If we attempt a discharge at a higher degree of saturation, the necessary initial temperature rises rapidly, as the required amount of air is thereby diminished; and it must not be overlooked that even to these temperatures must be added the heat requisite to make good that lost by radiation, and that imparted to the material itself.

Let us consider a lower range of temperatures, say a substance which will not bear a higher temperature than 150°. In this case, as the loss of heat in the air of discharge increases rapidly as we descend in temperature, we will allow a saturation of 0.60; to maintain this with such an initial temperature as circumstances will admit, we find that we must discharge at about 92°, and at this low temperature of discharge the heat carried by the air, and not utilized, is over 52 per cent. of that utilized in evaporation.

The following calculations illustrate how the initial temperatures above given are arrived at:

Saturated mixtures of air and vapor will contain in each lb. of air, at 172°, 0.46338 lb. of vapor; at 122°, 0.08584 lb. vapor; at 92°, 0.03289 lb. vapor.

Assume the normal temperature of air and material to be 62°, and vapor present in the atmosphere at 0.0075.

To evaporate 1 lb. of water from 62° we require 1116 B. T. U. (1178 — 62), which is the equivalent of

$$4687.2 \text{ lb. of air raised } 1^\circ \text{ in temperature, thus } \frac{1116}{0.238} = 4687.2.$$

With a discharge temperature of 172°, 0.50 saturated, we must have, to carry 1 lb. of vapor, 4.46 lb. of air,

$$\text{thus } \frac{1}{(0.46338 \times 0.50) - 0.0075} = 4.46. \text{ To carry the}$$

required heat our 4.46 lb. of air must part with 1051°, 4687.2

$$\frac{4687.2}{4.46} = 1051; \text{ and adding to this the discharge tem-}$$

perature, 172°, we get 1223° as the initial temperature required.

At 122° discharge, 0.50 saturated, we get, for carry-

$$\text{ing 1 lb. of vapor, } 28.23 \text{ lb. air, } \frac{1}{(0.08584 \times 0.50) - 0.0075}$$

$$= 28.23; \text{ difference of temperature } 166^\circ, \frac{4687.2}{28.23} = 166;$$

and adding to this the discharge temperature, 122°, we get 288° as the initial temperature required.

At 92°, 0.60 saturated, we get, required air, 81.73 lb.,

$$\frac{1}{(0.03289 \times 0.60) - 0.0075} = 81.73; \text{ difference of tem-}$$

$$\text{perature } 57^\circ, \frac{4687.2}{81.73} = 57, \text{ and adding, as before, } 57 + 92, \text{ we get } 149^\circ \text{ as the initial temperature required.}$$

The heat expended in evaporation is in each case the same, 1116 B. T. U. But the heat lost in the air of discharge varies greatly, being at discharge 172°, 1168 B. T. U.; at 122°, 338.1 B. T. U.; and at 92°, 583.6 B. T. U.: $172 - (62 \times 4.46 \times 0.238) = 116.8$; $122 - (62 \times 28.63 \times 0.238) = 338.1$; $92 - (62 \times 81.73 \times 0.238) = 583.6$.

These figures, which show the number of units of heat lost for every pound of water evaporated under the stated conditions, indicate the enormous waste of heat in large drying operations, as, for instance, in drying brewers' grains. To dry the grains from a mashing of, say, 2,000 bushels would involve the evaporation of upward of 80,000 lb. of water, and they cannot be safely subjected to a temperature much above 280°. Other materials will not bear even this temperature with safety.

How shall we maintain a reasonably high temperature of discharge, the necessary condition of economy, without raising the temperature of the intake to a destructive degree? This has been accomplished by the system of recirculating currents. This system was first referred to by B. F. Sturtevant, but its full significance does not seem to have been fully appreciated until recently.

It has, however, been employed with most satisfactory economical results in many establishments in the United States, principally in connection with the woolen and other textile industries. In this system, a volume of hot air, several times greater than that necessary for carrying off the evaporated water, is circulated through the drier, and is brought alternately in contact with the goods under treatment and with heated surfaces, giving up heat to the former and receiving it from the latter, which it should leave at the maximum temperature the goods will bear.

This continuous circulation is effected by a fan blower placed at any convenient point in the circuit, and a portion of the mixture of air and vapor at its maximum of saturation sufficient to carry off the vapor as fast as it is generated is continuously discharged, and is replaced by an equivalent of normal air admitted to the source of heat. The amount of air discharged is regulated by suitable valves, and the condition as to saturation is thereby controlled, it being found desirable to maintain a somewhat high drying efficiency, even of the discharged portion. It will be seen that in this system the same air serves repeatedly as the vehicle of heat, and the heating of a large volume of new air for this purpose, carrying away in its escape a large quantity of unutilized heat, is avoided. The exit temperature being decided upon, the temperature of the drying current at its initial point, i. e., where it first encounters the goods, will be determined by the relation of the volume of the discharged and recirculated currents, and may be adapted precisely to the particular requirements of the material under treatment.

In the form thus briefly described this system has been very successfully applied. There are, however, under some circumstances, important difficulties which it does not meet. Many substances in drying evolve corrosive gases, which, if driven through a heater, rapidly destroy the heating surfaces; others throw off

dust, which coats the surfaces, and, in addition to impairing their efficiency, char them and give off noxious and injurious odors. It is also entirely inapplicable in this form to the use of the gases of combustion, in which, as the entire heat generated by the fuel is introduced into the drier, there is the highest economy.

To adapt it to these cases, and, in fact, all where the heat may be derived otherwise than from radiating surfaces, I have devised the improved apparatus described in this paper. Circulating the current repeatedly and continuously through the drier and over the contained material, and discharging continuously a regulated quantity of the mixed air and vapor, I do not pass it over heat-imparting surfaces, but replace the expended heat by introducing into the system a fresh volume of hot air or gas, which must necessarily be the equivalent of the discharged portion. The recirculated mixture of air and vapor encounters and mixes with the incoming hot volume, and is brought to its maximum drying efficiency, in which condition, in a properly designed drier, it should be applied to that portion of the material which, having already parted with most of its moisture, relinquishes the remainder with greater difficulty. By varying the speed of the fan blower, by means of which the circulation is maintained, and the amount of the discharge, the volume relation of the circulated and discharged air can be controlled, and the temperature at the initial point in the drier be regulated. The fixed relations of temperature, the humidity of discharge remaining constant, are those of the intake and discharge, and the variable one, the maximum temperature within the drier, which is controlled by the volume recirculated. Thus, with a discharge temperature of 172°, half saturated, and an intake of gas or air at 1223°, we can, by recirculating about five volumes, bring the initial temperature below 300°, and, by increasing the speed of the fan, as much lower as may be desirable. Similarly, in the case supposed above, where the maximum temperature is limited to 150°, we may, by recirculating a greater volume, realize the economy of a high discharge temperature, say 110° or 120°, and corresponding high temperature of intake, without exceeding the desired maximum.

We can only raise the temperature of discharge by increasing that of intake; but as the loss of heat at a discharge of about 170° is inconsiderable, it is not necessary to exceed 1,200° F. in the intake, and, where gases of combustion are used, we are enabled, without material loss of heat, to maintain a very great drying efficiency throughout the apparatus, the maximum humidity being but 0.5, which is greatly reduced at the initial point. The intake temperature being far below that of the ordinary gases of combustion, we are not limited in the amount of air admitted to the fires as we are in the generation of steam, and, by admitting a large excess, can insure the perfect combustion of the fuel and the important economy resultant therefrom. The velocity of the current over the material is also a factor of some importance, promoting evaporation and the efficiency of the apparatus.

An important feature in connection with this system is the utilization of the waste gases from a boiler or other furnace, which can be used with great advantage where the combustion is without visible smoke, or where the substance to be dried would not be injured by the discoloration and odors, such, for instance, at garbage and fertilizers. Where the chimney gases are sufficient, the gases from a supplementary furnace may be mixed with them, and the temperature being thus raised, the advantages of a small volume of discharge may be secured.

Having considered the method by which the energy provided for drying may be utilized, the equally important problem of how we shall handle our material so as to bring it into contact with the drying current remains. The entire question of drying may be viewed as a contest between the occupation of space and time, on the one hand, and the employment of apparatus and artificial heat, both costly, on the other. In dry climates, where time and space are unimportant, and labor cheap, crude materials may be advantageously dried by spreading them in the sun and turning them over repeatedly. Where land and manual labor are costly, we must resort to other methods.

(To be continued.)

A SELF-LIGHTING GAS BURNER.

THE novelty which we introduce to our readers by means of the accompanying illustrations is one of the

most ingenious applications to a useful purpose of a well-known physico-chemical phenomenon that has lately come under notice. The figures represent, in elevation, section and plan, Duke's self-lighting gas burner. The patentee does not confine his device to ordinary flat-flame burners; but the principle and the method of application are sufficiently exemplified by the simple pattern here shown. Briefly stated, Mr. Duke's system is for the adaptation of the property of platinum to occlude hydrogen, with development of heat, to ignite a stream of gas issuing from a burner. He has succeeded in doing this very perfectly, with due regard to cheapness and substantiality of construction.

To the body of a governor burner, in the illustrations, is attached a small tube carrying at its top a plug of porous refractory material upon which plati-

num black has been deposited by a special process. Springing from this plug is a short piece of fine wire, composed of a platinum alloy, which spans the distance to the burner tip, with which it is parallel. This is the whole arrangement. All that is needed to light the burner is to turn on the gas, which has the effect, within six seconds at most, of causing the porous plug to glow. The draught of air through the small tube instantly helps to raise the temperature of the small wire to a point at which the effluent gas is ignited.

So beautifully simple and effective an appliance argues a long and arduous process of development; and we were therefore not surprised to learn from Mr. Duke that he has been many years engaged in overcoming numerous practical difficulties which he met with in the course of his efforts to make coal gas light itself by taking advantage of the phenomenon of the occlusion of hydrogen by platinum. The chief trouble was to obtain a material for carrying the platinum which would enable the operation to be completed quickly enough, and yet stand a fair amount of knocking about in transit and wear and tear. Asbestos, of course, suggested itself; but it proved disappointing. The material finally selected, the nature of which and its special preparation cannot at present be disclosed, for reasons connected with the latest patents, is not particularly fragile, though, of course, it will not bear to be brutally handled. We are informed that the permanence of the effect of lighting gas in this way has been ascertained by a protracted course of testing representing many thousands of ignitions and extinctions, besides the test of keeping burners continuously alight for months at a stretch, after which the material was found to act as well as ever.

It was once regarded as a wonderful thing to get "light without a wick," and it is no less so to be able to make gas light itself automatically without having to bring to it a flame or a spark. The possible range of utility of Mr. Duke's invention is immense. It raises the hope of being able to dispense with the pilot light—that usually evil-smelling, wasteful adjunct to all kinds of inclosed gas burners. Among other benefits, it should be an effectual cure for the peculiar American complaint of "blowing out the gas," which figures so frequently in United States mortality statistics.—*Journal of Gas Lighting.*

NEW COMBINATION OF ARGON: SYNTHESIS AND ANALYSIS.

By M. BERTHELOT.

THE knowledge of the action of carbon disulphide upon nitrogen when submitted to the electric effluve led me to try the same influence upon argon. The experiment has been fully successful; it gives rise to a combination more rapid and complete than that produced with benzene, and not apparently limited like that of phenomena of equilibrium. In each case the mercury intervenes chemically, as I have recognized in my recent experiments.

I operated upon 6.55 c. c. of argon, as pure as possible, and such that benzene, employed once, did not determine (under the influence of the effluve) a direct absorption exceeding nine hundredths. I brought the gas into contact with liquid carbon disulphide at about 23°, a temperature at which the tension of the sulphide rises to 0.98 meter. This fact has been taken account of.

After three hours of the effluve, under the conditions described in case of nitrogen, the absorption of the argon rose to 11 per cent. of its initial volume. After 8 hours it increased to 17 per cent.

The gases of the recipient were changed, and a new dose of carbon disulphide was added.

A third reaction of the effluve raised the absorption to 22 per cent., a fourth reaction to 34 per cent. and a fifth reaction to 39 per cent.

The gases of the recipient were changed again; a further dose of carbon disulphide was added, and the experiment was resumed. The total absorption increased then to 56 per cent. The argon represented only 2.9 c. c. An accident prevented me from prolonging this experiment, which had lasted about 60 hours.

But it is scarcely doubtful but that it would have ended in total absorption. It did not appear limited by an inverse reaction, and it is not accompanied at the ordinary pressure by a fluorescence visible in full daylight, and capable of giving rise in diffused light to special spectroscopic rays.

These characters distinguish the absorption of argon by carbon disulphide from its absorption by benzene. In fact, the latter is slower and is limited by reactions of dissociation which stop the direct action, effected once, at about 9 or 10 per cent. with pure argon. Indeed, on separating the unabsorbed argon from its products, we may renew the action, but always with difficulty. After 60 hours, with renewal, I have not gone beyond 16 per cent. Lastly, the absorption of argon by benzene determines the formation of a fluorescent vapor giving at atmospheric pressure a fine green, visible in full daylight, in which we distinguish among others the rays of the vapor of mercury, i. e., the indication of the presence of a volatile compound of mercury formed in the reaction of argon with the hydrogen carbide. On the contrary, no fluorescence of this kind at this pressure is observed during the absorption of argon by carbon disulphide.

I shall soon return anew to the study of this extraordinary fluorescence. But at present I may mention that it constitutes an essential difference between the combination of argon with the elements of carbon disulphide and its combination with the elements of benzene. Nitrogen gives nothing analogous.

I submitted the product of the reaction to a special examination. The compound naturally contains mercury, but we cannot decide whether this element is associated with argon in one and the same compound. If treated with sodium sulphide, it does not give reactions analogous to those of sulphocyanide, except a slight yellow coloration (after acidification) with ferric salts.

I have succeeded in regenerating argon from the compound just mentioned. In this new research I avoided taking the product which had absorbed the first doses of the gas, as it might contain nitrogen if any remained in the argon used for the experiment.

I operated upon the second product, which had ab-

sorbed 1.2 c. c. of argon; I submitted this product at once to the action of heat, in the same tubes in which it had been condensed over the mercury after the complete evacuation of the gases and operating as it had been done in case of carbon disulphide.

While this operation performed on the product of the absorption of nitrogen by carbon disulphide yielded only an insignificant residue, with the product of argon I obtained 0.62 c. c., i. e., equal to about half the volume of the gas absorbed. This number, however, is too low, considering that a very considerable part of the condensed product escapes the action of heat, because of the impossibility of causing the mercury to boil as far as the lower and expanded part of the test tubes, whereby a portion of the transformed matter is deposited. The contracted part alone is raised to about 500°. Thus the figures given have a merely qualitative meaning, being intended to give some idea of the order of greatness of the phenomena.

I will add that I have caused the condensed product in the annular intervals of the two tubes to undergo three successive heatings to dull redness, evacuating each time the gases produced and collecting them again separately. Their gross volume amounted to several c. c. by reason of the regeneration of the carbon disulphide, a circumstance which insures the most complete elimination of the other gases.

The first heating yielded, after the reaction of the alcoholized potassa and acid cuprous chloride, and final purification by potassa, volume = 0.41 c. c.; the second heating, 0.20 c. c.; the third heating, 0.01 c. c.

The decomposition of heat is thus exhausted in the portion of the substance capable of being heated to dull redness.

To verify if the gas thus regenerated is really argon, I had recourse to the only positive character obtainable in my apparatus, i. e., the production of the fluorescent spectrum developed by benzene at the ordinary pressure. I used effluve tubes of reduced dimensions, such that 0.40 c. c. of the regenerated gas occupied in the first place a length of 5 or 6 cm. By operating thus I succeeded, in fact, in obtaining most distinctly at a pressure bordering upon that of the atmosphere the green fluorescence characteristic of the compound of argon and benzene. The 0.40 c. c. were reduced thus in 8 hours to 0.35 c. c., the absorption taking place with the slowness characteristic of argon and reaching the same limit. I repeated the same test with 0.12 c. c. of the gas regenerated by the second heating with the same success, and I established in both cases the existence of the specific rays of this fluorescence developed in diffused light and near the normal pressure.

This experiment seems to me capital, since it demonstrates that argon can enter into combination and be regenerated with its original properties. — *Comptes Rendus*, cxx, p. 1316; *Chem. News*.

[FROM NATURE.]

ARGON AND HELIUM IN METEORIC IRON.

In the light of the new discoveries of argon and helium, it appeared that reinvestigation of the gas evolved on heating meteoric iron might promise interesting results. This anticipation has been fulfilled. Meteoric iron, heated in vacuo, yields a small amount of both argon and helium, besides a comparatively large quantity of hydrogen.

The investigation of gases occluded in meteoric iron was undertaken by Graham in 1867 (*Proc. R. S.*, xv, 502). From 45.2 grammes of a specimen of iron from Lenarto, in Hungary, Graham obtained by heating it in vacuo, 16.53 c. c. of gas, consisting of 85.68 per cent. of hydrogen, 4.46 of carbonic oxide, and 9.86 per cent. of "nitrogen." And eight years later Prof. Mallet investigated the gases from a specimen of meteoric iron from Augusta County, Virginia, and found 35.83 per cent. of hydrogen, 38.33 per cent. of carbonic oxide, 9.75 per cent. of carbonic anhydride, and 16.09 per cent. of "nitrogen." (*Proc. R. S.*, xx, 365.)

In the same year, Prof. A. W. Wright examined spectroscopically the gases evolved from two meteorites, one the "great Texas meteorite" in the museum of Yale College, which weighs 742 kilogrammes; another a specimen of meteoric iron from Tazewell County, Tennessee; and a third set of experiments was made with fragments of a meteorite from Arva, in Hungary.

The gases obtained were examined spectroscopically, and were found to show the usual spectra of hydrogen, carbon compounds, oxygen and nitrogen. He was searching for lines present in the spectra of stars, but found none; and he concludes that the spectrum of the solar corona is to be ascribed merely to atmospheric gases. A preliminary account of the examination of a fourth (a stony) meteorite is given in the same journal (*Amer. Journal of Science* [3] ix, pp. 294 and 459), and the full account in vol. x, 44. Suffice it to say that the last fractions of gas evolved contained 6.91 per cent. of "nitrogen." On p. 257 of the next volume (xi) Prof. Wright gives analyses of the gases from various samples of meteorites, which contain from 1.54 to 5.38 per cent. of "nitrogen." And lastly, in vol. xii, p. 165, he gives further details, including descriptions of spectra, in none of which he noticed anything unusual.

Prof. Wright's interesting papers are instructive, inasmuch as they show how little reliance is to be placed on the evidence of the spectroscopic as to the presence of any one gas in a gaseous mixture consisting of a large proportion of other gases. There is no doubt that in future much attention should be paid to the relative conductivity of gases. The characteristic spectrum of argon is almost completely masked by the presence of a few parts per cent. of nitrogen or of hydrogen; and that of helium is similarly affected, although to a less degree. Though no quantitative experiments have been made on the subject, yet I should judge that the presence of from 5 to 10 per cent. of nitrogen entirely obscures the characteristic yellow line; the other strong lines still remain visible. I hope soon to be able to communicate further information on this interesting subject.

The presence of both argon and helium has been demonstrated in the meteorite from Augusta County, Virginia, a sample of which was purchased from Mr. Gregory. Two ounces of turnings of this meteorite were heated to bright redness in a hard glass tube,

all air having been first removed in the cold by a Topler's pump.

From this iron, 45 c. c. of gas were obtained. It was mixed with oxygen in a gas burette, and exploded. It appeared to consist for the most part of hydrogen. After absorption of any carbon dioxide and the excess of oxygen with alkaline pyrogallate, the residue amounted to about half a cubic centimeter. It was transferred to a small tube and dried with a morsel of solid caustic potash, and with it several vacuum tubes were filled. The spectrum showed that it consisted for the most part of argon; the trace of nitrogen which appeared at first rapidly disappeared under the influence of the discharge.

The spectrum was carefully compared with that given by a tube of atmospheric argon, provided with magnesium electrodes. This sample of argon always shows the D lines of sodium, owing to the magnesium electrodes, and proves especially convenient for the detection of helium, the yellow line of which is not coincident with the lines of sodium. Both spectra were thrown into a two-prism spectroscopic at the same time and on careful comparison it was evident that all the argon lines were present. Besides these the yellow line D₂ of helium was faintly visible, not coincident with the sodium lines; and on comparing the spectrum of the gas directly with that of helium from cleveite, it was possible to recognize the identity of the red, blue green, blue and violet lines of helium in the meteoric gas. No other lines were visible than those of argon and helium. It may thus be concluded, on spectroscopic evidence, that both argon and helium are contained in meteoric iron, the former in much larger amount than the latter. This conclusion was verified by mixing about 90 per cent. of argon with 10 per cent. of helium. The spectrum of helium, under these circumstances, was much more brilliant than that of argon; hence it may be concluded that less than 10 per cent. of this gaseous residue consisted of helium.

It appeared likely that metallic iron might be induced to absorb argon. It had been noticed, last October, that in attempting to prepare argon by passing atmospheric nitrogen through iron tubes filled with magnesium turnings, and heated to redness, a smaller quantity of argon than usual was collected. This rendered it not improbable that iron at a red heat is permeable to argon. If permeable, then it might be permanently absorbed. An experiment was therefore undertaken by Mr. Kellas, to whom I have to express my indebtedness, to ascertain whether finely divided iron, obtained by the reduction of ferric oxide in hydrogen, would occlude argon.

About 14 grammes of the finely divided iron was placed in a combustion tube, the capacity of which was 53.6 c. c. The tube was connected by a three-way stop cock to a Sprengel's pump and to a water-jacketed reservoir containing argon over mercury. After exhausting the tube, argon was allowed to enter, and the temperature was slowly raised to 600° and maintained for three hours. Until equilibrium of temperature had been established, no perceptible change of volume could be noted. The tube was allowed to cool, connection with the argon reservoir was closed, and the gas was pumped off. The volume, corrected for temperature and pressure, was 54.2 c. c.

On heating the tube, about 59 c. c. of gas was given off; it was collected in three fractions, a, b, and c, the heating having been continued for twelve hours.

a. The volume of this gas was 30 c. c. It was collected at about 200° C. This was exploded with oxygen; and a residue was obtained, of which the greater part dissolved in caustic potash, showing that the gas had consisted of hydrogen and hydrocarbons. The final residue was 1.7 c. c.

b. The second fraction, collected at 450°, amounted to 15 c. c., and after treatment as above, the residue was 0.25 c. c. This residue was united with that from a, and a vacuum tube was filled. The flutings of carbon were visible, and also a trace of hydrogen, but no argon. This gas was sparked with 1 c. c. of oxygen, and on absorbing the excess of oxygen with alkaline pyrogallate, 0.45 c. c. remained. On transferring this residue to a vacuum tube, the banded spectrum of nitrogen was alone visible.

c. The third fraction, collected at a red heat, also showed only the spectrum of nitrogen, when purified and transferred to a vacuum tube, and on continuing the discharge it also disappeared and the tube became phosphorescent. Judging from previous experience, the presence of argon would have revealed itself after the nitrogen had disappeared. It may therefore be concluded that whether iron is permeable to argon at a red heat or not, it does not permanently retain the gas. It is not improbable that the condition of retention may be that the iron is heated to fusion in an atmosphere of hydrogen, hydrocarbons, argon, and helium, and that it is then suddenly cooled. This I should imagine to be the case if the iron were ejected from some stellar body at a high temperature. I am, however, unaware whether any of the lines of the argon spectrum have been identified in the spectra of stars; if not, it is probably because they are masked by the spectra of hydrogen and carbon.

W. RAMSAY.

REDUCTION OF ALUMINA, ETC., BY HYDROGEN.

THE refractory earths alumina, glucina, chromium oxides, etc., have hitherto refused to become reduced by means of hydrogen. Mr. H. N. Warren claims, however, to have lately succeeded in reducing not only the above named earths, but even zirconia, although silica and magnesia have as yet yielded no metal when exposed to the action of hydrogen gas.

The difficulty in obtaining a substance free from carbon, and, at the same time, one of difficult fusibility, has naturally been the chief drawback in reducing the oxides in quantity, but in several instances distinct globules of melted metal have been obtained.

The apparatus made use of consisted of a thin tube composed of compressed lime of excellent quality, the alumina inclosed therein being obtained by calcination of the aqueous chloride. To one extremity of the tube was attached an apparatus for evolving pure and dry hydrogen gas, while to the exterior of the tube, and upon the same spot wherein was inclosed the alumina, was allowed to impinge the flame from a powerful oxyhydrogen blowpipe, both gases being

under the same pressure. At the same time a slow current of hydrogen gas was sent through the tube for about ten minutes. The action of the melted alumina upon the lime very soon, however, determined the destruction of the calcareous lining, owing to the increased fusibility of the compound formed, while its interior showed no trace of metallic formation.

This, on referring to the action of hydrogen upon zinc oxide, will be better understood, a slow current of gas producing no effect, while, on the contrary, a swift current of gas readily reduces the oxide, through depriving the interior of the apparatus of the aqueous vapor formed, thus preventing reoxidation of the metal under formation. A second tube, arranged as in the former case, was, therefore, experimented upon, using a brisk current of hydrogen gas. The interior of the tube, upon examination, now contained distinct traces of metal, perfectly bright, while in a further experiment distinct beads of aluminum were detached and examined, resulting in pure metal. A mixture of $Al_2O_3 + CuO$ readily reduced to aluminum bronze, and tungsten and molybdenum were reduced and fused. Zirconia has as yet not afforded such striking results, while silica and magnesia have failed altogether.

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