650 per minute. In continuous automatic rapid firing the gun would last for 50,000 rounds at the rate of 600 per minute. In the heavier guns the barrel is cooled by water, but this is not feasible in the light infantry gun. Of course this high rate of speed in the light guns could not be kept up for any great length of time without renewing some of the parts. The gun is entirely automatic in its action after the first shot has been fired. The recoil from the exploded cartridge gives the barrel, which has a rear attachment, a backward motion. The recoiling motion is limited to about an inch, as a crank comes in contact with the breech casing, causing it to rotate and strike a buffer spring which returns it into firing position. A crank also works the breech lock. The cartridges are fed into the gun by means of the belt which passes through feed blocks. The recoil of the barrel from the discharge of the first cartridge inserts the next charge from the belt, raises the breech lock, cocks the hammer and fires, extracts and ejects the shells while the succeeding charge is being brought into position.

The test began by general firing at a flag 500 yards distant, the test being for rapidity and not accuracy. Single and bunch shots were made and then a volley of 50 shots were made in $\frac{5}{8}$ seconds. The expert was the only person who could make the gun fire one shot and stop. The next test was to determine the time necessary to unlimber the gun and get it into action. In less than 58 seconds from the giving of the word of command the expert had the gun in position and was firing at the rate of 500 shots per minute. The report from the gun is neither very loud nor very sharp, but when a number of shots are fired in rapid succession the noise is continuous and even the members of the Ordnance Board found it necessary to put cotton in their ears. The next test was to determine the time required to take apart the firing mechanism and insert the extra set carried in a knapsack. It was found to be $26\frac{1}{2}$ seconds. Changing the barrel between two shots took 1 minute $12\frac{1}{2}$ seconds. The other tests were made with blank cartridges and with good cartridges mixed with bad ones. The object of this was to determine whether the gun would eject the bad cartridges and prevent them from stopping the firing. The turning of a small lever quickly removed the dead cartridge and the firing was not disturbed. In a few days the gun will be tested for accuracy, speed and range.

The gun will prove of special value in a mountainous country, where a few guns well placed would wipe out an army. One hundred men armed with the gun could mow down ten thousand cavalymen with ease. The possibilities of the machine seem unlimited and its effectiveness is well summed up by a military man who witnessed the test. "It is the most deadly instrument of war I have ever seen. I have been told it was only a toy, whereas the accuracy and reliability are simply appalling." Each bullet will pierce the body of six men and its muzzle can be moved like the end of a garden hose.

THE REDUCTION OF THE RARER METALS FROM THEIR OXIDES.*

By Professor W. C. ROBERTS-AUSTEN, C.B., F.R.S.

MY communication can hardly be dignified by the name of a paper, but I thought, as the question of the reduction of the rarer metals from their oxides was one which was assuming very great importance, that it might interest the members of the society if I briefly showed them the methods by which this reduction can be effected.

When a metal is separated from a state of chemical combination it is said to be "reduced," and the process of separation is termed "reduction." For centuries the main agent employed for this purpose was either carbon or the gas carbonic oxide which is produced by its partial oxidation of carbon. Carbon has been used for the reduction of metallic oxides from times of which we have no written history, but the early metallurgists also availed themselves of a complex series of reactions which take place when metallic oxides are heated with metallic sulphides, without, however, understanding the nature of the mutual action of these substances on each other. Copper, for instance, must have been so separated from its ores without the direct action of carbon as a reducing agent from very early times, but carbon is still the agent by which reduction is effected in that vast metallurgical appliance, the blast furnace, used for smelting iron.

There are, however, many metallic oxides which will not part with their oxygen to either carbon or carbonic oxide. Alumina is an instance; its reduction by carbon can only be effected at a very high temperature, aided by the tearing effect of the electric current.

At the very high temperatures at which carbon may be vaporized, some 3,600° C., the reducing action of carbon vapor is probably energetic.

The history of the gradual introduction of other reducing agents is very interesting, but it will only be incidentally touched upon in order to make the nature of modern operations clearer than it otherwise would be.

At the beginning of the century, it became evident that metals might be used at high temperatures as reducing agents. Thus, in 1809, Davy, Gay-Lussac, and Thenard obtained the metals of the alkalies, and it was soon found that metallic potassium and sodium was a powerful weapon for separating oxygen from other metals. It often happened that the chloride was operated upon with the alkali metal; thus Berzelius obtained the metal yttrium, in the form of a gray powder, by heating its chloride with potassium.

Thus to take an important case, Wohler obtained metallic aluminum in 1822 as a gray powder by the action of potassium on aluminum chloride; and he afterward, in 1854, obtained it as a white, compact metal, unoxidizable in air, and acted on with difficulty by acids.

Mosander (1839) obtained metallic lanthanum and cerium by heating their chlorides with potassium and sodium respectively. Marignac was the first to prepare metallic didymium by heating its chloride with potassium. Or, to take another case: Wohler obtained crystalline chromium by igniting a mixture of anhydrous chromic chloride with finely divided zinc and sodium and potassium at the boiling point of zinc.

Freymy also prepared crystalline chromium by the action of the vapor of sodium on anhydrous chromic chloride in a stream of hydrogen. Uranium is another metal which was separated by the aid of sodium; for, in 1841, Peligot ignited oxide of uranium UO_2 with charcoal in a stream of chlorine. He thus obtained volatile uranium tetrachloride, UCl_4 , which, when heated with sodium, gave metallic uranium as a gray metal.

In 1863, indium was discovered in the Freiberg zinc blendes by Reich and Richter. It is best prepared by fusing the oxide with sodium as Winkler describes (Journ. Pract. Chem., cii, 273).

I hope at an early day to find time to deal fully with the history of the use of certain metals for the reduction of the oxides of the rarer metals; at present I would only refer to a very interesting paper by H. F. Keller,* who points out that Beketoff used aluminum for the reduction of potassium hydroxide. There can be no question that the cheapening of magnesium and aluminum will have a great influence in metallurgical operations conducted with a view to the extraction of the rarer metals from their oxides, and, as Keller states, Clemens Winkler, of Freiberg, has made a systematic investigation of the reducing action of magnesium upon oxides, while Seubert and Schnadt have conducted a similar investigation as to its action on chlorides.

Among the very early work in this direction on a practical scale must be mentioned that of Green and Wahl, whose patent is dated February 11, 1893 (No. 82). They obtained manganese and manganese alloys free from carbon, and this freedom from carbon is a point of the utmost importance. Manganese can be reduced from its oxides by the action of carbon and carbonic oxide, but the manganese so obtained always contains carbon, and when it becomes a question of the addition of manganese to a bath of molten steel, the simultaneous introduction of carbon may be a matter of great moment, as a few hundredths of one per cent. of carbon, in certain varieties of steel, is not to be lightly considered.

At a soiree of the Royal Society last year, Mr. Vautin exhibited some very interesting specimens of the rarer metals, which, aided by Mr. Picard, he had himself extracted mainly from their oxides by the use of finely divided aluminum—granulated aluminum, that is—which is obtained by vigorously stirring molten aluminum, while it is passing from the fluid to the solid state. Many of the specimens obtained by Mr. Vautin are exhibited to-night. I have obtained certain other specimens, and have employed them in the course of a recently conducted research.

There are certain experiments connected with the reduction of oxides by aluminum which it may interest you to see. I will therefore describe them.

In this little furnace there is a small crucible, which contains oxide of chromium and aluminum. The temperature is being raised to a point which we have very carefully measured; it is 1,015° C. I might have arranged the experiment with a thermo junction plunged into the mixed mass of aluminum and oxide of chromium, and you would have seen that as soon as a temperature of 1,015° is reached, the aluminum reacts on the metallic chromium. You will see a slight evolution of heat, light and smoke, and left behind in the crucible will be a little button of chromium. The reaction takes place comparatively quietly, but I think you will be able to see it. It requires a certain initial temperature for the aluminum to act on the oxide of chromium, and in this case that temperature is 1,015°.

[The reaction took place quietly, but a shower of sparks was projected from the crucible.]

We will break open the crucible presently, and there will be a little button of chromium left behind.

Now I will perform another experiment. I will take a little oxide of lead and metallic aluminum. Oxide of lead is very easily reduced; oxide of chromium is very difficult to reduce, as you have already seen. Oxide of lead in two minutes will be reduced with something approaching explosion. It is not at all an easy experiment to arrange, in fact it is very difficult; if you make the charge too large, you will blow the furnace to atoms, as we have done on many occasions. The difficulty is to produce a sufficient effect to satisfy you, perfectly free from any risk of danger [explosion took place like a rifle shot], and I am glad to say we have succeeded. The thermal conditions are all in our favor in this experiment; the aluminum reacts with great readiness on oxide of lead, and resents having so easy a task to perform, and expresses itself in a loud manner.

If you take, instead of oxide of lead, litharge which has been melted and ground up, the reaction is smaller, and explodes very much like a squib. When it is a case of a very difficult reducible oxide, the reaction takes place in a much more gentle manner. You may have variations from violent explosions, which will shiver the furnace, to the slow, gradual action of some of the more difficult oxidizable materials.

I now come to another totally different method of obtaining the rarer metals from their oxides, and the development of this method we owe to the distinguished French chemist, M. Moissan. He has pointed out that metallurgists have recently employed currents of high tension for the electrolysis of metallic compounds. The new method of preparing aluminum and magnesium are cases in point. The heat furnished by the electric arc can, moreover, be used in the reduction by carbon of certain oxides which have hitherto been considered to be irreducible. The great merit of Moissan's work consists in the fact that he has separated the heat action of the arc from the electrolytic action. He makes the heat reverberate on to the substance to be reduced, and by the use of currents of 400 amperes and 60 volts, he has given us a remarkable series of metals, usually, however, associated with carbon.

You almost always get carbides of the metals by this method. By placing oxide of uranium U_2O_3 in the electrical furnace, and passing a current of 450 amperes and 60 volts, Moissan obtained uranium containing 5 to 13 per cent. of carbon. From oxide of manganese, using 300 amperes and 60 volts, he obtained carbides of manganese containing 6 to 14 per cent. of carbon.

From chromium oxide Cr_2O_3 , using 350 amperes or 50 volts, or even less, he obtained carbides of chromium

containing 8.6 to 12.85 per cent. of carbon. Zircon, when treated in the electrical furnace, using 360 amperes and 60 volts, yields either carbon, free zirconium or a carbide containing 4 to 5 per cent. of carbon, according to whether you take a small or a large supply of zircon to reduce. Again, tungsten from tungsten acid, using 350 amperes and 70 volts, you get either carbon, free tungsten or carbides, with it may be as much as 18 per cent. of carbon; but you can easily get tungsten carbon free by melting the carbide with excess of oxide.

Molybdenum is obtained by calcining molybdate of ammonia, using 350 amperes and 70 volts; you get a very hard carbide, containing about 9.88 per cent. of carbon. Oxide of vanadium is obtained by calcining a salt of vanadium. You get carbides rich in carbon, containing 17 to 25 per cent. of carbon. In that way he has given us practically all the rare metals.

I cannot do better than project on the screen the interior of the furnace, not, however, using it for the reduction of metallic oxides, because if I did that, you would practically see nothing unless you waited for some twenty minutes. I prefer to melt up some chromium, and we will project the image of the fluid mass on the screen. Chromium is a very difficult thing to melt. Over a hole in the cover of the furnace is a mirror, and a lens so arranged that the light coming up will be reflected on the mirror and thrown on the screen. You now see the poles and the base of the furnace. You are looking down into the furnace as if you were standing over it. The chromium is hanging a little to the side, but it will gradually melt down. The arc is not passing straight from pole to pole, but is deflected down by a magnet.

You can measure the temperature in this way, by detaching a piece of the carbon pole and dropping it quickly in water. You thus find out how much heat is transferred to the water and in that way you can estimate the temperature. Subsequently you can so determine the temperature which has been attained in the furnace itself. Speaking from previous results, I know the temperature in the furnace before you now cannot be less than 2,500° C., and probably it is a little higher.

I will now melt some wrought iron nails, which you will see will run down very soon.

[The experiment was then performed.]

I was right in insisting upon the fact that I have not dignified this brief communication by the title of a "Paper," but the experiments are so very beautiful that I could not refrain from showing them to the members.

Of the uses of the metals, now that we have them, it is impossible to say very much, but I need only to remind you of the extraordinary importance in armor plates and projectiles of the introduction of the metal chromium or nickel in small quantities to show that these must have an important future. With apologies for the brevity of this communication, that is my case.

DISCUSSION.

Mr. C. T. J. Vautin said he was glad of the opportunity of referring to the reduction of oxides by means of heat generated by electric energy, and could not do so without referring to Siemens. Siemens, as was stated in every text book, had described an electric furnace in which one pole was at the bottom and the other at the top, and with that furnace he witnessed in Melbourne, some ten years ago, the production of nearly every one of the carbides, or combinations of metals in carbon, which the illustrious French chemist Moissan had since produced. It was knowing what had been done in a quiet way by a gentleman who, he regretted to say, never published anything at all, Mr. Newbury, with whom he was fortunate in being associated, and after Mr. Moissan started his work he determined himself, if possible, to try and produce some of the metals free from carbon. These results were obtained to a great extent in consequence of being able to obtain aluminum in a finely divided form, and this was only done after several mechanical means had been tried and failed.

It was through Mr. Pickard's energy and research that they were able to obtain aluminum in a form most suited for reduction. So far as chromium was concerned, very large quantities were now being daily produced in Germany, as much as 4 or 5 cwt. at one casting, containing as little as $\frac{1}{4}$ per cent. of aluminum and not $\frac{1}{2}$ per cent. of silicon. It was hoped that even that small quantity of silicon would be reduced by getting purer magnesia to work with. They were now producing alloys of calcium and iron containing 26 per cent. of calcium; and with these alloys experiments were being made for the purpose of desulphurizing iron; and from results which had been communicated to him, though not from his own experiments, he believed there might be some commercial application for such an alloy.

Referring once more to the splendid work of M. Moissan, he had the pleasure in Paris of looking at a number of his products, and the only thing which struck him there as being against the electrolytic method was its great cost as compared with the method of reduction by means of aluminum, which could now be obtained at as low a price as 3 marks per kilo—upward of 99 per cent. as it was produced at the Nordhausen works. Aluminum reduced with the greatest ease sodic oxide, calcic oxide and barium oxide. On the other hand, by no method he had heard of could they induce sodium to reduce alumina, and he thought it was doubtful whether potassium reduced alumina *per se*. On the other hand, the oxides of potassium and sodium could be reduced with the greatest ease by means of aluminum. There were some curious facts in connection with these reductions which were hardly fitted for that evening's discussion, but he hoped to have an opportunity some other time of bringing them forward.

Mr. Roger Wallace said he should like to say a few words in praise of the work that Mr. Roberts-Austen had been doing in connection with the rarer metals. The new use which had been pointed out for aluminum, in the reduction of other metals, was a factor of very great importance in the future of metallurgy.

With regard to the manufacture of aluminum in this country, he was pleased to say that the British Aluminum Company were now about to place this industry in

* Read before the Society of Arts, London, May, 1895.—From the Journal of the Society.

* Journal of the American Chemical Society, Dec., 1874, p. 883

its proper position, as far as Great Britain was concerned.

In the past, aluminum had been manufactured in this country by the chemical processes, but those processes had been altogether surpassed by the electrical process. The last he heard of chemical processes was when Mr. Vautin had produced, with very great industry and research, a sulphide of aluminum. He hoped for great things from that, but up to the present, he had not heard that Mr. Vautin had been able to reduce that sulphide. The company he had mentioned would soon be able to manufacture aluminum in Great Britain in the same way as it was produced in Nordhausen, and probably better, because, having the bauxite mines in Ireland and water power in Scotland, they would have every natural facility for success. In fact, they would be giving a new industry to Scotland, and also to Ireland, in the manufacture of aluminum from bauxite. He was glad to hear that Professor Roberts-Austen had a new use for aluminum, and felt that this furnace had a great future before it. Every one who had to do with chemistry knew that there was a very large future in the application of metals which, up to the present, had hardly been used at all. They saw it in the incandescent gas lighting, and in alloys of various metals, and this last use would probably be of very great importance. They knew that one of the great drawbacks to the use of aluminum had been its want of tensile strength, but there was little doubt that the addition of a very small percentage of some of these rarer metals, which had hitherto been beyond practical use, would enormously increase its tensile strength.

Professor Roberts-Austen said he had not specially dealt with all the beautiful specimens on the table, but had only taken up two at random, the magnificent mass of manganese carbon free and the equally fine fragment of a larger mass of chromium which he handed to the chairman as perhaps the most remarkable metallurgical specimen he had ever seen, both of which were produced by Mr. Vautin. On the table were also carbon-free tungsten, the only mass he had ever seen, uranium and some molybdenum which Mr. Pickard produced at the mint with him. There could be no question that a most important field was opening, and the cheapening of aluminum, to which Mr. Wallace referred, could not fail to play a most important part in metallurgy, by enabling them to get these rarer metals, and to add them to masses of their common associates, the effect of which was, in many cases, most remarkable. For instance, take the case of titanium, that would be most useful.

When the naval architects met in that room very recently, reference was made to the difficulty in the use of aluminum for torpedo boats on account of the boats corroding on the line between wind and water. He knew an instance where a yacht was built for a French proprietor who was very well pleased with it until he moored it, with an iron chain to an iron post, to which post was also moored a boat sheathed with copper. The result was that a gigantic battery was established, and the aluminum yacht was found to be dissolving away.

The addition of 0.2 per cent. of titanium increased the durability of such a metal as aluminum when subject to the solvent action of salt water. It was impossible to say what might happen when they had studied the properties of alloys containing minute quantities of the rarer metals. He hardly dared mention their uses in connection with electricity; "platinoid" and "manganive" had already attracted attention, and it was impossible to say what valuable results might be obtained.

THE CHILEAN HALL OF CONGRESS.

A TELEGRAM from Santiago announces that the Chilean Hall of Congress in the capital was totally destroyed by fire on May 18, the disaster being attributed to incendiarism. Santiago, the "city of rich people," as it is called on the west coast of South America, is famous for its fine streets and handsome public buildings. A third of a century ago (writes a correspondent) the church of the "Compania de Jesus," situated at the back of the cathedral, caught fire while mass was

THE CHILEAN CONGRESS HALL AT SANTIAGO, WHICH HAS BEEN TOTALLY DESTROYED BY FIRE.

being celebrated, and about 2,000 ladies lost their lives. The behavior of the priests on this occasion is said to have given the death blow to priestcraft in Chile. The church was not allowed to be rebuilt, but on its site was erected a hall for the Chilean Legislative Assembly, a building some 60 ft. in height and 300 ft. in length. It was profusely adorned with marble in its three large halls, one of which was used as the Chamber of Deputies, another as the Chamber of Senators, and the third for swearing in the president of the republic. One portion of the building was used as

offices for the engineers of the Public Works Department.—London Daily Graphic.

A NEW METHOD OF COMPUTING.

By E. W. SCRIPTURE, Yale University.

SUPPOSE that you have measured the heights of a group of twenty-five men, what do you do with the results, which vary, more or less, from one another? Let us take a case that occurs all over the country every year. Each graduating class of every college and school has the heights of its members measured. For the sake of comparison with preceding and succeeding classes, the individual heights are generally "averaged." Thus the "average" height of the class of '93 is said to have been, say, 66 inches, that of '94, 67 inches, etc.

But a great deal of dissatisfaction arises with this "average" height. The presence of a single very tall or very short man upsets the whole result.

Let us take a class of ten men, of the heights 65, 64, 65, 66, 66, 67, 65, 66, 76, 66, the average height is 67 inches.

Now let us take another class, with the heights 66, 65, 68, 67, 69, 68, 66, 67, 66, 67. Every man is taller by an inch than the corresponding man in the previous class, but there is no extraordinarily tall man there. Yet the average is 66.9, or a little less than that of the other class.

Now it is evident that the one very tall man ought

not to outweigh the influence of the other nine men. It is apparent that the average is a very unsatisfactory representative value in such a case.

What is especially striking is that every man influences the result in direct proportion to his deviation from the average. For example, in the first class the man of 65 inches influences the average by the amount

$\frac{67-65}{10} = 0.2$ of an inch, while the tall man influences it by $\frac{76-67}{10} = 0.9$ of an inch. This does not seem quite fair.

This difficulty and unfairness can be removed by treating every man alike, by allowing all measurements to affect the result to the same degree. This is done by the use of the median instead of the average.

The median was first considered as a representative value by Laplace, who treated some of its properties from a theoretical point of view. Fechner believed that it could be used for statistical purposes. He explained a crude method of computing it. But aside from a few isolated attempts, mainly as curiosities, the median was never practically used in computation until I introduced it into my laboratory in the year 1893. During the year 1894 fully 100,000 measurements of the most varied kinds were adjusted on the basis of the median in place of or in addition to the average.

On the strength of this experience I have published (Studies from the Yale Psychological Laboratory, Vol. II) an analytical and practical consideration of the median and its properties.

What is the median? It is the middle value in a set of numbers. Suppose the numbers to be arranged in order of size; then, beginning at the smallest or at the largest, count them off until you come to the middle one. For example, the first class mentioned above would run 64, 65, 65, 66, 66, 66, 67, 67, 68, 76. The middle value for ten measurements would be between the fifth and the sixth. In this case, both are the same and the median is 66.

How much influence does the tall man have? Merely that of one man; as long as he is above 66 inches, it makes no difference how tall he is. In like manner every value influences the median merely as one value above or below. As tall men or short men are added, the median goes up or down according to the number of men added, not according to the number of inches added.

For the second class we had 65, 66, 66, 66, 67, 67, 67, 68, 68, 69. The median is 67.

The median for n values is that one which is the

$\frac{n+1}{2}$

th in order of size from either extreme. For five

values it will be the third, for thirty the 15½th, etc. It is not necessary to write the values in order of size; they can generally be selected by the eye. For short sets of values the whole process can be done mentally.

Persons familiar with the science of measurement will realize the theoretical advantage of the value of middle probability, the median X_m , over the value of mean area, the average X_e , for all unsymmetrical curves of error (Fig. 1). When the curve is symmetrical, the median and the average are the same. The case is very striking when the integral curve of probability (Fig. 2) is considered. The values X_o and X_u are the over and under quartiles proposed by Galton for use instead of the mean variation in statistical measurements. Of the use of these values I do not approve.

Experience has shown that the median is a far better value than the average in all statistical and psychological measurements and in all measurements where psy-

chological factors come into play, e. g., in the so-called errors of observation of astronomical and physical measurements. Strangely enough such phenomena as the fluctuating price of corn or the varying records of the barometer are better represented by the median than by the average. Of course, in cases where the results are reckoned by the number of units and not by the number of things, e. g., meat by the pound, debts by the dollar, etc., the average is the proper value.

ELECTRIC CURRENTS.

PROF. GEORGE FORBES, F.R.S., delivered recently lectures at the Royal Institution on "Alternating and Interrupted Electric Currents." He said that in the course of the work in which he had been engaged during the past few years, he had had occasion to find some simple means of expression to convey to his own mind, as well as to the minds of others, clear ideas about more or less obscure electrical phenomena, and the analogies thus wrought out he intended to set forth in these lectures. Professor Dewar had told him that his listeners expected him to talk much of what he had been doing at Niagara. He was not responsible for that anticipation, and was sorry to disappoint them to a great extent, for he was going to speak more about the problems of submarine telegraphy, and in the experiments he intended to show had been assisted by several friends, more especially Mr. Swinton and Dr. Muirhead. Submarine telegraphy has hitherto been much wrapped up, he said, in the obscurity of mathematical symbols, and he hoped to make some of its more recondite phenomena intelligible to every one.

Professor Forbes then explained how a submarine cable has to be charged and discharged like a Leyden jar, the conducting wire forming the inner coating and the sea the outer coating. In early times electricity was spoken of as analogous to the flow of water through pipes, and in some respects an exceedingly good analogy it is. The pressure of the water symbolizes the electromotive force, and the friction of the pipe the resistance. The pressure may be supposed to be furnished by a centrifugal pump at the central station. Instead of using up the whole of the energy of the centrifugal pump in the pipe, we might have a very large pipe, with a little one at its farther end in which there is great friction, and that is analogous to the principle of electric lighting; or instead of a little pipe at the far end we may place a turbine there, and that would be analogous to an electro-motor to drive machinery.

There are, however, more obscure electrical phenomena to which the analogy of water flowing through pipes does not apply, and especially is this the case when alternating currents are used. In mechanics likewise we have obscure phenomena not easily explicable, as in those presented by the action of the gyrostaf, the principles of which it takes a considerable amount of thought to make clear. Again, suppose a revolving wheel, A, Fig. 1, to have an endless chain,

B, hanging on a groove in the circumference of the wheel, and turning with it, then let the loop of the chain be pressed at K out of the perpendicular and made to assume the form shown in the cut, it behaves like a rigid body, and when left to itself does not rapidly fall back into a perpendicular loop. No intelligent mechanic would have expected such a result beforehand, and still less would he have expected the following: A, Fig. 2 is a wheel of cardboard with a number of little weights fixed round it near its circumference. The wheel is made to revolve round its central axis, W. If now the top of the revolving wheel be bent over as at K, in the side view shown at B, Fig. 2, it will remain bent over so long as the wheel is driven at a particular rapidity, and a much greater speed has to be applied before it shows a tendency to assume the vertical.