the atmosphere by successive diffusions, I have spent several months in experiments with this end in view. Quite recently my efforts have been crowned with most promising success. The difficulty has been to find a suitable porous septum; one free from holes, and sufficiently fine grained to prevent more than a very slow passage of air, while a considerable surface is exposed to the atmosphere on one side and to a fairly good vacuum on the other. Many substances were tried. India rubber gave encouraging results, but was capricious, and very slow. The best results have been obtained with porous porcelain having its superficial pores nearly closed by suitable treatment. A tube of this kind, closed at one end, and exposing rather more than five square inches of surface to the air, was connected with the apparatus, and the whole kept exhausted to a pressure of 1.3 mm. About 19 c. c. of gas was diffused per hour. After 36 hours the diffusion tube was shut off, the exhaustion continued, and data for the curve, *m n*, obtained. It was found impracticable to carry the exhaustion below six millionths, because of the presence of moisture, which interfered with the action of the pump, no desiccating agent being used. As both phosphorus pentoxide and soda lime absorb the new gas, they cannot be used for desiccation. If the exhaustion had been carried as far as in the curve, *o p*, it is probable that a higher conductivity than in that curve would have been shown; i. e., a conductivity more than forty-two times that of hydrogen, or something like a hundred times that of air. Here we have the heat conductivity of air at very low pressure, increased something like a hundred-fold by one diffusion. I have not yet tried a secondary diffusion, but feel confident that successive diffusions of air will afford a practicable means of obtaining the new gas in a state of approximate purity.

Now let us discover, if possible, the meaning of the extraordinary heat conductivity of the new gas. I have tabulated the molecular weight, density, specific heat, mean molecular velocity, and heat conductivity of hydrogen, helium, carbon monoxide, air, and carbon dioxide, which are the known gases represented in the curve chart. For easy comparison, I have taken not only the density, but the specific heat, mean molecular velocity, and heat conductivity of hydrogen as unity. The similarity of values in the fifth and sixth columns, for molecular velocity and heat conductivity, is striking. On the chart, the curves for carbon monoxide, air, and carbon dioxide are evidently too high to correspond well with the relative values of molecular velocity in the fifth column; but these curves represent only the last 50 millionths of the complete curves. By following these back to 500 millionths, which is still a rather small pressure, and taking their values at intervals of 10 millionths from no pressure upward, we obtain as a mean of all these values for each gas the quantities shown in the sixth column. These agree fairly well with the molecular velocities.

COMPARISON OF GASEOUS PROPERTIES.

1	2	3	4	5	6
Gas	Molecular weight	Density D	Relative specific heat	Relative molecular velocity $\sqrt{\frac{1}{D}}$	Relative heat conductivity
Etherion	0.0002	0.0001	6000?	100?	100.
Hydrogen	2.	1.	1.	1.	1.
Helium	4.	2.	2.300	0.71	0.73
Carbon monoxide	27.8	13.9	0.072	0.27	0.33
Air	28.8	14.4	0.069	0.26	0.32
Carbon dioxide	43.8	21.9	0.064	0.21	0.21

I offer the suggestion that the relatively high conductivity of the last three gases at the low pressure shown in the chart is due to the dissociation of some of their molecules by unobstructed impact on the walls of the containing vessel, recombination being more and more retarded as the pressure is lessened, because the greater separation of the molecules reduces the frequency of collisions. Helium, perhaps because it is monatomic and therefore incapable of dissociation, has a nearly straight curve like hydrogen; and its ratio, given in the sixth column, varies but little throughout the whole range observed, which was more than a thousand millionths. I have taken the density of helium at 2; but Prof. Ramsay finds it a little less than this when purified as far as possible by repeated diffusions. This makes its relative molecular velocity a little more than 0.71, and brings it still closer to the observed value of its heat conductivity.

From the foregoing, we may reasonably conclude that the heat conductivity of gases at low pressures, and their mean molecular velocities, are closely related. Hence, if we can learn the heat conductivity of an otherwise unknown gas, we can form some idea of its mean molecular velocity; and from this, of its specific heat, density, and molecular weight.

As before indicated, the heat conductivity of the new gas at very low pressure, even when mixed with a large proportion of other gases, is something like a hundred times that of hydrogen. I shall not be surprised to find the conductivity of the pure gas a thousand or more times greater than that of hydrogen; but let us be conservative, and for the present purpose call it a hundred times, and see what follows. I have given it this value at the head of the sixth column.

If my inference that the heat conductivity and molecular velocity of gases are directly related is correct, then the molecular velocity of the new gas will be 100 times that of hydrogen, as shown at the head of the fifth column. As is well known, the mean molecular velocity of a gas varies directly with the square root of its absolute temperature, and is independent of pressure. The mean molecular velocity of hydrogen at the temperature of melting ice has been found by calculation to be 5,571 feet per second. Hence the mean molecular velocity of the new gas at the same temperature will be 557,100 feet, or more than 105 miles per second. At anything like this molecular velocity, it would be quite impossible for a gas to remain in the atmosphere, unless the space above also contained it. A velocity of only about seven miles per second, if unchecked except by gravitation, would be sufficient to

project a body from the earth permanently into space. Even at a temperature very close to absolute zero, the new gas would have sufficient molecular velocity to escape from the atmosphere.

Again, inasmuch as the molecular velocities of gases vary inversely as the square roots of their densities, it follows from our assumption of its molecular velocity that the density of the new gas is only the ten thousandth part that of hydrogen, as shown at the head of column 3. This is the one hundred and forty-four thousandth part the density of air. It is generally believed that the gases of the atmosphere distribute themselves in the long run, each as though the others were absent. Hence the new gas must extend a hundred and forty-four thousand times as high as the heavy constituents of the air, to bring about the same proportionate reduction of pressure, even if gravitation remained constant at all distances from the earth; but the restraining influence of gravitation on the expansion of the atmosphere diminishes as the square of the distance from the earth's center increases. It is evident, therefore, without a mathematical demonstration, that the new gas being present in the atmosphere must extend indefinitely into space without great loss of pressure. This is only another way of stating the result of its assumed molecular velocity. Now there is no doubt that the new gas exists in the atmosphere, though probably in very small proportion; perhaps much less than a millionth. Hence it seems really probable that it not only extends far beyond the atmosphere, but fills all celestial space at a very small pressure. In recognition of this probability, I have provisionally named it etherion or etherion; meaning "high in the heavens." Its symbol will naturally be Et.

I am aware that strong objections may well be raised to the hypothesis of an inter-planetary and inter-stellar atmosphere; but I can see no escape from the conclusion I have drawn, if I am not mistaken in my premises.

The estimated relative specific heat of etherion appears at the head of the fourth column, based again on the assumed relative molecular velocity. In estimating the specific heat, I have not made it inversely proportional to the density, as would be required by Dulong and Petit's law, giving a value ten thousand times that of hydrogen; but have used the formula suggested by Prof. Risteen in his work on "Molecules and the Molecular Theory," which requires that the product of the specific heat and molecular weight of gases shall vary with the number of degrees of freedom of their molecules. I have assumed as probably true that etherion is monatomic, with atoms possessing only three degrees of freedom.

Of course the values I have estimated for the molecular weight, density, specific heat, and molecular velocity of etherion are intended only to indicate the order of magnitudes we may expect to find on further investigation; and it must not be forgotten that they are based on two assumptions: first, that the heat conductivity of etherion is one hundred times that of hydrogen; and second, that the ratio of heat conductivity and mean molecular velocity is the same for all gases. As before indicated, I expect to find the heat conductivity of etherion much higher than the value here assigned to it. If so, the real values of its other attributes will be still more startling than those here given. The second assumption, while by no means proved, seems at least a good "first approximation" to the relation between heat conductivity and molecular velocity in gases.

There is some evidence that etherion is a mixture of at least two different gases. In the course of my experiments I have met with a great many specimens, obtained in various ways from various sources; but always mixed with a very large excess of other gases. Some specimens were almost wholly absorbed by the phosphorus pentoxide at first used for desiccation. Others were but partially absorbed; the absorption being very rapid at first, but in an hour or two dwindling to nothing and leaves a residue of gases permanently showing, by their heat conductivity, the presence of a very considerable amount of etherion. Soda lime absorbed etherion, but much less freely than phosphorus pentoxide, and gave it up again on heating. The gas thus recovered was but little if at all affected by phosphorus pentoxide.

In one experiment, the gases evolved from ten ounces of pulverized window-glass, both before and after heating, were passed through coarsely pulverized soda lime and then over fresh phosphorus pentoxide. Not a trace of etherion remained. The same result was obtained when another lot of the silicious sand already referred to was used as the source of etherion.

I will venture the conjecture that etherion will be found to consist of a mixture of three or more gases, forming one or more periodic groups of new elements, all very much lighter than hydrogen. If this proves true, I purpose to retain the present name for the lightest one.

The transmission of radiant energy through space has always been to me a fascinating phenomenon, and I have indulged in much speculation concerning the ether—that mysterious something by means of which it is effected. The remarkable properties assigned to the ether from time to time in order to account for observed phenomena have excited my keen interest; but I have long entertained the hope that some simpler explanation of the mechanism involved will be found. To me a less strain of the imagination is required in the assumption that, instead of a continuous medium, gaseous molecules of some kind, endowed perhaps with a mode or modes of motion at present unknown to us, are the agent of transmission; a gas so subtle and existing everywhere in such small quantity that it has escaped detection.

Perhaps the molecular hypothesis of the ether has proved so attractive to me because it supports the hope that we may some time compass the perfect vacuum—a portion of space devoid of everything. Such a vacuum would be opaque to light, and gravitational attraction could not, I believe, act through it. It might afford a new point of view from which to study the profound mystery of gravitation; an outside point.

The late De Volson Wood (Phil. Mag., Nov., 1885) considered the question of a gaseous ether mathematically, and deduced certain necessary properties

of the hypothetical gas; chief among which were exceedingly small density and exceedingly high specific heat. Possibly we are about to find a gas which will fulfill the required conditions. It may be etherion, or its lightest constituent if it turns out to be a mixture. I venture to express the hope that etherion will at least account for some phenomena at present attributed to the ether.

On account of the presumably extreme smallness of its molecules as compared with those of glass, etherion probably passes through the latter when any considerable difference of pressure exists on opposite sides, though the passage may be very slow. It seems to be condensed or compressed in glass as before indicated, and may evaporate on the side of lower pressure, and be absorbed on the side of higher pressure, after the manner of hydrogen in passing through palladium. In my own experiments the heat transmission ascribed to the ether may be due to the presence of the new gas inside the bulb. A small fraction of a millionth would be sufficient, and this might escape detection by the pressure gage, on account of the necessary compression in the gage head causing absorption by the glass. Again, etherion must always be present to some extent in all "vacuum tubes" (as well as in my own conduction bulb) on account of its long continued evolution from glass; and may be the medium of propagation of the Roentgen rays in the vacuum glass and air.

OSMIUM.

THE heaviest thing in the world is the metal osmium, the bluish white metal with violet luster, which Mr. Smithson Tennant discovered ninety years ago in the residue from dissolved platinum ores. This metal has a specific gravity of 22.477, that of gold being 19.265, lead 11.367, iron 7.79, and lithium, the lightest, only 0.594. The French chemist Joly determined that osmium is likewise the most infusible of metals. It could never be made to yield to the oxyhydrogen flame which makes platinum and iridium run like water. But Joly has been subjecting osmium to the excessively high temperature of the electric arc, which Moissan has of late employed successively in the manufacture of diamonds. Under this fierce heat the rare metal ruthenium, which used to be deemed all but infusible, readily melts. But osmium remains refractory, there being apparent only the faintest traces of fusion. On this account osmium cannot be prepared in sufficient quantity to make it very useful in the arts. But its alloy with iridium, which defies the acids, is of some value, nothing better having been found wherewith to tip gold pens. Being non-magnetic, its employment for the bearings of the mariner's compass has been advocated.—Popular Science News.

ALUMINUM CROWNS.*

By A. E. PRESTON, D.D.S., Delevan, N. Y.

A FEW weeks after making my first investment in aluminum caps a gentleman presented himself in my office with a number of decayed teeth, which he wished me to save if possible. One, a lower second molar, was in very bad shape for holding fillings, and I suggested to him that it would be a good tooth to crown with a gold cap. But the idea of placing so much money into one tooth I saw at once was not congenial to his ideas. Here, thought I, is a chance to try one of those new crowns, so I brought forward one of my aluminum caps, and, setting a figure upon it which I thought he would be willing to stand, I told him that I here had something which would be just what he wanted.

After a few questions concerning the metal, its color, keeping qualities, durability, etc., he consented that I should put it in place. I at once proceeded exactly as I would with a gold cap, and found that this material was even more easily manipulated than a gold cap, on account of the pliability of the metal.

After shaping and fitting the cap and tooth to each other, I allowed the patient to bite, at first gently, then afterward more firmly, until the bite was closed, thus doing nearly all the swaging of the cusps and intervening depressions himself by the act of occlusion.

These caps, you remember, are swaged in the first place, and are of nearly uniform thickness in every part, the same as swaged gold caps, and do not have built up or filled in cusps, as our homemade crowns usually do. Hence the ease with which the occlusion is made without the use of impressions, bites, or articulators; in fact, the whole operation occupied but a little more time than it takes to make a good amalgam filling.

This was nearly three years ago; since then I have seen the tooth several times, the last time being the first week of this present month. Everything was in good condition; the occlusion perfect, the color the same as when new, and the patient expressed the same praise for the work you so often hear of a well fitting gold cap: "Doctor, that is the best tooth in my mouth."

Case No. 2 was not so fortunate in its results. The patient, a young lady, presented a lower third molar, which had been filled and refilled, and was then broken down nearly to the gum margin. She thought the best thing for the tooth was extraction. But I suggested placing an aluminum cap, which would be much less expensive than gold, and seeing what the result would be. So that course was pursued. In this case I had to build up nearly all of the crown, which I did by undercutting the remaining dentin and filling the cap with cement and then pressing it to place, after having secured a good fit and articulation. The pulp was alive, and responded for few moments to the action of the cement, as a healthy pulp nearly always does. This crown did good service for nearly a year, when a small break occurred in the margin of the grinding surface, caused by biting too forcibly upon a hard kernel of popcorn. The break seemed trivial and very easy to mend; but now comes the part which shows what ignorance and thoughtlessness, combined with a desire to experiment, will sometimes do. I enlarged the opening with an engine bur, made a nice undercut in the cement underneath, and filled the cavity with

*Read before the Eighth District Dental Society, Buffalo, N. Y., April 26, 1898.—From The Aluminum World.

amalgam; then dismissed my patient, telling her that the crown was now as good as new.

In the afternoon she returned bearing in her hand a crumpled, rotten, distorted piece of metal, which had no resemblance to my handsome aluminum cap; but such it nevertheless was. This was her story: After eating dinner she sat down to talk with her husband, and remarked that that crown seemed loose. She placed her fingers in her mouth, and saying, "It is loose," removed it in her hand and immediately dropped it, exclaiming, "Oh, it's hot! It burned me." "What are you giving us?" remarked her husband, and at the same time picking the cap from the carpet. He also dropped it, saying, "Gee whiz! It is hot. It's a wonder it didn't burn your mouth." That's just what I said also when she told me the story.

Now, one thing I want to know is, why didn't it burn her mouth? Were the fluids of the mouth keeping it cool, or was it waiting for a contact with the atmosphere to start up the heat action? I learned one thing that I ought to have known before; that is, that mercury will unite with aluminum just as it will with silver or gold, and that amalgam should not be used to patch aluminum caps. I don't suppose any other dentist ever makes any of these little blunders, and that is why so few of them are ever brought to our attention. We prefer to tell of some of the brilliant successes we have had with some new appliance, or some intricate operation performed that has brought us fame and our names into prominence. Nevertheless the little things of daily office practice, when remembered, help to make our work more successful.

I replaced the destroyed aluminum cap by another of the same material, upon the good, solid cement crown, which was well preserved, and it is doing good service to-day.

My experience with aluminum caps has been very limited, but they have proved to be successful when rightly placed. I would not use them when I could use gold just as well, yet I believe they are worthy of a place in crown work.

SETTING BACK BULGES IN FURNACES.

By a BOILER INSPECTOR.

THE usual method of setting back bulges in furnaces is to apply a fire below, and then to force the fire by a blast led from a rivet-fire bellows. After the bulge has been sufficiently heated the fire is withdrawn, and a jack applied to force back the bulges. This must be quickly done, or else the bulge will have cooled down so much that it cannot be forced back. In the limited room for working, it is always an awkward and unpleasant job. In removing the fire it often gets spilled about, and the necessary packing to keep it up to the bulge has also to be cleared out of the furnace, and during the time this is being done the heated part is rapidly cooling. For reheating the fire has again to be packed up against the bulge, and the cycle of operations repeated till the furnace is sufficiently restored to shape. The whole of the work has invariably to be performed at the place where the boiler is worked, with what appliances can be most conveniently found, often by workmen who have had no experience with this class of work.

The writer designed the method shown on annexed sketch to get over some of the difficulties connected with this job, and he believes it is an improvement on

the usual methods. The whole of the materials required can generally be got, even in the most out-of-the-way places, with little trouble.

A wrought-iron pipe, about an inch in diameter, is fitted to the bottom of a wrought-iron bucket, as shown. The end, which passes a short distance through, being plugged up, the upper part inside the bucket perforated by a slot or several holes, and the bucket lined with fireclay, a cross handle to steady the whole is clipped on near the other end of the pipe, that end being connected, preferably by a hose pipe, with the rivet-fire bellows. The fire is kindled and got properly started before inserting in the furnace. A suitable crossbar with a notch in it is inserted in the furnace tube. The fire can be quickly placed in position under the bulge, and by grasping the cross handle and the end of the tube, can be quickly manipulated as required. It can be quickly withdrawn, and laid down well back from the boiler front, so as to be out of the

way, and the jack applied to the bulge with the minimum loss of time.

A 15 to 20 ton hydraulic jack is the best to use. A small piece of $\frac{1}{2}$ inch or $\frac{5}{8}$ inch plate, heated to redness and bent to the circle of the furnace, should be put on the top of the jack to prevent it from cooling and marking the furnace plate. A larger plate, bent to the circle of the furnace, should be placed below the jack to distribute the stress. If any packing is required to bring the jack against the bulge, a single block of good hard wood of suitable thickness should be used. The bulge should be pressed back by the jack; at the same time a little judicious flogging on the water side will make it go back easier.

After the furnace has been restored as near as practicable to original shape, the parts that have been set back should be heated to a dull red to remove any local stresses that may have been set up in the plates. As the fire can be easily shifted about to any desired part of the furnace, this can be easily done.—Engineering.

OLD METHODS OF CROSSING RIVERS BY PONTOONS.

MODEL OF A PONTOON OR PORTABLE BOAT FOR PROMPTLY THROWING A BRIDGE ACROSS A NARROW RIVER.

THIS machine can be used very advantageously, provided that the river over which it is desired to pass troops is not more than from 40 to 45 feet in width. It consists of a pontoon, *A*, which is provided with three sections of a bridge, *B*, *C*, and *D*. These latter are connected by joints, *E* and *F*, so that there is thereby formed a sort of double drawbridge that may be raised and lowered, as need may be, by the ropes, *G*, and the

double pulleys placed at the upper ends of the side posts, *H*.

The portion of this bridge marked *C*, which is that of the center, may, by means of the pivot, *I*, be put in two directions upon the pontoon. In order that it may occupy less space, it remains lengthwise when the pontoon is on the move, but is placed crosswise when it is desired to form the bridge. The two other portions, *B* and *D*, fold upon one another and always upon the one marked *C*; and, to this effect, the joints of the portion marked *D* are higher than those of the portion marked *B*. All the pieces of this bridge and those that may be added thereto in order to strengthen it as well as the pontoon or boat, *A*, are loaded upon a four-wheeled vehicle made for the purpose, as shown in the figure, and upon which the machine can be easily carried from one place to another. When it is desired to make use of it, all that is to be done is to put the boat, *A*, into the water, anchor it in the middle of the river, and, after setting up the side posts, *H*, and passing the ropes, *G*, over the pulleys, to lower the portions, *B* and *D*, and thus form a bridge of the width of the river.

All this maneuver is effected in a very short time. Thus one can, with this machine, easily conceal his march and the construction of a bridge, and allow troops to pass over it for surprising the enemy, or for any other expedition that one may judge proper.

MODEL OF A PONTOON FOR CROSSING THE MOAT OF A BESIEGED PLACE, PROVIDED THAT THE WATER WITH WHICH IT IS FILLED IS STILL.

In the siege of places where the situation does not permit of drawing off the water of the moats or of conveniently filling the latter in there may be used the present machine, by means of which one will be able to cross the moat in order to place a mine or to ascend to an assault.

The boats or pontoons that I propose for this purpose are provided with wheels, as the figure shows, and, during carriage, are united in pairs, one on top of another.

When it is desired to use them, they are assembled at the head of the moat, and afterward, in measure as they are put into the water, they are connected with each other end to end and pushed to the side of the escarpment where it is desired that they shall end. The first boats placed in the water are pushed by the following ones in succession until they form a bridge of the necessary length over the moat.

The wheels with which these boats are provided serve not only for moving them from one place to another, but are also of great service when it is desired to put them in water or to remove them therefrom, provided, moreover, that a glacis be formed at the descent to the moat—a matter of no difficulty. And, this glacis once formed, the laborers employed in the construction of the bridge will be able to work in the moat under cover from the fire of the besieged, and, without greatly exposing themselves, to push their boats into the water, even in broad daylight, provided they are favored by a hotter fire on the part of the besiegers.

Nevertheless, it is better to take advantage of the darkness of the night for performing this maneuver, in that the enemy can then throw fewer obstacles in the way, and that even the bridge being formed during the night, one is in a state to surprise the enemy

MODEL OF A PONTOON OR PORTABLE BOAT FOR PROMPTLY THROWING A BRIDGE ACROSS A NARROW RIVER.