the current strength will change from maximum to zero. The rapid demagnetizing of the magnet and the consequent drop in the strength of the magnetic field to practically nothing will cause a current to flow in the conductor, *C*. Not only the conductor, *C*, but conductor, *W*, crosses the path of the lines of force, they taking the direction as shown by the dotted lines. Therefore it is plain that not only is a current generated in *C*, but in the conductor, *W*, as well. The pressure of the current which is induced by changing the strength of the magnetic field is proportional not only to the change of the current strength but to the rapidity with which the change is made. Hence, breaking the current at *X* produces an induced current of high tension in the conductor, *W*, and this current, of high tension, will jump the short gap formed during the first break of the circuit at *X*. Note carefully that the magnetic field has been strengthened by means of the iron core and that a greater reactionary current is produced when a core of iron is present than when the coil, *W*, is not wound around an iron core. If the circuit is broken, as in the hammer-break igniter, within the cylinder of a gas engine, it produces a spark sufficient to ignite the charge. The pressure of the current produced in the coil is directly proportional to the number of turns of wire lying in the magnetic field. Suppose that about the conductor, *W*, in Fig. 2, there are wound several thousand turns of very fine wire, as shown at *S* in Fig. 3. Then when the circuit, *W*, is broken at *X*, a current of very high tension is produced in the fine wire winding strong enough to jump across the gap, *G*. If the gap, *G*, were inside the cylinder of the gas engine, as in the spark plug of the jump-spark system of ignition, there will be sufficient heat generated to ignite the charge.

In Fig. 4 is shown in greater detail the principles of the hammer-break system of ignition. The coarse wire winding, *w*, say N. 16 gage, is wound about a core, *c*, consisting of a bundle of soft iron wires, the ends of the wire, *w*, being attached to the binding posts, *b b*. One of these binding posts is connected to a terminal of the battery, *B*, and the other by means of the wire, *I*, to the stationary electrode of the igniter. This electrode is insulated from, i. e., kept out of electric contact with the cylinder of the engine. The other terminal of the battery is connected to the electrode, *m*, or as *m* is in electric contact with the engine, this wire may be connected to any point upon the ironwork of the engine. Both terminals, *m* and *n*, are within the compression space of the engine. Just before the time for ignition these terminals are brought together and the current then passes from *B* through the spark coil, *C*. At the proper moment for the ignition, *m* is jerked away from *n*, producing a quick break in the circuit and the relative spark already described. With reference to the spark coil *C*, it should be noted that it takes a small fraction of a second for the current to fully magnetize the core, *c*. Therefore the igniter points should be brought together a small fraction of a second before the time for ignition. The longer the coil, the longer time is required for the core to reach full magnetization, or in other words, to become fully magnetized. If the time the circuit is closed is too short, the resulting spark will be weaker than if the circuit is closed long enough for the core to be magnetized. A long spark coil requires a longer time to reach full magnetization than a short coil. Hence short coils should be used for high-speed engines and in automobile practice they should not be over 6 inches long, a 5-inch coil being preferred.

Diagram No. 5 illustrates the jump-spark system of ignition. The Ruhmkorff coil consists of a core, *a*, made of a bundle of soft iron wires, usually 22 gage, and surrounded by a primary, *p*, of coarse wire, usually 16 gage. About the primary winding is a secondary, *s*, consisting of a very long winding of exceedingly fine wire, quite frequently 36 gage. Opposite one end of the core, *a*, is a soft iron armature, *j*. Attached to the spring, *i*, are contact points of platinum, making a gap at *f*. In the base of the coil is a condenser, *x*, made of a number of layers of tinfoil separated from each other by oiled paper. Alternate layers of tinfoil form one side of the condenser and are electrically connected to the contact screw, *o*. The remaining layers of the condenser are electrically connected to the spring *i*. The spark plug consists of a brass or steel body, *m*, threaded at one end with a pipe thread for screwing into the cylinder and the central conductor, *e*, insulated from the body, *m*, by either mica, porcelain or some form of artificial stone, as lava. The insulation must necessarily be of high resistance in order to insulate the high-tension circuit of the secondary. Projecting from the threaded end of the body, *m*, is a wire terminal, made usually of platinum or German silver and approaching but not quite meeting the left-hand end of the central conductor, *e*, forming a gap at *w*, about 1-32 inch wide. The contact maker consists of a body, *d*, on which is mounted a pillar carrying the adjusting screw, *y*, and another carrying the spring, *h*. Attached to the end of the contact screw and to the spring are platinum contact points forming a gap at *n*, similar to the one at *f* on the coil. On the end of the spring, *h*, is a knob, *g*, and on the cam shaft is a cam, *k*, having a notch at one point in its circumference. A rod, *q*, connected to the operating lever is used to rotate *d* around the cam shaft.

The operation of the system is as follows: The current passes from the source of energy, the battery, *B*, to the spring, *h*, by the gap, *n*, to the adjusting screw, *y*, thence through one of the binding posts of the coil to one end of the primary winding. The other terminal of the battery is connected to another binding post

of the coil, thence it passes to the adjusting screw, *o*, crosses the gap, *f*, goes on through the spring, *i*, and to the other terminal of the primary. As the cam revolves the knob, *g*, falls into the notch and the contact points at *n* come together, closing the circuit to the primary. The moment the circuit is closed through the primary, the core, *a*, is magnetized, attracting the armature, *j*, breaking the circuit at *f*, and demagnetizing the core. When the core, *a*, is demagnetized, it releases the armature, *j*, and the spring, *i*, closing the circuit at *f*, when the operation is repeated. This, it will be seen, causes a rapid change in the strength of the magnetic field each time the circuit is broken at *f*. This magnetic variation induces a current in the coil, *s*, which, being composed of a great number of turns of a very fine wire, produces a high tension and a spark leaps the gap at *w*. So long as the vibrator is working, there will be a series of sparks occurring at *w*. The condenser, *x*, is connected across the gap, *f*, and its purpose is to reduce the volume of the spark at that point. When the circuit is broken at *f*, the conductor neutralizes the effect of the reaction. If it were not for the condenser a great deal of the energy would be wasted by producing a spark at *j*, and thus cut down the spark at the gap, *w*, of the spark plug.

In some coils, notably those used on the motor bicycle, the vibrator, *j*, is omitted, and but one spark is produced by breaking the circuit at *n*. With the vibrator coil, ignition takes place at the time the knob, *g*, falls into the notch in the cam. With the non-vibrator coil the point of ignition is when the knob is lifted from the notch. There is little or no spark at the time of breaking the circuit, for the reason that the change in the strength of the magnetic field is slower owing to the small interval of time it requires to magnetize the core, *a*. The advance of the spark is readily altered by rotating the contact maker around the cam shaft by means of the rod, *q*. If the contact maker is rotated in the same direction the cam shaft is revolving, ignition will occur later, while if it is rotated in the direction opposite to the motion of the cam shaft, the spark will be advanced.

The catalytic system of ignition is illustrated in Fig. 6. Catalytic defined, means "contact," and the system is nothing more than hot-wire ignition. The battery, *B*, of large current capacity, is connected in series with a coil of fine platinum wire, *C*, within the compression space. At *R* is shown a rheostat with a sliding contact, *X*. Sliding *X* to the left cuts down the resistance of the circuit and raises the temperature of the wire at *C*. The writer does not know of any commercial use of this system, it having been used only in an experimental way in Europe. It is said that by raising the temperature of the wire the ignition will be advanced and *vice versa*; therefore, the time of the ignition can be controlled by use of the sliding contact, *X*.

In comparison of the several systems of electric ignition it may be said that the objection to the primary or hammer break are the moving parts within the cylinder, the wear of the parts while operating at high speeds, and especially wear of the igniter points at the gap in Fig. 4, and it has a somewhat greater current consumption than the jump-spark system. The jump-spark system has the objection that there are more parts to take care of, that high tension makes insulation difficult, and the ignition plug is easily put out of commission by a crack in the insulation. However, for a variable lead the jump-spark system is easier to manipulate and has all the moving parts at the outside of the cylinder, where they may be kept cool and are easy to get at and adjust when the engine is running. It may be said of the hammer-break system that when it is arranged for variable lead there is very nearly, if not quite, as much mechanism involved as with the jump-spark system. As a matter of fact, the writer's opinion is that the jump spark has a slight advantage over the hammer-break, but that both of them are equally effective for high speeds. However, when it comes to igniting multiple-cylinder engines, the jump-spark system has an advantage over the hammer-break in the simplicity of mechanism, because one contact box can be made to answer for all the cylinders. In regard to the catalytic system, it is so new and untried that it is too soon to compare it with the systems using the electric arc.—Automobile Review.

ELECTRICALLY-HEATED CARBON TUBE FURNACES.*

PART I.

By R. S. HUTTON, M.Sc., and W. H. PATTERSON, B.Sc.

It is surprising, when the importance of the subject is considered, how very little laboratory work has been done with the electric furnace under properly adjusted and fixed temperature conditions in those higher regions of temperature where the electrical is practically the only possible method of heating. Up to 1,300 deg. C. the furnaces in which an electric current passes through a nickel or platinum wire have fully proved their usefulness, while in the case of experiments of short duration platinum wire or foil heating coils have been employed for temperatures up to about 1,600 deg. C., but seemingly suffer very rapid deterioration when used for any length of time under these conditions. The iridium tube furnace of Nernst and Heraeus, even where its high cost is not prohibitive, seems to be unsuited† for all but the most delicate of experiments, although with it temperatures up to 2,100 deg. C. can be attained. Mention might also

be made of the oxy-hydrogen furnace at Moissan* and the oxy-retort-graphite and water-gas furnaces of Victor Meyer and H. Biltz,‡ since these have served for somewhat delicate work, but, of course, in these cases the temperature conditions are not so fixed as when electrical heating is employed.

Several workers have recently employed furnaces constructed with a carbon tube through which an electric current is passed.‡ This type of furnace seems to be the most readily available for the very highest temperature; despite some inherent disadvantages due to the presence of carbon, it is capable of very wide application.

The authors do not propose to claim any superiority§ of their types of carbon tube furnaces over those constructed by other workers. As, however, they have been able to get satisfactory results with a very simple type of construction, they thought that a brief account of their preliminary work in this direction might be of some general interest.

General Considerations.—The most important points in the construction of carbon tube furnaces are, first, the provision of a satisfactory device for leading the current to the ends of the tube, and, secondly, the protection of the tube from contact with the air or other material capable of reacting with the carbon to burn it away. It is, moreover, a very great advantage to closely jacket the tube with some substance which, while not tending to combine with the carbon, forms an efficient heat-insulator. Even with the most carefully constructed system of exterior concentric tubes with intermediate gas spaces a great amount of heat is carried away by convection currents in the gases, and consequently much more power has to be expended in the tube to attain any required degree of temperature than when the tube is closely jacketed by some material of low thermal conductivity.

The connections at the ends of the tubes should be so constructed as to remain sufficiently cool to prevent any oxidation of that part of the carbon which is exposed to the air. Moreover, provided the ends are kept cool, it is an easy matter to make a gas-tight joint for the passage of any desired gas through the tube.

Graphite Tube Furnace.—The first furnaces made use of were constructed of Acheson graphite, a tube being bored from a solid rod of about 3 centimeters diameter, as shown in Fig. 1. Doubtless, when only a few experiments have to be carried out, this method of construction has its advantages. Blocks and rods of graphite are so frequently required in experimental electric furnace work, that the necessary material is almost sure to be at hand in any laboratory where such furnaces are wanted; whereas the methods of construction, to be described later, require a special provision of carbon tubes of the particular dimensions suitable for the current and power available. The tube was screwed to graphite plates, which served to lead in the current, the graphite plates being held between thick copper clamps, mounted on stands capable of sliding on a smooth plank; to these clamps the cables were connected. One of the sliders was balanced so as to more easily admit of expansion of the tube without fear of breakage. For heat insulation the graphite tube was surrounded with magnesia, or, later, carborundum held in place by brickwork not shown in the figure. On account of the very great shrinkage of calcined magnesia this material was not found satisfactory as a jacketing material. After the tube has been in use for a short time fissures are formed, which allow the air to come into contact with the carbon, and consequently considerably curtail its life; probably by using fused magnesia in the form of powder, better results could be obtained, and experiments in this direction are now in progress.

Both for these graphite tubes and also for the forms of furnace described later, carborundum has been found to be an excellent jacketing material. It is a fairly good heat-insulator, and has the advantage of being a reducing agent, consequently protecting the carbon from burning away.¶ This material has been used in a fine granular condition (the grains just passing through a sieve 180 meshes to the linear inch). So soon as the graphite has attained a fairly high temperature, these grains frit together, forming an adherent, tube-shaped jacket around the graphite, which serves to strengthen and protect it.

The material to be heated in this furnace is placed in a small boat made of graphite or ordinary agglomerated carbon, the bottom of the boat being shaped so as to touch the tube at only a few points, and thus not itself to conduct any appreciable amount of the current.

The temperature is estimated by having a number of small carbon holders on each side of the boat, with pieces of various metal wires placed upright in them.¶

At approximately the melting-point of the metal the wire sinks and disappears from view. For higher tem-

* H. Moissan, Ann. de chim. et de phys. Sér. 7. xxiv. 289 (1901).

† V. Meyer and M. von Recklinghausen, Berichte, xxx. p. 1926 (1897). H. Biltz, Z. physik. Chem. xix. 385 (1896).

‡ F. Haber, "Grundriss der Techn. Elektrochemie" Munich, (1898), p. 330. Lummer and Pringsheim, Ber. deutschen. Phys. Gesell. 1903. 3. H. N. Potter, U. S. A. patents 715,506 to 715,509, Dec. 9, 1902, and 756,891, April 12, 1904.

§ In particular, the construction of some of the furnaces of Mr. H. N. Potter is obviously more perfect in many of the essential details; although probably they could not very easily be made and installed for ordinary laboratory work.

¶ For instance, one of the smaller tubes, after ten or twelve experiments, in nearly all of which it had been heated well above the melting-point of platinum, was found to have altered only to a quite insignificant extent in internal and external diameter.

¶ The practical constancy of temperature throughout the central portion of the tube was determined by having a number of small boats containing projecting nickel wires at regular intervals, and noting, when the temperature was slowly raised, that those in the central 15 centimeters melted at very nearly the same time.

* A paper read before the Faraday Society on Tuesday, April 4, 1905.

† W. Nernst, Trans. Amer. Electrochem. Soc. iii. 75 (1903); Z. Elektrochem. ix. 623 (1903). W. C. Heraeus, Z. angew. Chemie, 1905, 49-53.

peratures little cones of pure alumina or magnesia have been used, but more recently an optical pyrometer has been obtained, which it is hoped will prove very serviceable for experiments of this kind. The thicker ends of the graphite tube and the graphite plates get too hot to admit of a rubber or cork stopper being used; the glass tubes which serve for the gas inlet and outlet were therefore fixed with a plug made of fine asbestos string.

Agglomerated Carbon Tube Furnaces.—Where a considerable amount of work has to be done, the time necessary for boring and turning graphite tubes, which on account of the thin walls are always mechanically weak, is obviously a disadvantage. For most of our experimental work, therefore, we have made use of agglomerated carbon tubes, which can readily be obtained of almost any desired size from the several manufacturers of arc carbons. The amorphous carbon, being very hard, cannot be machined in the simple manner which is possible with graphite, and even grinding with carborundum wheels is a somewhat laborious operation; it was therefore decided to adopt a quite different method of making the electrical connections.

The construction finally adopted has proved itself so excellent in actual use that we believe it to be capable of wide application in electric furnace work, and have already adopted it for several types of resistance core furnaces.

The ends of the carbon tube, which may with advantage be somewhat roughened by filing, are electro-coppered, and then soft-soldered to thick copper tubes just large enough to slip over them. The copper tube is provided for a short distance with a brazed-on water jacket, which effectively cools the joint and protects it, even when very high current-density is necessary; at the further end of the copper tube a copper clamp connected with flexible cables leads in the current. By soft-soldering the carbon to copper tubes with brazed water jackets, it is always possible to easily replace the carbon without any fear of injuring the joints of the water jacket. The length over which the soldered joint has to be made obviously depends on the size of carbon tube and the strength of current to be sent through it, but with this water cooling the necessary surface of contact is surprisingly small.*

For the earlier experiments, carbon tubes 30 centimeters long, 15 millimeters internal, and 20 millimeters external diameter were employed; these were jacketed as before with carborundum, which was generally kept in place with an external asbestos tube and asbestos washers fitting tightly up against the ends of the water jackets.

A similar construction has been used with much larger tubes (60 centimeters long, 67 millimeters internal, and 82 millimeters external diameter), as

FIG. 1.—GRAPHITE TUBE FURNACE.

The tube is bored and turned from a solid rod, and is screwed at the ends into graphite plates (2.6 x 5.2 centimeters), which are clamped to copper holders not shown. The glass extensions, which are fixed into the graphite tube at A and B by asbestos, serve for the passage of gas through the tube; the plate-glass ends enable the progress of the experiment to be observed from either end. The central portion of the tube is surrounded with carborundum, or other heat-insulator, not shown in the figure. The material to be heated is placed in small carbon boats which are advanced to near the center of the tube.

shown in Fig. 2. The horizontally placed tube is capable of taking a number of small crucibles containing the material to be heated, but it is hoped to use these and still wider tubes in a vertical position, in which case a useful means of heating larger crucibles will be available. With these large tubes it is advisable to use some sort of diaphragm near the ends to prevent the radiated heat from burning the surface of the rubber or cork stoppers, which, as the copper is effectively cooled by the water jacket, can serve to attach the gas inlet and outlet extensions; with the small tubes there is no need to take this precaution.

During the past few months tube furnaces of this simple type have been in constant use and have been found to work with satisfaction. The rapidity with which a very high temperature can be obtained and the regulation of that temperature by simple variation in the strength of the current render their use very convenient. On the other hand, by starting with a relatively small current it is possible to raise the temperature as slowly as desired and thus not to exceed any required maximum. Without the more trustworthy data, which it is hoped to obtain by the use of the optical pyrometer, it does not seem advisable to hazard any estimate of the highest temperatures which can be reached with this method of heating.

Owing to the porosity of the carbon tubes at high temperatures, it is difficult, even with a fairly rapid current of hydrogen, to keep the gas in contact with the heated material free from carbon monoxide. Since this was highly desirable in some of the experiments

we have been carrying out, a modified form of construction was adopted for this special case. In the first modification the carbon tube was surrounded with a water-cooled, gas-tight, metal jacket through which hydrogen was passed, but with this arrangement the convection currents in the external gas carry off an enormous amount of heat, and a very high current density is required to reach even moderately high temperatures. On the other hand, when the carborundum-jacketed tube is, as a whole, surrounded with the gas jacket, the gas in the inner tube still contains 1 or 2 per cent of carbon monoxide, which is probably due to the carborundum containing a small amount of unre-

FIG. 2.—SIMPLE CONSTRUCTION OF AGGLOMERATED CARBON TUBE FURNACE.

The ends of the carbon are coppered and soldered at A and A' to copper tube extensions provided for a short distance with water jackets B, which keep the joint cool. The current is led in by copper clamps D. Glass tubes C are connected to the ends of the copper tubes by rubber stoppers, and serve for the passage of gas and for observation of the progress of the experiment. Smaller tubes of essentially the same construction have also been much used.

duced silica. The arrangement finally adopted (see Fig. 3) has worked well, and is, moreover, considerably more efficient than when a bare carbon tube is surrounded with a large gas inclosure. The central carbon tube (30 centimeters long, 15 millimeters internal, 20 millimeters external diameter) forms the heating tube proper, and alone carries the current; it is surrounded by another carbon tube (3.0 centimeters internal diameter), which is jacketed with carborundum as a heat-insulator. Both carbon tubes are provided with water-cooled copper-tube extensions. Hydrogen is passed through the space between the two carbon tubes, as also through the inner carbon tube, and in this way it is easy to keep the gas in contact with the heated material almost absolutely free from oxygen compounds.

For a large number of purposes these precautions are quite unnecessary, and the simpler form of construction is all that is required; we have therefore ourselves confined the use of this furnace to some experiments in which it was desired to study the action of carbon on some metals without the intervention of carbon monoxide.

In all our experiments we have had to use continuous current, although obviously low-tension alternating current obtained by the use of a transformer would be much more convenient, particularly with the large-sized tubes.

In many laboratories the high currents required will certainly be a hindrance to the employment of such carbon tube furnaces, but in these cases it may be an advantage to increase the resistance of the tube by some such method as that proposed by E. Ruhstrat and E. W. Grimmer,* who cut a spiral on the carbon tube, and thus form a more or less narrow helix, which can be made to take quite small currents at correspondingly higher voltage.

In view of the prospect of shortly having fairly trustworthy data as to the temperature variations during the experiments, it is thought advisable to retain for a later paper full details as to the current and voltage readings at different temperatures. The following are only approximate values, which will, however, suffice to indicate the conditions under which the experiments have been carried out. The readings are those observed when the temperature indicated had been reached, and since the resistance obviously decreases as the temperature rises they must not be taken to indicate mean values.

Type of Furnace.	Jacketing material.	Observations.
Graphite: 28 cms. long, 2.0 external, 1.5 internal diameter.	Carborundum	35 amps. at 8.2 volts melts nickel in 26 mins.; 320 amps. at 9.6 volts melts nickel in 13 mins.; platinum in 16 mins.
Agglomerated carbon: 27 cms. long, 2 cms. external, 1.5 cms. internal diameter.	Carborundum	140 amps. at 7.7 volts melts nickel in 19 mins.; platinum in 28 mins.
Agglomerated carbon, 27 cms. long, 2 cms. external, 1.5 cms. internal diameter.	None; bare tube surrounded with hydrogen.	235 amps. at 16.4 volts required to melt nickel (5 mins.)
Agglomerated carbon: dimensions, etc., as Fig. 3.	Carborundum outside outer carbon tube.	300 amps. at 21 volts melt nickel in 3 mins.; current increased to 240 amps. at 25 volts, melting platinum, in further 2 mins.
Agglomerated carbon tube: 60 cms. long, 8.2 cms. external, 6.7 cms. internal (as Fig. 2).	Carborundum	600 amps. at 8.6 volts give 1,000° C. in 30 mins. (temp. still rising 7° per min.); 850 amps. at 13.0 volts melt nickel in 12 mins.; platinum in further 84 mins.; later much hotter and takes 860 amps. at 11.1 volts.

* British patent 24,472, Nov. 18, 1903.

Important differences manifest themselves according to the type of furnace construction adopted. With a bare tube surrounded with a gas jacket, a given current very soon brings the carbon up to a temperature which remains more or less constant, or at the most only continues to rise very slowly; on the other hand, with carbons closely jacketed with a granular material, which is a good insulator, the temperature continues to rise for a very long time, and in this way, with a much smaller current and expenditure of power than is required in the previous case, a high temperature can be built up. As the temperature rises, however, the jacketing material becomes an electrical conductor, and even pure oxides at or near fusing-point become good conductors, and by carrying some of the current tends to limit the temperature attainable. Further experiments are required to show the relative behavior of different materials in this respect.

One of the great advantages of such furnaces over those in which the heat is obtained from an electric arc or a granular resistance material lies in the fact that the temperature can be much more easily regulated and kept constant.

There is such a vast amount of physical and chemical high-temperature work which can only be carried out when the heating is under perfect control that we feel confident in finding numerous applications for these carbon tube furnaces.

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THE LATEST PERFORMANCES OF TYPICAL FRENCH, ENGLISH, AND AMERICAN AIRSHIPS.

ACCORDING to the old German and Swiss legend, the *Berggeist* were in the habit of invariably attempting to overwhelm the adventurous mountaineer who had the hardihood to attempt to climb previously unscaled peaks, by sending upon him at a critical moment thunderstorms, whirlwinds, and various kinds of avalanches. Once a peak had been scaled the *Berggeist* usually retired in dudgeon, and subsequent adventurers could essay the same road with comparative safety. It must be admitted that similar strange phenomena have been observed at every step in man's progress toward the conquest of natural forces. The attempts made upon the empire of the air provide plenty of instances of the kind, and two of the most painful of them have been illustrated by the history of the Lebaudy airship. It was just as "Lebaudy No. 1" had completed her tour from Moisson to Paris, and from Paris to Challais Meudon, and was actually alighting on the ground, that she was caught by a squall, hurled against a tree and broken up. Similar destruction overwhelmed the splendid airship at the end of her recent tour. She had made a record journey largely against the wind from Moisson to the camp of Chalons, encountering al-

FIG. 3.—SPECIAL TUBE FURNACE FOR EXPERIMENTS IN PURE GAS ATMOSPHERE.

The central carbon tube A A' carries the current and is the heating tube proper; it is provided with copper water-cooled extensions B C, to which the current is led by clamps not shown. To insure the purity of the gas in the tube A A' it is surrounded by a concentric carbon tube E E', which is also provided with copper water-cooled extensions F H, a gas-tight joint between the two tubes being made by the rubber stoppers P. The outer carbon tube is jacketed with a granular heat-insulator to prevent, as far as possible, the radiation of heat. This granular material is held in place by asbestos washers L and asbestos tube K. Glass extensions M serve as in Fig. 2 for the passage of gas through the heated tube, and for observing the progress of the experiment.

most a storm during the latter stages of the tour, which, however, she successfully surmounted, and arrived in triumph in Chalons Camp, where she had hardly been moored when the storm developed into a hurricane that even threw down telegraph poles. Moored in the open, no conceivable airship could stand a tempest of this kind, and it is certainly most singular that tempests of such ferocity are decidedly rare in the middle of France. The cables were pulled out of the hands of the thirty soldiers who held them and the airship was driven against some trees, causing the gas vessel to burst. Fortunately, the occupants of the car were within a few feet of the ground, and escaped practically uninjured. It is too soon to be certain whether the airship can or cannot be repaired, but in any case the designers and owners of the great machine—by far the most successful aeronautical contrivance, as our readers are aware, of modern times—may console themselves by the reflection that, like Gustavus Adolphus, "Lebaudy II." had won her battle when she met her end.

The irritating part about the situation is that it is quite possible the airship might have escaped injury had the hurricane come up while she was *en route*, as she might then have been able to run before it, and beat back when the violence of the storm was exhausted.

Messrs. Lebaudy and their collaborators have shown themselves such enthusiasts in the cause of aerial navigation that we feel confident that they will not be deterred by this very untoward and incalculable misfortune at the very moment of victory from prosecuting their experiments and researches further. We feel sure that before long a "Lebaudy No. 3" will rise from the ashes or remains of "Lebaudy No. 2." But the important question is whether it is really fair that private

* An experiment was carried out to test the perfection of these joints. One of the smaller tubes was surrounded with calcined magnesia, and heated with 300 amperes until the tube was practically completely destroyed. After cooling, the core was examined, and found to have burnt away to a mere shell right up to the copper; the joint, however, was still undamaged, and not even a drop of solder had melted out of it.