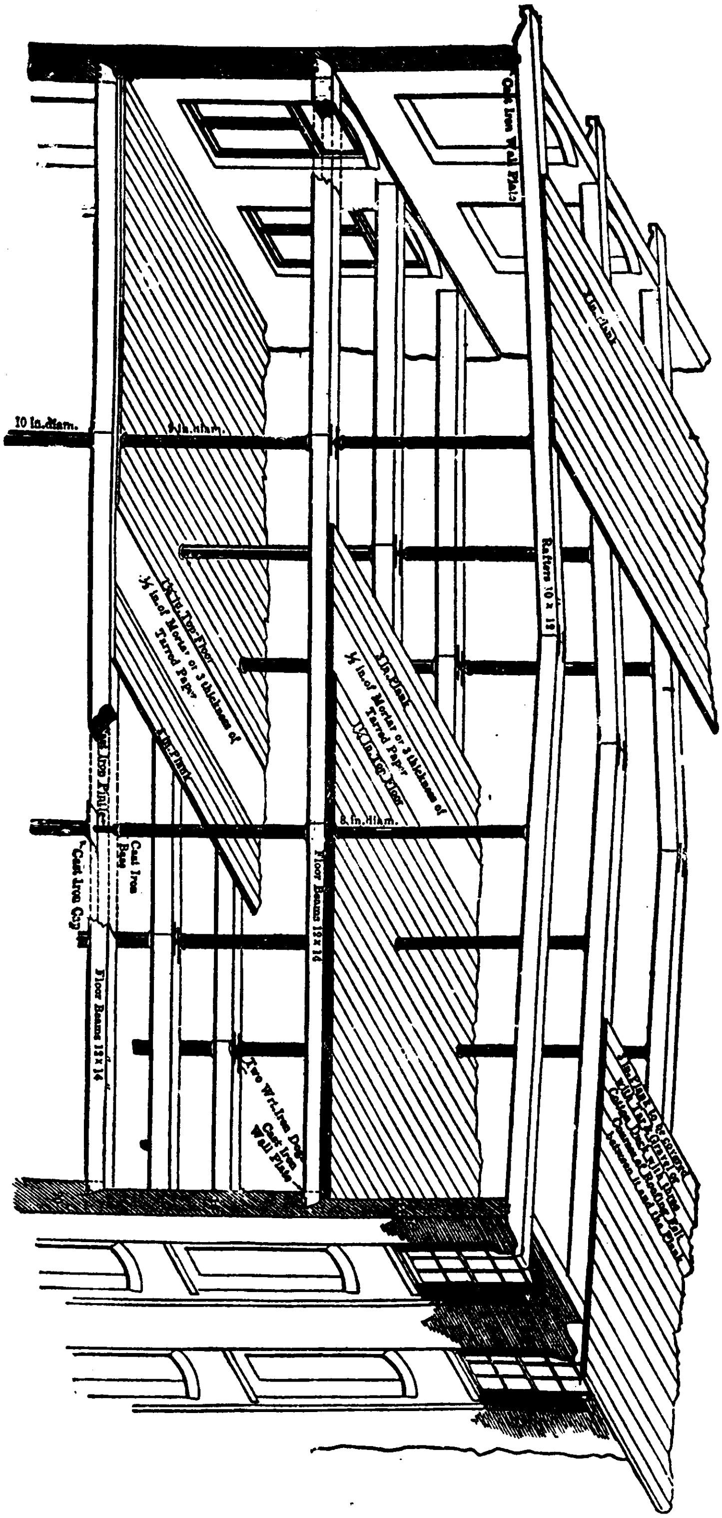
It is suggested that when this construction is used for warehouses or other buildings, where it is considered necessary to paint or varnish the floor beams, two sticks 6 by 14 inches each should be substituted for each floor beam, and two sticks 12 by 5 inches each for each rafter, laid with an air space between to afford ventilation and prevent dry rot. If solid sticks are used, they should be bored from end to end with 1-inch holes, and small transverse holes for ventilation.

The columns should be bored from end to end with a 1-inch hole and bored transversely near the top and bottom with ½-inch holes for ventilation and to prevent dry rot. Pintles may be cylindrical or Greek-cross shape in horizontal section.

The posts, if round, should not be tapered. Posts 8, 9 and 10 inches square are stronger than round posts of the same diameters

The windows on the right are drawn of the customary size. It is suggested that much more light may be gained if the windows are made much wider, the wall between the windows narrower and four inches thicker, as drawn on the left. Windows may be hung in the ordinary way, as shows on the right, or may be made of large plates of rolled glass, as shown on the left ; the lower ones fixed, the upper one to open on hinges for ventilation.

A cause of danger which prevails to a greater extent among paper mills than in the modern textile factories is the custom



SECTION OF MILL, SHOWING CONSTRUCTION OF TWO FLOORS AND ROOF.

of suspending one or two floors from the roof by rods held with trusses. There is much greater danger of the complete destruction of a mill under these conditions than there is when the floors are properly supported from below. There are many cases where the attic requires no floor, provided the roof were thick enough to prevent the condensation of moisture generated within the mill upon the under side of the roof. Such attics, when floored, are apt to be made use of for the storage of combustible material, by which the danger is much increased. We therefore advise the removal of such attic floors wherever it is possible. The floor boards may be carefully taken up, and fastened between the roof timbers upon the under side of the roof boards. Many roofs in textile factories have been made thicker in this way, with correspondingly good results. The passage of heat and cold through the roof will be very much less, the condensation of moisture may be wholly prevented, and the condition of the room below the attic in which the work is done may be greatly improved, while the risk of fire will be very much diminished. The better and safer way is to remove the pitched or French roof wholly, and to substitute a thick, flat roof. Some paper mills are now being improved in this way. This has been done in many textile factories with great benefit to owners as well as underwriters. Where the floor below the attic is also suspended from the roof, it should be supported from below. Hanging a floor from a roof truss is an unfit method of constructing a mill—costly, dangerous, and unsuitable. Much of the objections to posts is imaginary. There are no special objection to posts in a paper mill any more than in a textile factory. We therefore advise the substitution of posts or piers in all possible cases for the hanging rods by which floors are now suspended from a roof. These conditions will hereafter be considered in making the rates of premium upon paper mills.

We again condemn the pitched roof and the so-called French roof, especially when slated. These forms of roofs are out of date and out of place. They were always bad, and are now worse than ever before, in contrast with the modern flat roof made of solid plank three or four inches thick. The time is not far off when all such roofs will be removed, not only from paper mills, but from factories of all kinds, by owners who give such attention to their own interests as the subject calls for, without any regard to the contract of insurance or to the rate of premium on the policies.

We have suggested that hereafter no roof should be put over any part of a paper mill except a flat deck made of plank not less than three inches thick, pine perferred, grooved and splined, sheathed underneath between the timbers if it is thought to be necessary for a finish, and covered on the outside with a suitable material; over the machine room one inch of mortar may be put upon the plank, and then a covering of suitable roof boards. Such a roof over a machine room, fitted with a system of ventilation as applied by Professor Woodbridge of the Institute of Technology, will entirely do away with the condensation of moisture over the Fourdrinier machine.

There remains, however, the problem of the outer covering of this roof with suitable materials to shed rain, or, in common speech, "to keep out the weather." For this purpose the material in common use is either tin or one of the compounds of asphaltum or of coal tar and gravel. Tin is to be avoided wherever there is the slightest possibility for humidity to pass from within to the under side of the metal. Hollow roofs with air spaces in them are a snare and a delusion.

We have ventured to suggest the use of cotton duck properly prepared and carefully applied. This mode of covering a flat roof is on trial.—*Manufacturer and Builder.*

THE WIND AS A FACTOR IN ELECTRIC GENERATION.

The immense usefulness of electricity is at length fully recognized. It is seen to possess merits when used as a motor, an illuminating agent, and for other purposes which can hardly be too highly estimated.

Conspicuous amongst its merits is that it is so easily transmissible from the source of power. No cumbrous machinery of riggers and belts, or even mains and supply tubes is required. Simply a wire of sufficient sectional capacity, properly insulated, suffices to convey the powerful agent from the source of its generation to the spots where its work is to be done, and whether it be to actuate a machine or to illuminate a street or an interior, its services can be called upon or dispensed with with a magical rapidity not even excelled by the operations of the genii or magician of some old Arabian story.

But electricity is unquestionably somewhat expensive to generate, and if the dynamo be actuated by a steam-engine or gas-engine, this is a considerable drawback.

The subtle and useful power is much more cheaply procured, where, as is often the case in America, the dynamo can be driven by water power, and it is probable that in point of economy no method of production with our present appliances can be more economical than this.

Yet there is another force in Nature as useful as water and quite as generally available, which might well be applied to the driving of dynamos; but of which up to the present time little use has been made, though thoughtful electricians both in England and America are at last turning their attention towards it.

We allude to the wind as utilized by the medium of a windmill.

The credit of first suggesting the use of windmills for driving dynamo machines to charge electrical accumulators belongs to the eminent physicist and electrician, Sir William Thompson, and dates back to the year 1881, viz., to a presidential address delivered by him before Section A of the British Association for the Advancement of Science, on the "Sources of Energy in Nature available to Man for the production of Mechanical Effect."

It is true that in the same paper, and at the same time, Sir William threw some cold water on his own suggestion, by urging, as a difficulty in the way of adopting the windmill in its then state of development, that the first cost was too great.

Mr. A. R. Wolff, an American engineer and scientist, who has devoted much attention and thought to the perfecting of windmills, remarks, anent Sir William's observations, that that gentleman erred in overlooking the fact that interest on capital, not capital itself, is an item, and by no means the only item of current expense by which the economy of prime movers should be judged. Mr. Wolff goes on to remark, upon this point:

"When the only correct basis of comparison of the economy of different prime movers is instituted, viz.—the cost of obtaining the horse-power developed per unit of time, such cost consisting of the same of interests, repairs, and depreciation of plant, cost of fuel, oil, and attendance, and similar items of expense entering the power account, the windmill is the most economical motor for the development of power in moderate or small quantities."

He then combats the idea that the non-employment of this means of utilising natural energy is not due to the fact that the rate of revolution of the windmill, according to the varying force of the wind, is too irregular to run a dynamo for the purpose of charging a storage battery, or that the wind cannot be depended upon for a sufficient length of time per day.

He goes on to show that a well-constructed wind mill will work whenever the velocity of the wind exceeds six mills per hour, and, moreover, that in the countries lying in the north temperate zone, it is found, from experience, that, for at least eight hours out of the twenty-four of each day, the wind exceeds this velocity of six miles per hour, the average velocity of wind, during the eight hours of run, being sixteen miles per hour. Total calms of any lengthened duration are almost unknown in such latitudes.

The fact that the windmill is at rest, often at short intervals, aggregating not quite sixteen hours out of the twenty-four, is no objection to the motor for the purpose of driving dynamo machines to charge electric accumulators, for one of the very features and acknowledged requisities of such accumulators should be that they can be charged spasmodically at will, and at odd times.

"The result of study of this question," says Mr. Wolff, "must be that the reason windmills are not used in this way is not that windmills are not sufficiently economical and reliable, but that the electrical accumulators are not yet a satisfactory and assured success. When they are, windmill will come into extended use as prime movers, for the generation of electricity, and electricans will be glad to avail themselves of the most economical motor, utilising the force of wind, otherwise going to waste, for that purpose.

The windmill at the present day is in a developed state, a practical success, ready and available for this new use at once. It awaits the electrical accumulator that is a thorough practical success also.—*Builder's Weekly Reporter.*

BRICKLAYING IN WINTER.

In Norway building operations are carried on without interruption through the winter, unless the temperature falls less than 14° to 18° Fah. The whole secret of the matter is that the Norwegians buy their lime, not slaked, but only burnt, and, like the ancient Romans, mix their mortar only in small quantities for immediate use. The bricks are kept under cover prior to use, and the upper courses of bricks which have been laid are shielded from rain or snow by means of planks and mats during the night, or whenever work is suspended. By attending to these simple precautions, building operations can be carried on through the winter, to the benefit of all concerned.—*Exchange.*

Most people seem to be agreed that some sort of technical education is necessary, but they are not at all in accord as to what form this education should take. Many of them consider that the multiplication of colleges is all that is wanted; these may do well for the higher class of students who have already received a moderately advanced education, but for all ordinary purposes, for technical education, that is to say, as a preparation for the lifework of 99 per cent. of individuals, they are perfectly useless; even in the case of the remaining 1 per cent. they fall short of what is requisite, and especially in workshop practice.

There can be no proper practical training without practical work. The hand and eye must be trained as well as the mind, and nowhere is this fact so apparent as in the wood-working trades. An artistic and economic manipulation of wood can only be acquired by long practice and close application.—*Exchange.*

IMPROVED PETROLEUM FURNACE.

The accompanying illustrations exhibit the general appearance and construction of a highly efficient furnace, designed to burn petroleum as a fuel, and which will be found especially serviceable for metallurgical, assaying and ceramic work. The inventor, Dr. C. H. Land, of Detroit, Mich., is well known to the dental fraternity from having devised a number of ingenious and practical forms of furnaces and accessory apparatus designed to facilitate the application of porcelain in dental work, and which have worked something of a revolution in mechanical dentistry. The present furnace, though adapted for miscellaneous uses as well as for dental work, owes its meritorious features to the careful study of the subject of furnace construction, and the experience gained in the art by the inventor. In this form of furnace, Dr. Land has succeeded in utilizing, very advantageously, crude petroleum, which, as is well known, possesses heating qualities of the highest order; and the pictures represent the design of the furnace now in operation in the inventor's workshop, for the manufacture of artificial teeth.

In dimensions, the improved furnace is about the size of the ordinary base-burner stove—4 feet high and 14 inches in diameter. In construction, it is similar to a stove made of cast iron and lined with fire-brick, as shown in the figures. The tray, or support, shown in the pictures, is made so as to be adjustable to either the front or side of the furnace. The furnace space above this table is designed to be occupied by the muffle, two by four inches, which is contained in a suitable frame or drawer, fitting into the space referred to, the table affording a necessary and convenient adjunct for the easy handling of the crucibles when full of molten metal. A series of drawers is provided, some especially for different size muffles, or made specially to accommodate various sizes of crucibles. Furthermore, a drawer may be inserted that will be suitable for forge work; another for tempering, annealing, etc.

For the handling of fifty or hundred pound crucibles, a larger and cheaper furnace is constructed, and a suitable track is provided for the convenient insertion and withdrawal of the same. In this case a tilting crucible is placed in the drawer, and, when ready for casting, it is run out on the track, which passes over the molds, and enables the operator to handle the crucibles with a great degree of comfort and safety.

With the furnace here shown, a 10-inch muffle can be maintained at a temperature of 2,800° to 3,000° Fah., with a consumption of not more than two quarts of oil per hour. Estimating the cost of the best grade of oil, this would represent a cost of less than two cents per hour. Starting from a cold muffle with this improved furnace, it takes but forty minutes to attain the maximum intensity of heat which the fuel is capable of yielding—sufficient to fuse gold, copper, iron, and porcelain wares with the utmost facility.

Not the least important feature of this improved apparatus, is the fact that all this is accomplished with the ordinary draft of a chimney. No blast is required; no steam jet; no spray apparatus, or artificial draft of any kind. The oil is simply allowed to fall into the combustion chamber, where it comes directly in contact with the air, and is consumed in as simple a manner as the wood in a stove. A simple zigzag grate does the work. This arrangement is illustrated in Fig. 2, from which the simplicity of the combustion chamber will be visible.

The inventor informs us that as soon as a company can be organized, facilities will be established to place these furnaces, together with a series of others, on the market.—*The Manufacturer and Builder.*

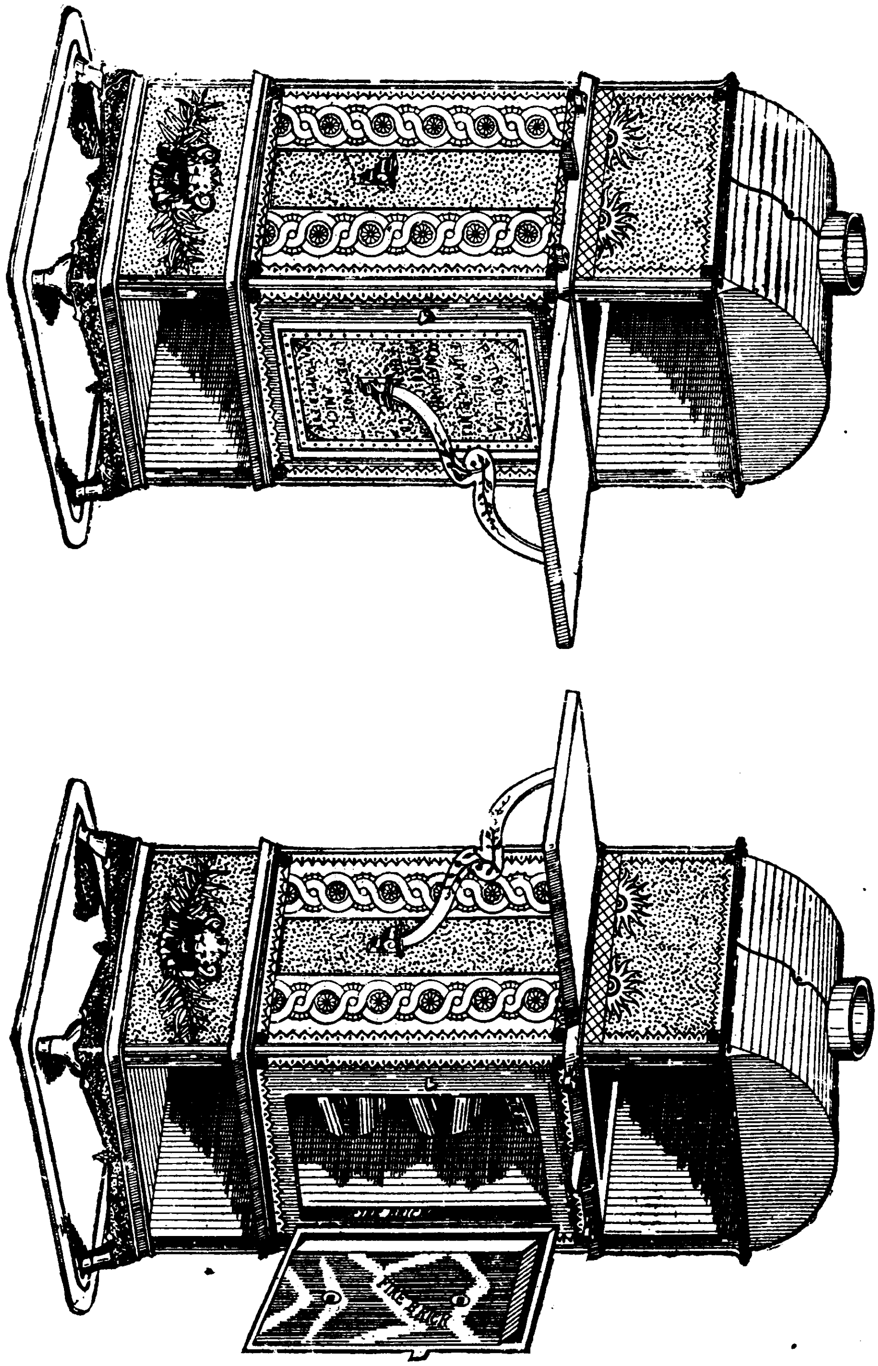


FIG. 1. THE LAND IMPROVED PETROLEUM FURNACE. FIG. 2.

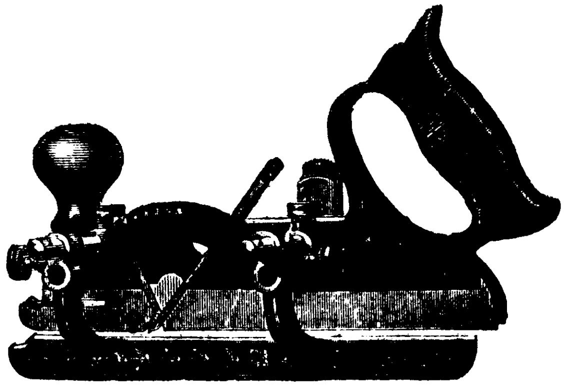
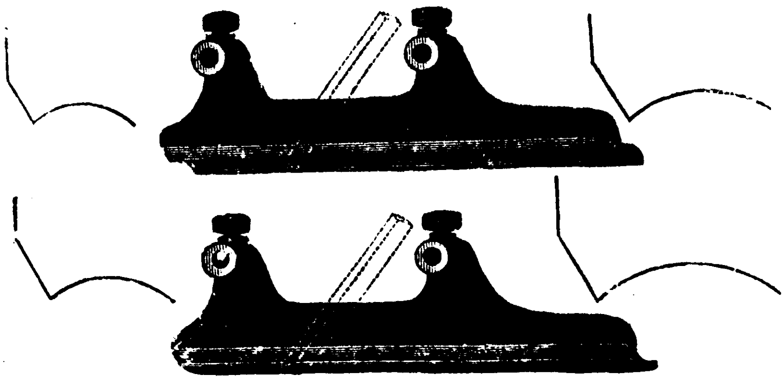
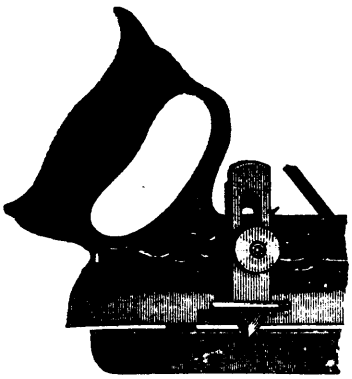


Fig. 1.





S. S. I. R. O. J.

Fig. 2.

THE JOINER AND HIS TOOLS.

BY OWEN B. MAGINNIS.

I am enabled, through the kindness of the Stanley Rule & Level Co., to describe in detail, one of the combinations mentioned in the last paper.

There is a great difference of opinion among mechanics as to the superiority of the wooden and iron planer, some preferring wood, and some iron, but the general prevailing opinion seems to run in favour of the iron plane, which, on account of its superior finish and the easy way in which they fit together, renders them much handier than the old style. Readers can, however, judge for themselves, but it is to be remembered that there is much more iron used now than formerly, and though very cold to the touch in winter, they are extremely accurate in working and fit together like a clock.

The combination, Fig. 1, embraces or combines nine different planes, namely: Beading and centre beading planes, rebate plane, filletster, dado, plow, match planes, and a slitting plane or cutting gauge, its extreme length from the extremity of the handle to the front of the sole iron is 10⅛ inches, and its entire weight mounted with the bars and fence and sliding section ready for use is 3¼ lbs.

The "stock" or bit holder and handle are formed of cast malleable iron in one casting, which is bored through with two holes, one 1 inch directly before the handle, and the other 1 inch before the opening for the bit, and are screw tapped to receive the bars or arms. On the left side a $\frac{1}{8}$ inch slot is cast to receive the bit, which is inserted from that side, and is securely held in position by a conical plug fitting in a conical hole, and with one section cut-off straight, so that when the plug is drawn into the hole by the thumb screw on the right side, the straight side of the cut off section presses the bit against rear side of the slot and holds it securely in position. On the front a polished rosewood knob is screwed vertically for the purpose of pressing down the bit on the stuff whilst working. On the right side, just in front of the bit, the depth gauge for rebating and plowing is placed, sliding up or down in a hole cast to receive it in the stock, and secured in a fixed position by a thumb screw. On the bottom the gauge plate is affixed, regulating the depth to which the bit works, and directly before the handle another $\frac{3}{8}$ inch vertical slot is cut for the purpose of adjusting the slitting tool. Through the middle of this the prolonged screw of the rear arm passes $\frac{3}{4}$ of an inch, and the slitting tool is cast with an opening (see Fig. 2), to fit over it into the slot, at the same time permitting the tool to be raised or lowered vertically for fixing the depth to be slit; and the slitting gauge likewise, fits over the screw similarly stamped out, so that they both fit over the screw and are fastened in their place by an extra large thumb screw and washer. The position of the slitting tool, as shown, is a very good one, as the joiner is able to give his whole downward strength in cutting. The front gauge can be also used when using the tool in slitting off parting beads, etc. The handle on the stock is encased with rosewood and very comfortable to the hands, so there is no danger of blistering.

The *sole plate* on this plane is shaped out of sheet iron, and is $1\frac{3}{16}$ inches width, and solidly riveted to the iron stock above in two pieces, one before and one behind the bit, beveled from the inside, giving a straight side, and is rounded on the front corner to allow it to run easily over the stuff. Immediately in front of the opening for the bit a very ingenious arrangement for a cutter in working across the grain is inserted. It consists of a steel circle or ring of $\frac{5}{16}$ inch in diameter, out of which project three $\frac{1}{8}$ inch long circular cutters, which on lacking the small screw which retains them in a sinkage made for them in the side of the plate, can be taken out and set with one of the cutters projecting below the sole plate ready for use. When not required, the three can be snugly turned back in the plate, where they fit flush out of the way.

The first important addition to the above is *the sliding section*, which is added to form a wide sole when dadoing or rebating, and to support the left side of the bit which is held on the right in the stock. It is made in the same way as the stock, the upper piece being cast with a circular band which allows the shavings to pass out from the bit when cutting, and joins the front and rear pieces together. It is drilled with two holes which slide on the arms and can be screwed fast to them with two thumb screws on top. Just in front of the forward arm there is another hole for the fence, where it can be placed when the tool is in use as a sash filletster. The adoption of the sliding section enables the use of the bead plane either as a side bead (with the fence), or as a scratch bead and reeds, and makes the whole tool very steady under the hand pressure without that wobbly motion, so well known in the old wooden planes. On the left side of the sole plate of the sliding section, in its neceessary recess, another of the triple set of spurs or cutters is inserted, for use in dadoing or rebating.

The third and last main piece is the *fence*, which is of cast iron, consisting of a planed face which works against the wood in plowing, rebating and beading or slitting, and two arms, which are drilled vertically with two holes on each arm so as to be able to raise or lower the fence, to slide under the sole plate of the sliding section or to be placed against its side in rebating, tonguing and side-bedding. A thumb screw on each arm retains the fence in its fixed position on the bars, like the sliding section, and so arranged that it can be fastened when the arms are in either the top or bottom holes, and the curved shape of the bars allows the fence plate to go close up to the sole plate of the stock when using a small plow bit.

All the bits, including bead and tonguing bits, are about $\frac{1}{8}$ inch in thickness, of the best cast steel and perfect temper, like the cuts, *I* and *J* being the tonguing bit having brass casting affixed to its centre, so that it can be conveniently fixed in the plane and the depth of the regulated tongue. Each of the arms are over $\frac{3}{8}$ inch in diameter, turned bright and polished so that the main accessory parts can slide on them.

In addition to the above, a hollow and a round, and bits can be added when required. They are of cast iron as before, slide on to the bars and held with a similar thumb screw; all thumb screws are slotted, so that they can be screwed tighter, if the hand be insufficient. These are not furnished by the manufacturers with the plane, but can be had in any size, to any radius if desired, at a slight extra cost. Criticising the plane entirely as a tool it must be admitted it is extremely useful and compact, and its readiness of adjustment when the mechanic is familiar with its construction, makes it a very valuable tool for shop work, and I would strongly recommend it to joiners who are in small country shops, and to builders for use in their shops, as it would save a lot of time looking around for different tools.—*Builder and Woodworker.*

DOMESTIC MOTORS.

The word "motor" has come into very general use of late, and it speaks well for the age in which we live that so much attention has been paid to the subject; it is full of interest alike to the scientist, the natural philosopher, and the hard man of business, and, indeed, all are interested in the uses to which the forces of nature are being turned, and we are glad to notice that a large amount of time and talent are being employed for the purpose of lessening the sum of human labour. At one time the inventive faculty was exercised for the favoured few; now the thought is how can "the sweat of the brow" be softened and tempered to the masses by the application of the forces of nature, and the invention of labour-saving machines; while man stands at the side to touch the lever and guide the pent-up forces at his command. We hail this as one of the signs of the times in which we live; as beneficent and ennobling, and calculated to help in enhancing the dignity of man.

Will it ever come that "power" will be "laid on" like gas and water, to be used at pleasure? Some think that we are on the eve of such a consummation. "Go" is the characteristic of the age, and there is a demand for science and mechanics and the application of these laws to every-day occupations; but there is the ever-active force of human prejudice ready to resist the removal of old methods and the introduction of new; and every enterprising man has found again and again that this is the most serious obstacle to overcome, even though it be silent or passive. We ought rather to look for and welcome alterations and improvements as in the natural order of growth and progress. We could imagine that the toilers in the workshop, the warehouse, and the home would call upon the scientific and inventive to ease their labour by using some of the ample resources of nature which lie around us.

The characteristic of past ages was that the consumer was also the producer of the things he consumed. The feudal system practically made every castle a town of limited area, with all its resources of supply and demand within itself, and having little dependence on the outside world ; and there then followed a long period of divided production and demand—making *here* and using *there*. Consumers had to send for their food, their drink, their light, and their clothing. All this entailed a vast waste of human labour. *Now* the characteristic is that well-nigh everything is brought and put down at the consumer's doors. Thanks to our railways, goods—large and small—are conveyed from one end of the kingdom to the other with express speed. Gas and water are laid into every apartment ; the telegraph communicates our wishes and records our will all round the world ; and he who has no sympathy with all this is naturally looked upon as a fossil. All these achievements have brought vast saving and advantages to the community.

We can readily imagine that good housewives would view with some objection the idea of "power" being introduced into the sacred precincts of their homes. We can remember how long the old homes stood siege by gas and water companies, and that some even resisted the innovation to the day of their death. Doubtless, the introduction of "power" into our houses will meet with a similar and determined opposition. It has been common for the sterner sex to invite wives and daughters to the works to see some new process. Perhaps the scales may be turned some day, and the weaker sex come to invite their husbands and brothers to see some brilliant display of domestic talent. We have already had the "lord of creation" invading the culinary department, and tasting delicate preparations straight out of the saucepans ; only a few more steps will carry them through the whole of the domestic offices, where they may see "power" used to wring the clothes, mangle and iron them, clean the saucepans, work the sewing machine, saw the wood, chop and mince the meat, and do a host of other things, besides pumping the water and working the "lift." All this, and more than this, is in the not distant future, and putting aside anything that savours of a joke, we seriously advise the "better half of creation" to welcome the introduction of motors or power into their homes.

Then as to the nature of the motive power. Will it be a self-contained machine, worked by spirit, hot air, electricity, gas, water, or compressed air ? All these forces are applicable, each in its own way, but they may not all be within reach, or the cost may stand in the way of the purchase of a separate motor for domestic use. This brings us to a point on which we are anxious to dwell. Is there any sufficient reason why these little engines should be so costly ? The country is flooded with sewing machines, and the production reaches many thousands a year, and it occurs to us to ask—Why cannot a domestic motor be produced at a similar cost ? The question is one of considerable importance, and in our judgment should engage the attention of the trade. The price demanded for these small motors places them beyond the reach of persons of moderate means, and it appears to us clear that their production at a reasonable cost would create a large and ever-growing demand. The convenience and the comfort which they would bring to the homes of the middle classes would insure a rich harvest to the inventor who could produce a substantial and reliable machine designed to minimise the heavier and more exhausting labour of the household and at the same time reduce, in a measure, the sum of domestic worries.—*Ironmongery*.

PURE AIR.

One evening last week I stepped on a cable car to return home. The car was crowded, and just in front of me stood about two hundred pounds of masculine selfishness muffled in furs, who had tarried too long at the still. A sufficient number of the ventilators were opened, but my neighbor opened two more and stood with the snow and cold air pouring in directly on his head and making it uncomfortable for all near by. On reaching my room I found my room mate sitting in the room heated by a base-burner and lighted by three gas jets. Every door and window were tightly closed, the snow packed about the window outside making it impossible for any air whatever to enter. Here I had found the extremes—one ventilation crank and the other a crank who is always afraid of a current or exposure to a draught. While the fire burned I mused. There may have been some impossibility to the conclusions at which I arrived, but in my musings there was a dream of paradise. A new world formed about me, the population of which consisted of the resultant of these two opposing cranks. I mentally melted them together and produced an individual who knew what to breathe and how to breathe it.

Bread may be called the staff of life, but one will live longer without bread than without air. Men very seldom attempt suicide by starvation, but self-destruction is often wrought by breathing nothing, or by breathing poison. People who shudder at the thought of suicide and turn away from the contemplation of such melancholy ending of life, shut themselves up in closed rooms and begin self-destruction by a slow but sure process, prolonging the agonies of death through suffering years. We avoid contagion, accidents, and dangers, protect ourselves against exposure and the evils of intemperance and extravagances, yet we are ever careless regarding the air we breathe—not only breathing it over and over again, but burn the purity and life-giving property out of it. We build our houses with close regard for convenience, economy and appearances, but with almost criminal carelessness regarding comfort and sanitation. It has ever been so, and will probably largely remain so, until my new generation, evolved from the union of my two cranks, shall have peopled the earth.

As the fire burned I mused some more. The gas jets were burning low and yellow, the stove was throwing out heat from its acquired momentum, and a sense of languor and half-painful dulness pervaded the room. I could have slept and dreamed, and died there, the victim of a crank, who, fearful of a "cold draught," invited suffocation. There were the gas and stove consuming more oxygen than the occupants of the room, with no fresh supply added from the air without, and I wondered how long it would take for these objects to consume all the oxygen the room contained. Dr. Hammond, in writing of pure air and ventilation, has given some important information regarding the subject. He says :

"In regard to the extent of contamination produced in the air of houses by the artificial means of illumination employed very definite results have been obtained. We know that combustion takes place at the expense of the oxygen of the air. Tallow, wax, spermaceti, oil, etc., contain as an average about

90 per cent. of carbon and 12 per cent. of hydrogen. In burning these substances unite with the oxygen in the atmosphere, producing carbonic acid and water. In one hour I found a sperm candle burned away to the extent of 135 grains. In this amount are contained 108 grains of carbon, absorbing from the atmosphere 288 grains of oxygen to form 396 grains of carbonic acid, equivalent to eight hundred and forty-one cubic inches.

"The room contained 1,500 cubic feet of air, and had it been perfectly air-tight and the candle had continued to burn for about 45 hours the oxygen contained in its atmosphere would have been converted into carbonate acid. Experiment has shown, however, that air containing as much as ten parts of carbonic acid in 1,000 is not fit to be inspired; 841 cubic nches of carbonic acid were formed in one hour, and consequently 84,100 cubic inches of air, or 58·4 cubic feet, were so far deteriorated as to be unfit for the purposes of respiration. In twenty-five hours the whole air of the room would have been rendered injurious to health if respired even if fresh oxygen had been supposed to take the place of that uniting with the carbon.

"My own experiments go to show that about 12,000 grains of carbonic acid are exhaled from the lungs of an adult man in twenty-four hours. In addition, over 5,000 grains of vapour of water are expired. A single candle in the same time causes the formation of 9,500 grains of carbon, or only about 2,500 grains less than the respiration of an adult man during the same period. But many kinds of candles burn away much faster and give rise, in being consumed, to a considerably larger quantity of carbonic acid, so that it is within the bounds of truth to say that a candle, while burning, in the main causes as great a deterioration in the atmosphere as does an adult person breathing in it during the same length of time.

"But gas poisons the atmosphere to a still greater extent. By accurate measurement I have found that a gas-burner in the room in which I am in the habit of sitting, allows, when the gas is fully turned on, of the consumption of 4·25 cubic feet per hour. A cubic foot of coal gas gives origin, during its combustion, to about 1·25 cubic feet of carbonic acid, so that for each hour 5·31 cubic feet, or 4,322 grains, of carbonic acid are given off to the atmosphere of the room. For the twenty-four hours the quantity would amount to 128·50 cubic feet, or 103,728 grains."

If the air thus contaminated were allowed to remain in the room, it is here demonstrated that one such burner as above mentioned would cause more carboni c acid to be formed in a given time than is evolved from the respiration of eight adults, and, so far as the deleterious results of the carbonic gas is concerned, causes more deterioration of the atmosphere of a room than would result from the presence of eight persons.

These conclusions, as demonstrated by actual experiment, point out the great importance of careful and adequate ventilation. Many of the complaints lodged against plumbers would disappear if more attention were paid to the means of admitting fresh air. Houses are constructed with windows and doors, and ventilation apparatuses are made for the intelligent use of all occupants. The gasfitter so understands it, and his business is to get proper arrangements made for the safe supply of gas, and his work has nothing to do with windows and doors.

People do not want to return to the cabin, with its broad fireplace, open doors and windows, and tallow dip, and residents in cities cannot be provided with them. Intelligent regard for health will supply this demand in the modern dwelling and in crowded cities. Here is no theory or expert needed. Common sense in a properly constructed building will supply the means of keeping the air fresh and pure.

I lowered the top sash and let the fresh air in my room. The gas burned brightly, the heat was not oppressive, languor disappeared, and the room smelled fresh and sweet. I do not know what became of the ventilation crank, but the cold-air crank was made a convert to the invigorating influences of pure air.—H. H., in the *Sanitary News*.

OXYGEN.

Pure oxygen gas, says A. H., in the *English Mechanic*, may be obtained from the atmosphere at a trifling cost, so as to enable it to be collected in unlimited quantities in gasometers, like coal gas, for application in the arts, manufactures, etc. This process depends upon a peculiar property possessed by the earth baryta of absorbing oxygen at one temperature and evolving it at another. The process is as follows:

Mix the baryta with a portion of hydrate of calcium or of magnesium; place the mixture in an earthen tube heated to dull redness; oxidize it by passing a current of atmospheric air over it. As soon as the oxidation is complete, connect the tube with the gas holder, and allow a jet of steam to act upon it. This converts peroxide of barium into hydrate of barium, and the excess of oxygen is given off and collected in the gas holder. The baryta is then again oxidized by a fresh current of air and deoxidized by steam. The whole process may be repeated as frequently as required. One ton of baryta thus treated yields about 2,500 cubic feet of pure oxygen every twenty-four hours, and this, as it does not lose any of its properties, at the mere cost of fuel and labor.

THE DANGER OF GAS.

Much has been written regarding the attempt to put electric wires in gas mains, but far more yet remains to be said about how to keep gas out of electric conduits. Deaths among electric workmen from asphyxia and from injuries due to explosions caused by the presence of illuminating gas in underground conduits are being recorded with an increasing and unpleasant frequency.

What to do to keep the gas out, and if it is present how to render the operation of laying underground conductors a safe one, are problems which confront the electrical engineer. Obviously, if all the conditions were under control of the electrical company, the remedy should be applied to the first causes, leaky gas mains; but as such a treatment of the subject is impracticable, and as accidental leaks may occur at any time even in properly constructed mains, the electrical subway, should be made as far as possible gas tight. No matter how much care may have been exercised in the construction of subways, they may at any time be found to contain gas in dangerous quantities, and precautions should always be adopted to guard against accident by those entering the manholes.

A good plan, much used by cable splicers when compelled to work in a manhole which is found to contain gas, is to allow fifteen or twenty minutes for ventilation after taking off the cover before entering; then to proceed to close up with pipe clay all the openings into the ducts. Pipe clay is used in perference to cement because it does not harden and can easily be removed. In those ducts into which cables have been drawn there is between the cables and the walls of the ducts more or less space which should be carefully filled with this clay

During all the time that the splicer remains in the vault his helper on the surface sends down a supply of air from a rotary blower which is operated by a crank. This keeps the manhole ventilated and renders the work of splicing comparatively safe. Without the sealing up of the ducts all attempts at ventilation may prove useless, because if communication with neighboring manholes is allowed, a sudden draught of air might suck into the working chamber a volume of gas sufficient to smother the workman while his helper was contendedly turning the crank of the air pump on the surface above.

It is well to bear in mind that the treatment for asphyxia is similar in many respects to that used in resuscitation from drowning. If a workman should be overcome by gas, his life may depend on the way he is handled before the arrival of a physician. He should be brought into the fresh air at once. Efforts should be directed toward keeping up the heart's action and restoring the circulation, and for this purpose stimulants may be given. The foul gases should be expelled from his lungs and artificial respiration practiced if necessary.

Unless a general system of subway ventilation is carried out, this plan of sealing up the ducts should be extended to all the manholes whether there are men at work in them or not, otherwise a leak at one point might flood the entire system with gas. Under the latter condition an explosion at one place may be transmitted through the connecting ducts to a number of manholes, causing great destruction.

To detect the presence of gas is not an easy matter, especially in view of the fact that certain kinds of illuminating gas are inodorous. It has often been suggested that some chemically prepared paper, to be used after the manner of litmus paper, which is turned red by acids and blue by alkalies, might be devised for this purpose, but it hardly seems possible that anything of this kind will be produced, as it is necessary to know not only that gas is present, but also in what quantities. It is too much to expect that there ever could be devised an apparatus for the quantitative and qualitative analysis of gases simple enough to be operated by a subway laborer.

All ordinary underground cable-laying operations can be conducted without the use of a torch in the manholes, but there are cases where its use becomes necessary, and in those instances unusual precaution should be taken to make certain that an explosive mixture of gases is not present. The introduction of underground wires has brought with it new troubles, and it would seem for the interest of all that something should be done by the various companies toward securing uniformity of practice in dealing with this dangerous element, which threatens not only the lives of the cables, but also the lives of our workmen.—*Elec. Review.*

TALL CHIMNEY ENGINEERING.

Some very striking examples of the resources of engineering have been furnished by the treatment of tall chimneys, in some cases the tragic side of the profession coming into relief. The problems presented for solution by these structures are difficult. It often happens that a chimney settles a little on one side, and becomes dangerously inclined from the perpendicular. In such a case it has to be straightened. Sometimes the operation is successful, but in a number of instances the chimney has fallen after the operation.

Probably the worst of these accidents on record happened in the case of Newland's mill chimney, Bradford, England, a shaft rising 260 ft. from the top of the foundation. When it was nearly completed, it was found to be bulged on one side and hollow on the other. The settling occurred during a single night. To straighten it two cuts were made extending about one-half around it, which, as fast as made, were filled with stone one-half inch less in thickness than the cut. Iron wedges were driven above the new stone to take the weight. The cuts were made little by little, so that no change occurred until the wedges were knocked out. The chimney then settled down on the side where the cuts were, and was straight. It was then completed. Nine years later some cracks appeared and were repaired. Again, after ten years more had elapsed, some pieces of the outer casing dropped off, and two days later the whole upper portion of the chimney fell, killing 54 persons and doing about 100,000 dols. worth of damage. Just before the collapse stones and mortar were observed to burst out from the locality of the cuts.

In the neighborhood a successful operation of the same character was performed. A chimney at Bingley, near Bradford, was found to be 4ft. 6in. out of perpendicular. A gap a foot high was cut clear through one side of it. Screw jacks were inserted in the cut as fast as the cut progressed, and as each was put in place it was screwed up hard against an iron top plate. A similar plate was placed under each jack. When about half the circumference of the chimney was cut through, the jacks were slowly turned down until the chimney was nearly straight. The gaps between the jacks were bricked up, the jacks were taken out one by one, and masonry was put in their place. When all were removed the shaft was perfect, the compression of the new work having completed the straightening.

In another instance a chimney 132ft. high settled until its top was 3ft. 2in. out of the perpendicular. This was at the works of Matthews and Sons, in Gloucestershire. A course of bricks was taken out for five-eighths of the circumference and replaced by a course of 1⅝in. less in height. As fast as the cut was made the new course was laid and iron wedges were driven in above it. When all was in place, the wedges were driven out, and the chimney came back to within an inch or two of the perpendicular.

Chimneys will stand these operations if of good material originally; but if the brick and mortar are inferior, they will be apt to succumb. A shaft in Oldham was being straightened in the above manner. The owner protested, taking the ground that the mortar should alone have been sawed, and went off a little distance with one of the workmen to observe it, when suddenly the pile fell, burying one man in the bricks and destroying an adjacent building. The brick and mortar were both of inferior quality.

It is by no means the universal custom to treat the problem in so radical a manner as by the removal of a portion of the bricks or stones. Often the mortar between two of the courses of brick is sawed out on the higher side, and the operation is repeated on the other joints until the work has been completed.

The moving of a chimney has been successfully accomplished. In Brunswick, Maine, a 78-foot chimney was moved 20ft. on greased planks. It weighed about 100 tons. Inside of nine hours it was again at work in its new position, receiving the products of combustion from the fires.

The erection is generally conducted by the ordinary methods in use in regular building. Sometimes a radical departure is made. An iron chimney over 150ft. high has been built from the bottom upward. A section of the chimney 20ft. high was first built. This was raised vertically 4ft. and a circle of plates 4ft. high was riveted to it at the bottom. The whole section, now 24ft. high, was lifted again 4 ft., and a new course was riveted on, and this was continued until the whole was complete. A hydraulic ram did the lifting. Of course this method could not well be applied to other than a sheet iron shaft.

In the demolition of a high chimney some ingenuity can be shown. A chimney in Middlesbrough, England, was taken down brick by brick from the top downward. A long chute one-half an inch longer and wider than a brick in its cross sectional dimensions was first erected within the flue. It was airtight and rose from an airtight box placed at the bottom of the chimney. The bricks were dropped one by one through this chute, and were cushioned by the air so that none were broken or injured. From time to time the box was opened and the bricks that had accumulated were removed. —*Scientific American*.

WALL PLASTERING.

Among all the improvements in building methods and materials, it is strange that so important a factor in the construction of a building as wall plastering should have stood still so many years. For some years past, however, the common mortar in ordinary use has not been standing still, but has, on the contrary, been growing worse and worse each year. One reason for poor mortar is carelessness in making up and seasoning, but the chief cause is the use of lime made from limestone, which is very hot, and even with the greatest care refuses to slake evenly. This heating quality causes the disagreeable effect known as "pitting out." The tiny lumps of lime in the plaster which refused to slake before being applied to the wall, swell as they come in contact with the air, burst and fall off, so that many a job of plastering, which seemed at the time of finishing to be a first-class piece of work, has looked after a few weeks as though it had been afflicted with the smallpox. Lime made from shells is much cooler, and therefore better for the manufacture of plaster than that made from limestone; but in a limestone country the latter is of course cheaper, and is therefore more generally used. The recent valuable inventions in wall plaster mark a new era in the history of building, and bid fair to revolutionize that branch of the business. The ancients were thoroughly acquainted with the secret of manufacturing a perfect and durable mortar, specimens having been found in these modern days which have stood the test of ages and still retain the firm and enduring qualities of the hardest stone. "There is nothing new under the sun," and perhaps the recent inventions are but the recovery of a lost art.

Saccharine matter is said to have entered largely into the composition of ancient plaster, and is also more or less used at the present day for special occasions: whether it enters into the new plasters or not we cannot say, but think it quite probable that it is one of the ingredients.

Sawdust is now much used in mortar, where it forms an excellent substitute for sand. In some localities it is impossible to obtain good, clear, sharp sand suitable for use in the composition of mortar, but sawdust is always to be had in almost unlimited quantities. The latter has the advantage of being lighter, and renders the mortar not only easier for the laborer to carry, but, being only half the weight of that mixed with sand, is much better for ceiling, as it is less apt to fall off. Mortar made of quicklime and sawdust in place of sand, and mixed with a proper proportion of cement, makes an excellent mortar for brick or stonework. Sawdust enters largely into the patent plasters.

By the use of these new inventions in plaster, rapid building is greatly facilitated, as there is no waiting for mortar to season; the composition, being all prepared, has only to be mixed with water, when it is ready for use. There is also no delay and soon becomes as hard as stone. The plaster can therefore be directly followed by the inside finishers.

Previous to the introduction of the new varieties of plaster came improvements in the styles of lathing, and there are now many excellent kinds of metal lathing upon the market, each laying claim to some special advantage over all others.

With the new styles of plaster and metal lathing, and by encasing floor beams and posts in fireproof cement, and filling all interstices between walls and floors with "mineral wool," it is possible to-day to make even a frame house practically fireproof, particularly if, in addition to other precautions, the roof be of slate or metal, perferably the latter, as slate is apt to crack and break if subjected to intense heat.—*Builder and Woodworker*.

USEFUL ITEMS.

A German trade journal advocates the following method for testing the quality of roof slates: The samples of the slate to be tested should be carefully weighed, and then put into boiling water for a quarter of an hour. The water, must, however, be fairly free from lime, saltpetre and ammonia. The slates are then re-weighed, and those that show the greatest increase of weight are the most capable of resisting deterioration.

A very complete filling for open cracks in floors may be made by thoroughly soaking newspapers in paste made of one pound of ordinary flour, three quarts of water and a tablespoonful of alum; these ingredients to be thoroughly boiled and mixed, the final mixtures to be about as thick as putty, and it will then harden like papier mache, and may be used for moulds for various purposes.

To clean lamp-burners, take a piece of sal soda the size of a walnut, put into a quart of soft water, put your lamp-burner in it (an old tomato can is good enough), set it on the stove; after boiling five minutes remove the burner, and when put back on the lamp will be as good as new. All the carbon on the old burners should be removed once every month. Another way to keep your wicks from smoking is to immerse in strong vinegar and dry them thoroughly.

A process, called the Cooper process, of lining iron pipes with glass is reported, which is said to have stood the severe test of having water passed through them at the boiling point and immediately followed by water at temperature of 33 degrees, and without in any way cracking or damaging the glass. If the invention shall prove equal to such changes of temperature in ordinary service without injury, it will be found exceedingly valuable.

Oak finished antique will be as much used as ever in the manufacture of furniture next year. It is the most popular of all the woods, and the demand for it is steady, and no signs of a change in popular favor are yet apparent. Walnut is nowhere in the race with oak for popularity, and furniture of that richest of all materials, especially for the bedroom, boudoir and dining room, remains in the warerooms uncalled for and in no demand. Mahogany is used now, as it always was and will be for the finest goods, and cherry takes a high rank, but oak stands first in favor and will continue in the front rank for another year as least and probably much longer, as there is nothing to take its place. For the cheaper grades of furniture, ash, maple, birch, and these woods, with various stains and finishes, continue, as they always will, in favor.

FACTS ABOUT METALS.

Silver will absorb a considerable number of times its own volume of oxygen when highly heated in that gas, or even in common air. This oxygen is not combined with the silver, but is given off at the moment of the solidification of the metal, a circumstance which produces the peculiar frosted or arborescent appearance common to masses of the pure metal. The presence of a small percentage of copper prevents the absorption of oxygen. According to Lampadius and Depretz, silver gives of vapor at very high temperatures. The presence of a small quantity of arsenic greatly increases the ease with which it is volatilized.

Silver alloys readily with nearly all the metals, but their use in the arts is limited to a few employed in the decorative arts and in coinage. Next to copper, it is the most readily deposited on other metals by galvanic action, hence it is used in great quantities for electro-plating. Like gold it was known to the ancients, who used it for coinage and for ornament.

Bismuth melts at about 518° F. It is but slightly oxidized by contact with air, if strongly heated, it burns with a bluish flame; at a high temperature it volatilizes freely. Its princial use in the arts is for the production of the so-called "fusible alloys," above spoken of. These are compounds of lead, tin and bismuth, in varying proportions. Several of these melt below the boiling point of water.

Copper melts at about 2100° F. It is very ductile, malleable and tenacious; at very high temperatures it is slightly volatile; it is unaffected by dry air, but in the damp becomes coated with an adherent green crust. When exposed at a red heat to the air, it is rapidly oxidized, and becomes encrusted by a black scale. At a high temperature copper burns with a green flame. Its uses in the arts and manufactures are too well known to need repetition here. Its principal alloys are brass, bronze and German silver.

Nickel is somewhat less fusible than pure iron: this would put its melting point at about 3000° F. Like iron, it is capable of becoming magnetic, but loses this property at temperture above 660°F. Though combining readily with oxygen, it is only slightly oxidized when highly heated. Its most important alloy is that with copper, called German silver. Of late it has come into very general use for electro-plating miscellaneous objects of every description.

Cadmium melts at about 500° F. It is commonly associated with ores of zinc, and being a very volatile metal, distills off when zinc ores are roasted.

Manganese has a high melting point, but fuses when exposed to the heat of a good wind furnace. It has a strong attraction for oxygen, and will even take it from water at a low temperature. A variety of bronze containing manganese is highly esteemed.

Iron, intrinsically the most important of the metals, fuses at temperatures dependent on its purity. When containing carbon, or in the condition of cast iron, it melts at 2786° Fah., but when pure, or in the condition of wrought iron, a temperature of 3280° Fah. is necessary to melt it. Iron softens before melting, and possesses in a marked degree the property of welding. It has powerful affinities for oxygen, taking it from the air when moist, a circumstance which explains the fact that it is seldom found in a pure or metallic state, except in meteorites. Dry air at ordinary temperatures does not affect it, but when heated to redness it absorbs oxygen and becomes coated with a scale of black oxide. When in a finely divided state, the metal burns while falling through the air; and even in the condition of ordinary fillings it burns with brilliant scintillations when thrown into a fire or the flame of an ordinary gaslight.

Tin melts at a temperature of 455° Fah. It is not acted on to any great extent by air or water. When exposed to a temperature somewhat above its melting point, it absorbs oxygen greedily, and is then converted into a whitish oxide, known technically as putty powder. Tin alloys with nearly every known metal. A large proportion of the tin of commerce is consumed in the production of tin plates for roofing, and the production of tin utensils, cans, etc. Other uses are for the production of solders, and it forms one of the constituents of bronze and Britannia metal.

Zinc melts at about 770° Fah. It undergoes a series of remarkable changes under the influence of heat. At ordinary temperatures it is comparatively brittle; between 250° and 300° Fah. it is quite malleable, and in this state may be readily rolled or beaten into into sheets which have the valuable property of retaining their malleability when cold. The brittleness of the metal at ordinary temperatures is doubtless to be attributed to its crystalline structure, which is probably effaced during the operation of rolling at higher temperatures. At 400° Fah. zinc becomes so extremely brittle that it may be readily powdered. Zinc is very volatile at a bright red heat, and in the presence of air burns with a bluish-green flame. Brass is the most important alloy. It amalgamates readily with iron, and articles thus coated are know as "galvanized" —a misleading term.

Antimony melts at about 900° Fah. It is quite stable in the air, and so brittle that it can be readily pulverized. Its principal use in the arts is for the manufacture of type-metal.

Mercury (or quicksilver) is the only metal (except the exceedly rare metal, gallium) that is fluid at ordinary temperatures. It boils at 660° Fah. It amalgamates freely with gold. silver, copper, zinc and tin, but only sparingly with iron. Its chief uses are, for coating mirrors, in the manufacture of barometers and thermometers, and in amalgamating with gold in the production of that metal.—*Boston Journal of Commerce.*

ILLITERATES.

A census of the illiterates in the various countries of the world, recently published in the *Statistische Monatschrift*, places the three Sclavic states of Roumania, Servia, and Russia at the head of the list, with about 80 per cent of the population unable to read and write. Of the Latin-speaking races, Spain heads the list with 63 per cent, followed by Italy with 48 per cent, France and Belgium having about 15 per cent. The illiterates in Hungary number 43 per cent, in Austria 39, and in Ireland 21. In England we find 13 per cent, Holland 10 per cent, United States (white population) 8 per cent, and Scotland 7 per cent, unable to read and write. When we come to to the purely Teutonic states, we find a marked reduction in the percentage of illiterates. The highest is in Switzerland, 2·5, in the whole German Empire it is 1 per cent; in Sweden, Denmark, Bavaria, Baden, and Wurtemberg there is practically no one who cannot read and write.

To stain brick red, melt one ounce of glue in a gallon of water; then add a piece of alum as large as an egg, one-half pound of Venetian red and one pound of Spanish brown; redness or darkness is increased by using more red or brown. For coloring black, heat the brick and dip in fluid asphaltum or in hot linseed oil and asphalt.

A FEW HINTS FOR PAINTERS.

STAINING WOOD (Mahogany).—To stain wood, mahogany, take logwood and boil until you have a strong decoction. When cold, add some apple cider vinegar, say one-third of the quantity required. A simple application to the wood will give a good imitation, but if a fine job of staining is required, have some burnt umber mixed with just enough glue to bind or fasten the colour on the wood, being careful not to put on any more than just enough to accomplish that, as too much glue will spoil the next operation, and make the whole job a botch. Try it on a piece of wood first, and if after this umber is dry the wood takes the stain of logwood, it is right; if it does not absorb quickly, then it has too much glue in it. Mucilage is a little more expensive, but I prefer it to glue, using it in the same manner. When this is applied, or while wet, wipe with a rag; when dry, stain the wood very freely with the logwood, using a sponge or rag to wipe out what the wood does not take, but do not rub so strongly as to work up the umber. Then shellac and varnish, or polish, as the case may be. The idea of the umber treated in this manner, is to have it enter the grain of the wood, and lines seen through the logwood staining show the darker shades, the same as the natural wood.

CHERRY WOOD.—Take common yellow ochre, getting the dark shade. Break it in water, add a little stale beer, and stain the wood with this for the first coat. Sandpaper lightly, to cut where the grain may have rises, then have some good red lake, ground in distemper for common work, but for better work in turpentine only, and add a few spoonfuls of drying japan, according to the quantity to be used, merely to bind it to the wood, and no more, wiping away all surplus, then shellac and varnish or oil. If you need something very fine, use a common grade of Munich lake. This will make the cherry now being used so extensively on furniture and house trimmings. Try it and you will like its richness, especially when polished.

POLISHING WOOD (Varnish Polishing).—To polish wood is to give it a smooth glossy surface, and at the same time show all the beauty of the grain. It is an old art, and was used long before high-gloss varnishes came into common use. At first these varnishes were very expensive, and therefore common material was used, and by friction a high gloss was secured. Then the material or varnish used was not of such a high grade as to retain a gloss as long as polish would, and so, even for fine furniture and fine house-ornamenting, polishing was resorted to, and it is still done to this day on a great many articles where the wood is to be finished in the natural state, and for all fine articles, made of expensive wood, that are handled much, such as musical instruments, fine furniture, house-furnishing ornaments, and rich wood decorations for interiors.

There are two kinds of polishing—varnish polishing and French polish. Varnish polishing is used for pianos and furniture with large surfaces, and is done in the following manner:—Take common corn starch, mix with turpentine and a little drying brown japan, and add any pigment to give it the colour of the wood to be filled. This can either be mixed thin enough to be spread and rubbed into the grain of the wood, or made into a paste and spread with a broad putty knife. When this is dry, sandpaper, holding the paper evenly on, or under a block, and do it just enough to let the substance remain in the cells or grain of the wood, and take off the surplus. If a common job, or one that is not extra, two coats of polishing varnish can be applied after this, but if a first-class job is to be done, lay on a very heavy coat of scraping varnish. This can be bought already prepared, and will dry hard in about a week or ten days. Now, with a well-sharpened steel scraper proceed to take off all this scraping varnish. You must start at one corner and proceed carefully, not cutting into the wood, but only the varnish. It is not a very hard job, as the varnish is prepared on purpose for this operation. Rub all over lightly with fine sandpaper, say No. ½, and clean and dust off. Over this give two coats of the best polishing varnish. Put away for at least a week or ten days, and longer if possible.

Next rub with fine pulverized pumice-stone and water, until a smooth level surface has been secured, but you must be careful not to cut into the wood. Clean off with sponge and water, and dry with chamois skin. Then rub very evenly with sweet oil and woollen cloths and rotten stone. When all the surface seems to have a little gloss and no scratches wipe with soft rags until all the oil and stone is cleaned off. Now take a piece of silk, and spreading some clean sifted wheat flour, rub strongly until you have a fine polished surface. The flour absorbs all the oil, and where the work is handled it does not leave a mark that a light rub of the palm of the hand will not take off.

GRINDSTONES.

A correspondent of an Eastern paper gives a description of a visit to the Bay of Fundy and along the shores, where the grindstone quarries are located. The superintendent of the quarry says when the tide is out his men go down at the rocky shore and work out near the water. At low tide the men on the shore drill some holes in the ledge, put in powder, and blast out great pieces of rock. When the tide rises again they float out big logs and empty-barrels over where the loosened rocks are. When the water goes down again they fasten a big rock to the raft with heavy chains, so when the tide again rises it lifts up the raft and the rock with it. Then they tow it as near shore as they can. If it is the right kind and size for a millstone, sometimes it is allowed to lie there until the workmen, with stone-chisel and hammer, work it into the proper shape. At other times, by means of a derrick, it is drawn out on the wharf. Then it is rolled on a track and hauled to the factory.

At the great stone factory the large piece of rock is placed on a carriage, and with a saw similar to the up and down saw in a mill, the rock is sawed into great slabs of the right thickness of the grindstone. The saw does not have teeth, but wears its way through the rock with the aid of sand and water, which are continually pouring on. Then the slabs are taken, a hole made in the centre, the edges trimmed off with a chisel, and the whole placed on a kind of lathe, turning it until it is true and the edge smooth. The rock from which the grindstones are made is a kind of sandstone, and there is a great difference in the "grit," some being coarse and some fine. Often several different degrees of "grit" are found in the same quarry. There are many quarries along the Bay of Fundy. The reason stone is taken from under the water, when there are many quarries a little distance from the shore, is because the best stone comes from the bottom of the bay, where it is covered at high tide.

TO REMOVE STAINS FROM MARBLE.—An equal quantity of fresh spirits of vitriol and lemon juice will remove stains from statuary marble. Put in a bottle and shake up well, wet the spots with the mixture, and in a few minutes rub with a soft linen cloth till they disappear.

PETROLEUM AS A MEDICINE.

It is a matter of surprise that the medical profession has not given more investigation and publicity to the virtues of native petroleum as a remedial agent in many diseases. Common coal oil has cured many acute cases of inflammatory rheumatism, just by rubbing it on the parts affected. Incipient consumption has been cured by taking the *native* petroleum internally. The writer knows of one case where the disease was so far advanced that the voice had lost power to speak above a whisper, and his voice was fully recovered, and his body was restored from its emaciation. The oil he used was pure native West Virginia natural oil of 29° gravity—a lubricating grade. He used about one gallon in doses of a teaspoonful, and was restored to robust health. It has also proved beneficial in dyspepsia. The oil-well borers are constant tasters of crude oil, and say it gives them perfect digestion and operates as a mild laxative.

Care must be exercised in procuring the right quality. Pure native petroleum of a gravity of 29° to 30° is the proper kind to use, and it cannot be obtained short of West Virginia. All the oils in market called "West Virginia" are manufactured in the still and are unfit for internal use. California oil contains asphaltum, and is unfit to use.

Dr. Blache states in the *Bulletin de Therapeutique*, that a refiner of petroleum, having been prohibited by a prefet the distribution of petroleum in medicinal doses, the fact led to an inquiry being made as to its alleged utility in affections of the chest. The native petroleum from Pennsylvania and Virginia was that experimented upon first. It is a very safe substance, for even large quantities, when drank by error; and in such cases has caused only a little nausea. In chronic bronchitis, with abundant expectoration, it rapidly diminishes the amount of the secretion and the paroxysms of coughing, and in simple bronchitis rapid amelioration has been obtained. Its employment in phthisis has been continued for too short a time as yet to allow of any opinion being delivered as to its efficacy, beyond that it diminishes the expectoration, which also loses its purulent character. The petroleum is popularly taken in doses of a teaspoonful before each meal, and after the first day any nausea, which it may excite in some persons, disappears. M. Gardy, a Paris druggist, has prepared capsules, each containing 25 centigrammes of petroleum, or, as he calls it, *huile de Gabion* from the name of an ancient petroleum spring, and this Dr. Blache considers as the most favorable mode of administering it.—*Exchange.*

The *Lancet* (London), raises its voice of warning to apartment house occupants, which is worth considering. An ordinary householder has access to every portion of the building in which he lives, and should he suspect a defect, he can ascertain how far his suspicion is correct, and remedy it. But in the case of flats, while the actual apartments rented may be free from all risk of evil, the tenant is, in point of health, almost entirely at the mercy of his landlord and of the occupiers of the basement, in so far as the main drainage of the premises is concerned. If this latter be wrong, the whole mansion is apt to be filled with foul air from below upward. A number of cases have come under our notice in which very serious ill health has been thus induced, and in which tenants have only been too glad to pay what was demanded of them in order to get out of the premises with the least possible delay. While no one should take a residence without skilled advice as to its sanitary state, this precaution is more than ever necessary in the case of flats, where the entire premises, including, above all things, the basement, should be thoroughly overhauled.

AN OIL ROCKET.

Results of the scientific test of an oil rocket designed to calm the raging of a troubled sea, appear to have been satisfactory enough to warrant the hope that shipwrecks will be rare occurrences ere many years. Four rockets, the same in appearance as those commonly used in ordinary pyrotechnical displays, but with the exploding cap removed and a light tin cylinder holding one pound of train oil substituted, were sent up at varying angles of projection, the result being that the sea was calmed for thousands of feet around the spot above which they exploded and fell. The oil spread into a thin, silk-like sheet, which, extending rapidly, appeared to have the power of keeping the waves within peaceable limits. Through the centre of the oil runs a small tube containing two ounces of gunpowder, which ignites as soon as the motive power of the rocket is spent, and, exploding, scatters the oil in a fine spray over the water. The action of the oil upon the water is almost instantaneous.—*Manufacturer and Builder.*

HOW IT WAS SETTLED.—The question as to whether the upper part of the wheel of a vehicle in motion travels faster than the lower part has been settled by instantaneous photography, in experiments made by S. W. Gardner. Mr. Gardner takes the photograph of an omnibus *en route*, and in this photograph, while the lower ends of the spokes immediately adjacent to the ground are not perceptibly unsharpened by the motion, the tops of the upper spokes show an angular motion corresponding to about 10 degrees. The photograph most successfully expresses the fact that the wheel it represents is in rapid motion.—*Exchange.*

THE DISCOVERY OF THE MICROSCOPE.—M. Govi, an Italian savant, has presented a paper to the French Academy of Sciences, in which he claims for Galileo the distinction of having discovered the microscope as well as the telescope. He has found a book, printed in 1610, according to which Galileo had already directed his tube fitted with lenses to the observation of small near subjects. The philosopher himself stated shortly after this date that he had been able to observe through the lens the movements of minute animals and their organs of sense. In a letter written in 1614 to a Signor Tarde he states that he has with his microscope "seen and observed flies as large as sheep, and how their bodies were covered with hairs, and they had sharp claws." The date usually assigned to the discovery of the microscope is 1621, and the invention is attributed to Cornelius Drebble, a Dutchman; but, according to M. Govi, the date must be thrown back 11 years, and the credit of the first construction awarded to Galileo.—*London Standard.*

INDIAN INK.

I find that a color apparently identical to Indian ink can be produced by the action of sulphuric acid on camphor.

An excess of camphor should remain some twenty-four hours in strong sulphuric acid; it then results in a gelatinous mass of a slightly reddish color. This, when heated, effervesces, gives off fumes of sulphurous acid, and turns intensely black. By evaporation the superfluous sulphuric acid and camphor (for there remains an excess of both, the weakened acid not acting on the cam hor) can be driven off. The remainder when applied to paper as a paint appears, to my unartistic eye, to be Indian ink.

When dissolved in water, it remains an indefinite time without precipitating. It appears to be dissolved, not held in suspension.—B. PIFFARD in *Chemical News.*