of the chimney over the burning candle. It is exactly the same action, and caused by the very same substance that issued from the candle; and in this way we can get carbonic acid in great abundance—we have already nearly filled the jar. We also find that this gas is not merely contained in marble. Here is a vessel in which I have put some common whiting chalk, which has been washed in water, and deprived of its coarser particles, and so supplied to the plasterer as whiting. Here is a large jar containing this whiting and water, and I have here some strong sulphuric acid, which is the acid you might have to use if you were to make these experiments (only in using this acid with limestone, the body that is produed is an insoluble substance, whereas the muriatic acid produces a soluble substance that does not so much thicken the water). And you will seek out a reason why I take this kind of apparatus for the purpose of showing this experiment. I do it because you may repeat in a small way what I am about to do in a large one. You will have just the same kind of action, and I am evolving in this large jar carbonic acid exactly the same in its nature and properties as the gas which we obtained from the combustion of the candle in the atmosphere. And no matter how different the two methods by which we prepare this carbonic acid, you will see, when we get to the end of our subject, that it is all exactly the same, whether prepared in the one way or in the other.

We will now proceed to the next of our experiments with respect to this gas. What is its nature? Here is one of the vessels full, and we will try it as we have done so many other gases—by combustion. You see it is not combustible, nor does it support combustion. Neither, as we know, does it dissolve much in water, because we collect it over water very easily. Then you know that it has an effect and becomes white in contact with lime water, and when it does become white in that way, it becomes one of the constituents to make carbonate of lime or limestone.

Now, the next thing is to show you that it does dissolve a little in water, and therefore that it is unlike oxygen and hydrogen in that respect. I have here an apparatus by which we can produce this solution. In the lower part of this apparatus is marble and acid, and in the upper part cold water. The valves are so arranged that the gas can get from one to the other. I will set it in action now, and you see the gas bubbling up through the water, as it has been doing all night long, and by this time we shall find that we have this substance dissolved in the water. If I take a glass and draw off some of the water, I find that it tastes a little acid to the mouth; it is impregnated with carbonic acid; and if I now apply a little lime water to it, that will give us a test of its presence. This water will make the lime water turbid and white, which is the carbonic acid test.

Then it is a very weighty gas; it is heavier than the atmosphere. I have put their respective weights at the lower part of this table, along with, for comparison, the weights of the other gases we have been examining:—

	PINT.	CUBIC FOOT.
Hydrogen	$\frac{3}{4}$ grs.	$\frac{1}{12}$ oz.
Oxygen	$11\frac{9}{10}$	$1\frac{1}{3}$
Nitrogen	$10\frac{4}{10}$	$1\frac{1}{6}$
Air	$10\frac{7}{10}$	$1\frac{1}{5}$
Carbonic acid	$16\frac{1}{3}$	$1\frac{9}{10}$

A pint of it weighs $16\frac{1}{3}$ grains, and a cubic foot weighs $1\frac{9}{10}$ ounces, almost two ounces. You can see by many experiments that this is a heavy gas. Suppose I take a glass containing nothing else but air, and this vessel containing the carbonic acid; and suppose I pour a little of this gas into that glass, I wonder whether any has gone in or not; I cannot tell by the appearance, but I can in this way [introduces the taper]. Yes, there it is, you see; and if I were to examine it by lime water, I should find it in the same way. I will take this little bucket, and put it down into the well of carbonic acid—indeed we too often have real wells of carbonic acid—and now, if there is any carbonic acid I must have got to it by this time, and it will be in this bucket, which we will examine with a taper. There it is, you see; it is full of carbonic acid.

I have another experiment by which I will show you its weight. I have here a jar suspended at one end of a balance—it is now equipoised, but when I pour this carbonic acid into the jar on the one side, which now contains air, you will see it sink down at once, because of the carbonic acid that I pour into it. And now I examine this jar with the lighted taper. I

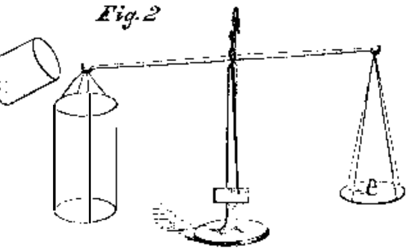


Fig. 2

will find that the carbonic acid has fallen into it, and it no longer has any power of supporting combustion. If I blow a soap bubble, which, of course, will be filled with air, and let it fall into this jar of carbonic acid, it will float. But I shall, first of all, take one of these little balloons filled with air. I am not exactly sure where the carbonic acid is; we will just try the depth, and see whereabouts is its level. There you see we have this bladder floating on the carbonic acid, and if I evolve some more of the carbonic acid, you will see the bladder lifted up higher. There it goes; the jar is nearly full, and now I will see whether I can blow a soap bubble on that and float it in the same way. [The lecturer here blew a soap bubble, and allowed it to fall into the jar of carbonic acid, when it floated in it midway.] It is floating as the balloon floated, by virtue of the greater weight of the carbonic acid than of the air. And now, having so far given you the history of the carbonic acid, as to its sources in the candle, as to its physical properties and weight, when we next meet I shall show you of what it is composed, and where it gets its elements from.

ROMANCE OF THE STEAM ENGINE.

ARTICLE XVIII.

IMMENSE INCREASE OF ENGINES,

Our article this week being principally of a statistical and reflective character, is not, as usual, illustrated with an engraving. We have now brought down the chronicles of the steam engine to 1800, when the patent, extended to Watt, by the Act of Parliament, for twenty-five years, expired and was thrown open to the public. It was supposed that numerous new improvements would at once be brought into the field by other inventors, and that the firm of Bolton & Watt, which had enjoyed the monopoly so long, would be eclipsed. A new era in steam improvements was announced to commence, and, assuredly, this was really the case, but not in the sense anticipated. Owing to the exclusive manufacture of engines being in the hands of the Soho company, a public prejudice prevailed against its members, and many manufacturers, who were not aware of the great benefits conferred upon the world by the invention, hung back, as it were, from using steam engines, under the idea that when the patent expired they would obtain engines at much lower prices. It is stated that in London, in 1800, engine power to the extent of only 650 horses was all that was in operation; in Manchester, 450-horse power; in Leeds, 300; while on the whole continent of America there were only four steam engines—all Watt's. One of these was in New York, two in Philadelphia, and the other in Virginia.

When the patent was opened to the public, there was certainly a considerable rush made by millwrights—the only mechanical engineers of the time—to make and improve the engine, but the whole of them failed of success excepting those who copied Watt's engine in every essential particular. There was, however, a great and sudden demand made for new engines, and it is stated as an extraordinary fact, in proot of the long-continued monopoly of a patent not being beneficial to the patentees themselves, that in the first five years after the patent had expired, Bolton & Watt sold twice the number of engines that they had during an equal time when they possessed the sole right to manufacture them in England. The same company has transmitted the business to their descendants, who still carry on the manufacture at Soho on a most extensive scale, and they furnished the screw engines for the *Great Eastern*.

Since their first engine was built, in 1770, up to the present date, they have constructed 1,650 engines, of an united power equal to 177,000 horses; and the steam power of Great Britain, in ships, locomotives, and manufactories, is estimated at no less than 10,000,000 horses, or about one hundred millions of men.

It is not alone by the development and application of a new power to arts and commerce, for abridging human labor, that the steam engine has proven to be the modern apostle of civilization, but by the concentration of so vast a power into a very limited space. Results are now achieved that would have been deemed miraculous two hundred years ago. Some idea of this may be formed when we conceive a steamship, such as the *Vanderbilt*, driven across the ocean with a power equal to that of 2,000 horses drawing it; or a locomotive weighing only 24 tuns snorting along at the rate of 40 miles an hour, with a power equal to more than 200 horses. At the present day we cannot justly estimate what the steam engine has done for us. Had we lived before it was introduced, and had we seen the clumsy and inefficient machines which it superseded, we could have formed a more intelligent opinion of its benefits. There is one interesting case on record, however, which throws much curious light on this particular; it is that of the celebrated water engines at Marly, France.

In 1682, Louis XIV. had machinery erected at the village of Marly, upon the Seine, by the great engineer Rennequin, of Liège, to raise water for the town of Versailles. It was a gigantic specimen of the race of mechanical megalosaurians. The water was raised by fourteen large water wheels and a series of pumps, pipes, cranks and rods, remarkable for their ingenious complexity and the wonderful noise which they made while working. Dessaguliers said "the engine at Marly covers a mile in length of ground, its breadth is greater than that of the river Seine. It is a stupendous machine. It is stated to have cost over eighty million of French livres"—about $20,000,000. This machinery for raising water was held to be one of the glories of old France; no other country could show such a vast, ingenious and powerful machine. No sooner, however, was Watt's engine in successful operation than France became ashamed of what its people were formerly proud of, and Watt himself was sent for to construct an engine for Marly. It is said that one of his 50-horse engines, afterwards erected there, raised more water than the whole mile in length of the old machinery.

French Treatment of Croup.

A paper on this dangerous malady was lately communicated to the French Academy of Sciences, by Dr. Ozanan, who has devoted especial attention to this disease since 1849, and has made a great number of experiments with chemical agents in treating it. It is stated in a report of his paper that the chloride of potassium dissolves the false membrane in the throat in the course of 24 hours; chloride of sodium dissolves it in 36 hours; a solution of bromide potassium (1 part to 99 of water) dissolves it in 12 hours, and glycerine has the effect of softening it in 24 hours. Dr. Ozanan prefers alkalies as dissolvents in treating croup, but he quotes a peculiar case of successful treatment with a solution of common salt. A country physician in France, in 1860, while attempting to cauterize the throat of a patient with a stick of caustic, to his great dismay found the caustic sucked out of his fingers, and swallowed. In terror, he hastily prepared a strong solution of common salt as an antidote to counteract the effects of the poison, when to his own surprise it not only effected this object, but cured the croup also. Common salt, then, is a most simple and excellent agent for croup.

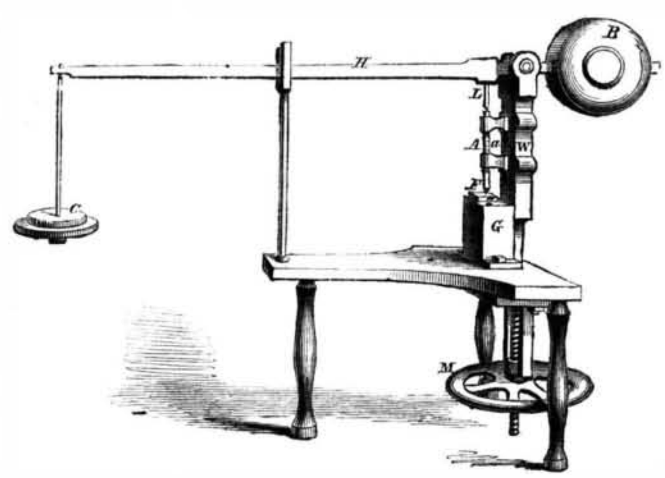
SPIRALS OF PLANTS.—It is a well known fact that certain plants grow spirally, some tending to the right and others to the left. Some new light has lately been shed upon this subject by Professor Wiedeman, who, in a communication to the Royal Society, London, attributes the phenomena to positive and negative electric currents. He states that in some experiments made by him with iron wire, he found that when he twisted it in the manner of a right-handed screw, after the passage of an electric current through it, the point at which the current entered always became a positive pole; and when he twisted it to the left hand, the point of entrance became a negative pole, and the wire magnetized. Currents of electricity flow through all plants.

The Hardness of Metals and their Alloys.

[From Dingler's Polytechnic Journal.]

Formerly, in order to determine the hardness of different bodies, the bodies had been rubbed against one another, and that one which cut the others was considered the hardest. In this manner the following series was obtained :—Diamond, topaz, quartz, steel, iron, copper, tin, lead. This method is insufficient in its results, and, furthermore, it cannot be used to determine the hardness of metals and their alloys. A new method has therefore been thought of and used by Professor T. C. Calvert and B. Johnson, which allows of representing the hardness of the different metals and their alloys by figures.

For this purpose they used an apparatus consisting essentially of a lever, arranged so that the pressure exerted by the same on the piece of metal in question can be diminished by a weight attached to the shorter of the two arms of said lever. The apparatus is represented in the engraving, and it consists of a lever, H, with the sliding balance weight, B, and the dish, C, which receives the weights for increasing the pressure. The point, L, rests upon a square iron rod, A, which is guided by the lugs, E. The iron rod, A, is provided with a scale at a, and it is furnished with a conical steel point, F, 0.275 inches long, 0.197 inches wide at the base and 0.049 inches wide at the point. This point rests upon the piece of metal, the hardness of which is to be determined. A block of iron, G, supports the latter, and the standard or fulcrum, W, can be raised or lowered by means of a screw, M. By turning this screw the entire weight of the lever is thrown upon the standard, I, and upon the screw itself, and if it is desired, by turning said screw, the effect of the balance weight on the rod can be restored.



In order to determine the hardness of a substance, it is brought upon the block, G, and while the point, F, rests on it, the position of the scale, a, on the rod, A, is marked. The weight on the dish, C, is now increased until, during half an hour, the point, F, has penetrated to the depth of 0.125 ($\frac{1}{8}$) inch, and then the weight is marked. In repeating all the experiments twice results have been obtained which differed but slightly from each other.

The annexed tables give the degree of hardness of the various metals. The experiments have been restricted to such metals as are used by machinists and engineers, and, for them, it is of particular value to be able to determine the hardness of the various alloys :—

Metals.	Weight used. Pounds.	Calculated. Pig iron = 1000
Staffordshire pig iron, No. 3	4800	1000
Steel	4600 ?	958 ?
Bar iron	4500	948
Platinum	1800	375
Copper (pure)	1445	301
Aluminum	1300	271
Silver (pure)	1000	208
Zinc (pure)	880	183
Gold (pure)	800	167
Cadmium (pure)	520	108
Bismuth (pure)	250	52
Tin (pure)	130	27
Lead (pure)	75	16

From this table it appears that pig iron, as compared with other metals, contains a high degree of hardness ; but, notwithstanding many alloys have a very extraordinary hardness, not one of them is equal in this respect to pig iron.

The first series of alloys which has been investigated has been that of copper and zinc ; the second, the various compositions of bronze ; the third, alloys of tin and zinc ; the fourth, alloys of lead and antimony ; and the last, alloys of lead and tin.

ALLOYS OF COPPER AND ZINC (BRASS).

Formulas according to the equivalents. Alloys.	Contained in 1000 parts of the alloy. Copper.	Lead.	Weights used. Pounds.	Obtained. Pig = 1000	By calculation. Pig = 1000
Zn Cu5	82·95	17·05	2050	427·08	280·83
Zn Cu4	79·56	20·44	2250	468·75	276·82
Zn Cu3	74·48	25·52	2250	468·75	276·04
Zn Cu2	66·06	33·94	2270	472.92	261·04
Zn Cu	49·32	50·68	2900	604·17	243·33
Cu Zn2	32·74	67·26	Broke with 1,500 pounds. The point did not sink in.		
Cu Zn3	24.64	75·36	Broke with 1,500 pounds. The point sunk in to the depth of 1-64th of an inch.		
Cu Zn4	19·57	80·43	Broke with 2,000 pounds. The point penetrated a little deeper than before.		
Cu Zn5	16·30	83·70	The point penetrated to the depth of 1-16th of an inch with 1,500 pounds. Broke with 2,000.		

From this table it appears that those alloys which contain a surplus of copper are much harder than the metals themselves which constitute the alloy ; and it is singular that this increase is owing to the zinc, the softer of the two metals contained in the alloy. If the quantity of zinc contained in the alloy exceeds 50 per cent, the alloy becomes so brittle that it bursts as soon as the steel point begins to sink in. It is thought that some of these alloys with a surplus of zinc merit the attention of engineers, notwithstanding, on account of their white appearance, they are not sold in the market. In particular, it is the alloy expressed by the formula Cu Zn, and containing, in 100 parts, 49.32 parts copper and 50.68 parts zinc, which deserves every attention. Notwithstanding it contains 20 per cent more zinc than any ordinary brass, its color, if the same is properly made, is much more beautiful than that of brass. The only reason why it did not come into use is probably because, if the quantity of the zinc used in the alloy exceeds 33 per cent the brass becomes so white, the m nufacturers considered it advisable not to exceed this proportion. But if they had taken the quantity of zinc exactly up to 50.63 per cent, and if they had mixed the metals well, they would have obtained an alloy of a color equally rich as that containing 90 per cent of copper, and of a hardness three times greater than that of the latter. In order to make the value of this alloy better understood to engineers, we give a table of the different kinds of brass generally manufactured :—

Brass.	Contained in 100 parts. Copper.	Tin.	Zinc.	Lead.	Hardness of the alloy. Weight used. Pounds.	Pig iron = 1000 Obtained.	Cal'd.
Large bearing	82·05	12·82	5.13	—	2700	562	259
Mud plugs	80	10	.10	—	3600	750	262
Yellow brass	64	—	36	—	2500	520	258
Pumps & pipes	80	5	7.5	7.5	1650	343	257

The alloy Cu Zn contains still another quality, viz., the inclination to form prismatic crystals, that is, prisms about half an inch in length and of an extraordinary toughness. There is no doubt that this alloy is not a mixture but a chemical composition of the two metals, the same as a great many alloys, which is clearly shown in t e article on the conductibility of different metals and their alloys, published on pages 36 and 87, Vol. III. (new series), of the SCIENTIFIC AMERICAN.

BRONZE ALLOYS.

Formula according to their chem. comp'tn.	Contained in 100 parts. Copper.	Tin.	Hardness. Weight used.	Pig iron = 1000 Obtained.	Calc'd.
Cu Sn5	9·73	90·27	400	83·33	51·67
Cu Sn4	11·86	88·14	460	95·81	59·56
Cu Sn3	15·21	84·79	500	104·17	68·75
Cu Sn2	21 21	78·79	650	135·42	84·79
Cu Sn	34.98	65.02	With 700 pounds the point sunk in 1-32d of an inch, and the alloy broke.		
Sn Cu2	48·17	51·83	Broke with 800 pounds. The point did not sink in.		
Sn Cu3	61·79	38·21	Broke with 800 pounds in small pieces.		
Sn Cu4	68·27	31·73	Broke in two with 1,300 pounds. The point did not sink in 1-64th of an inch.		
Sn Cu5	72·90	27·10	The same as before.		
Sn Cu10	84·32	15·68	4400	916·66	257·08
Sn Cu15	88·97	11·03	3710	772·92	270·83
Sn Cu20	91·49	8·51	3070	639·58	277·70
Sn Cu25	93·17	6·83	2890	602·08	279·16

The results obtained with this series of alloys are very remarkable. All the alloys containing a surplus of tin are very soft ; and if the quantity of copper—one of the toughest metals—is a little increased, the alloy is rendered brittle, for the alloy $Cu Sn^2$ is not brittle, while this is the case with the alloy Cu Sn. And the same is the case with all the other alloys up to $Sn Cu^5$, and the brittleness only ceases with the alloy $Sn Cu^{10}$, which contains 84.32 parts copper to 15.68 parts tin ; and this alloy, notwithstanding four-fifths of its weight are copper, is nearly as hard as pig iron. The small quantity of tin mixed with the copper renders this alloy, and all those which follow, remarkably hard.

Since copper and tin, mixed with tin or zinc, obtains a much larger degree of hardness than it has when pure, it was of some interest to find out whether the alloys of tin and zinc also become harder than theory would let us believe. The following table contains the results of some experiments made with such alloys :—

ALLOYS OF TIN AND ZINC.

Chemical composition.	Contains in 100 parts. Zinc.	Tin.	Hardness. Weight used.	Pig iron = 1000 Obtained.	Calc'd.
Zn Sn2	21·65	78·35	300	64·50	60·83
Zn Sn	35·60	64·40	330	68·75	82·70
Sn Zn2	55·61	47·49	400	83·33	110·00
Sn Zn3	62·43	37·57	450	93·70	124·58
Sn Zn4	68·86	31·14	505	105·20	131·22
Sn Zn5	73·43	26·57	600	125·00	142·08
Sn Zn10	84·68	15·32	580	120·83	158·33

These results show that these two metals have no influence on each other, and the figures representing their hardness are almost without exception smaller than those obtained by calculation. The same results have been obtained in regard to the conductibility of heat of these alloys, which shows conclusively that they are mere mixtures.

We add two tables of alloys, consisting of tin and antimony, and also consisting of lead and tin. We find that in the alloys of tin and lead, the tin increases the hardness of the lead, but not in the same degree as that of the copper.

ALLOYS OF LEAD WITH ANTIMONY.

Chemical composition.	Contained in 100 parts. Lead.	Ant'y.	Weight used.	Hardness.
Pb Sb5	24·31	75.69	900	The point sank in to 7-64 inches, and the block broke.
Pb Sb4	28·64	71·36	900	The block broke when the point had penetrated 7-64 inches.
Pb Sb3	34·86	65·14	875	182
Pb Sb2	44·53	55·47	600	The block broke when the point had penetrated 7-64 inches.
Pb Sb	61·61	38·39	500	109
Sb Pb2	76·32	23·68	385	80
Sb Pb3	82·80	17·20	310	66
Sb Pb4	86·52	13·48	300	64
Sb Pb5	88·92	11·07	295	63

ALLOYS OF LEAD WITH TIN.

Chemical composition.	Contained in 100 parts. Lead.	Tin.	Hardness. Weight used.	Pig iron = 1000 Obtained.	Calc'd.
Pb Sn5	26·03	73·97	200	41·67	23·96
Pb Sn4	30·57	69·43	105	21·62	23·58
Pb Sn3	36·99	63·01	160	32·33	22·83
Pb Sn2	46·82	53·18	125	26·04	20·09
Pb Sn	63·78	36·22	100	20·83	19·77
Sn Pb2	77·89	22·11	125	26·04	18·12
Sn Pb3	84·09	15·91	135	28·12	17.23
Sn Pb4	87·57	12·43	125	26·04	17·08
Sn Pb5	89·80	10·20	110	22·92	16.77

Enormous Profits of Telegraph Companies.

At the late session of Congress an attempt was made to procure an extension of Morse's telegraph patents, and the attempt was opposed by Dr. Leverett Bradley. From Dr. Bradley's memorial in opposition to the extension, it seems that the line between Boston and New York yields sufficient profits every three months to pay for building the line ! Stock has been issued for large amounts more than the line cost, and on this artificially inflated stock great dividends are made.

The capital stock of the American Telegraph Company for their line between Boston and Washington is now $1,535,000, upon which the net profits amount to over 20 per cent per annum. It is known that responsible parties will give bonds to build a line over the same route and stock it, to do the same amount of business now done, for $75,000.

A dividend of cent per cent was paid, a few years ago, upon the inflated stock of the greatest of the Western companies, after which the stock was multiplied by five so as to amount to some millions.

No definite statement can be made of the amount of the present wealth of Professor Morse, as that is a private matter which it might be deemed to his interest to keep from the public ; but from what he has received from his patents it ought to be very great. He must, however, under any circumstances, have realized an immense sum. From the large amount of very valuable telegraph stock Mr. Morse holds now, and from the highly valuable real estate in his splendid mansion near the Fifth-avenue, New York, his estate at Poughkeepsie, and other property, it is clear that he is a rich man, and his riches have been realized from his patents. He stands on the books of one of the telegraph companies, viz.: The American Telegraph Company, as the owner of 1,007 shares of stock of $100 each, on which the net profits have been the last year from 20 to 25 per cent. (The stock of that company is over $1,600,000.) He is also the owner of a large amount of stock of other telegraph companies, owning the lines from Washington to New Orleans *via* Richmond, Charleston, Savannah and Mobile ; also the lines from New York to Buffalo, Louisville to New Orleans, and other lines. Mr. F. O. J. Smith, who owned one quarter of the Morse patent, sold that quarter with stocks acquired from it, reserving a remaining interest of $75,000, for $300,000, as appears from the contract sale with the American Telegraph Company.