time; the task of stoking is very light, and the temperature of the stokehole very much less than that with an ordinary furnace. By means of the arrangement of air flues the quantity of gas generated and the temperature of the glass furnace may be regulated with great precision, the furnace being, of course, smokeless. For a six pot glass furnace each grate surface is 20 ins. by 24 ins., and burns about 14 lbs. of coal per square foot per hour. Each coal box holds about 2 cwt., and coaling is required about every five hours. The furnace is shown at Fig. 4 as applied to a Cornish boiler, and this application of the gas furnace promises to effect as great a saving in labor and fuel as has already been secured in the glass furnace.—*Engineer*.

GAS GOVERNORS.

MR. W. WHITE's automatic valve-governor is exhibited in the annexed woodcuts, Figs. 1 and 2, which are a vertical section and an elevation with lid removed to show the interior of valve-chamber. In a cast-iron box or chamber is contained a flap-valve, hung by a strap, and hinged at two places to insure the metallic valve, which is faced, always coming into close contact with the seat. This latter is at a slight inclination from the vertical, so that the tendency of the valve is to close. For the purpose of weighting the valve to the pressure desired, a pipe, A, is brought to the surface, through which lead shot is dropped into the pocket fixed to the back of the flap. A siphon-box is attached to the bottom of the governor to receive the fluids condensed in the main,

FIG. 1.

FIG. 2.

the vertical pipe, B, shown in Fig. 2 being for the purpose of applying a pump at the surface for emptying the same.

A compact and useful district governor has been invented by Mr. W. Foulis, and is illustrated in Fig. 3. This apparatus, which is made by Messrs. W. & B. Cowan, is altogether novel in design; and, being most sensitive in its action, and occupying the minimum of space for a wet governor, it is peculiarly valuable for the purpose intended. The drawing represents one for an 18-inch pipe, and is to a scale of three-fourths of an inch to the foot. The outer case, A A, is of cast iron, closed both at top and bottom,

FIG. 3.

and having a valve-seat, D D, cast within it. B is the inlet and C the outlet pipe. The valve, E, is formed of two inverted cones, having a cylindrical prolongation, with the necessary float, the object of making the cone double being to neutralize the effect of the inlet pressure; or, in other words, to prevent the inlet pressure from exerting any influence on the action of the governor. In order further to attain this object, the triangular space formed by the two cones is inclosed by a continuation of the cylindrical portion of the valve. In this, slits are cut of sufficient area, and so adjusted that when the valve is open to the full, the area of the portion of the slits below the valve-seat is rather greater

than that above it, thus establishing a uniform pressure in the triangular space, and so equalizing the pressure on the two conical surfaces.

A small pipe, F, is led in at the bottom of the outer case into the interior of the valve. The valve is guided by three pulleys fixed on its top, and the same number of pulleys attached to the outer case at some distance from the bottom. By this arrangement the valve may be withdrawn on removal of the top cover. The vessel is charged with glycerine to prevent freezing. The apparatus is used as a station governor, but it is with its arrangement as a district governor that we are now dealing. When the pipe, F, is connected with the inlet-pipe, and the float loaded to the required amount, the governor is differential in its action—that is to say, the difference between the inlet and outlet pressures is constant, thus enabling the pressure on the district governor to be reduced to any required extent below that at the works.

The differential governor of Mr. H. E. Jones is exhibited in the accompanying drawing, Fig. 4. It consists of a cast-iron box, divided into two chambers, upper and lower, by a central diaphragm division-plate, on which is supported a vertical pipe; the diaphragm has slotted holes on its side near the top, which latter may be surmounted either by a flat plate or by an upright cone. If the former be used, a conical collar or ring is attached to the under side of the crown of the holder, and seats itself on the plate; but if a cone be employed, the ring is less in depth, and is made, as

FIG. 4.

usual, to fit the cone base. When the governor is fixed in the line of main, it has no communication with the atmosphere, for the small vertical pipe is intended only for the attachment of a siphon-pump, and is capped in the ordinary way.

The action of the apparatus is as follows: The gasholder being weighted so as to require, say, 6-10ths of an inch pressure to raise it, the gas, on entering the bell, has first to overcome its resistance, and if the incoming pressure is less than 6-10ths, it is evident that the holder will not be raised from its seating, and therefore no gas can pass. If, however, the pressure exceeds the 6-10ths, the gas holder is lifted, but only such quantity of gas passes as is due to the pressure in excess of 6-10ths, for that pressure must of necessity be maintained underneath the bell in order to support it. Thus suppose the pressure on the inlet to be 10-10ths, then that on the outlet will be 4-10ths; on increasing the pressure on the inlet to 20-10ths, the outlet pressure becomes 14-10ths, and so on. Consequently the governor responds to changes in the initial pressure at the works during the hours of day and night.—*Journal of Gas Lighting*.

TRANSMITTING GAS.

This invention, by Newman & Duesbury, of Litchurch, Eng., has for its object improvements in apparatus for transmitting gas from the retorts to the hydraulic main.

The gas from the retort is at present conveyed into the

TRANSMITTING GAS FROM THE RETORTS TO THE HYDRAULIC MAIN.

hydraulic main by a pipe dipping into the liquor contained in the main, so that the gas has to force its way through the liquor. This invention is to obviate this, by so constructing the pipe hereafter described, which forms the connection (with the pipe G) between the ascension-pipe and the hydraulic main, that it will contain a chamber.

In the annexed drawing, the pipe, H, H, H, which forms the connection between the ascension-pipe, E, and the hydraulic main, F, is constructed in two parts, one part so that it will contain the chamber, A, for the purpose of allowing the clack and spring to work. In this chamber are placed a clack and spring, marked B and C, also a smooth face-plate, marked D, for the bed of clack, which will open when carbonizing coal, and instantly close against all back pressure. G is the dip-pipe connecting the pipe, H, with the hydraulic main, F.

The gas will be delivered into the hydraulic main, F, free from any seal or dip, thus removing all hydraulic pressure from the retorts, and thereby lessening the formation of carbon on the retorts, and giving an increased yield of gas from the coal carbonized. The effect will also be to carbonize the coal in less time, and to lengthen the durability of the retorts.

The apparatus, being self-acting, removes the absolute necessity for exhausters or engines.

AIR SHIPS.

By R. GRIMSHAW, C. E.

THERE are two principal systems proposed for aerial navigation: first, devices lighter than air, or aërostats, which rise and maintain themselves at a height by reason of their very light density, so that it is merely necessary to guide and move them; second, apparatus heavier than air, which must be raised, moved, and guided mechanically. This latter class has two subdivisions: aëroplanes, consisting essentially of a plane, moved by some motor (as a screw or other device), and sustained by the resistance of the air to their movement; and apparatus endeavoring to imitate exactly the flight of a bird.

The first of these three systems of propulsive aërostation is best represented by the Dupuy de Lôme apparatus. This is a balloon so elongated as to present the least possible resistance to displacement of the air, propelled by a screw, and guided by one or more sails acting as rudders. The screw is carried by the car so that it draws the balloon; and from this results an "unleveling," increasing with the speed.

The second system is generally called *aviation*; and we will describe two modes of attempting it.

The first is that of Mr. Pénard. His little model flew a long distance. It had a screw propeller in advance, and on its axis prolonged there was a light rectangular plane, with its longest sides parallel to the screw-shaft. On each of these sides is hinged a nearly semi-elliptical wing, which can be inclined to the plane of the parallelogram. The forward edge of these wings is a little raised. On their rear side, terminating in a straight line, are hinged two rudders—one for each wing. In this test apparatus the rotation of the screw was accomplished by the torsion of an India-rubber cord. The car should be below the wings. The principal plane of the apparatus and the lines of hinging are in the plane of the screw propeller. The wings being disposed symmetrically, the device resembles a huge butterfly.

The second apparatus, on the same general principle, is that of Mr. Du Temple. It has the form of a great bird. The body is a lattice car like a pilot boat, containing a steam engine for operating a screw propeller placed ahead of the boat-car with its shaft resting on its bulwarks and in the plane of symmetry. The wings are of light frame-work, bound tightly to the car, on which they rest. They are perfectly rigid and cannot flap like the wings of a bird. Thus, the bulwarks of the boat, the wings, and the axis of the screw are in the same plane, in this not differing from Pénard's plan. Astern there is a vertical rudder and a horizontal tail, hinged horizontally. On the ground, the device rests on three feet supplied with rollers, and so arranged as to incline the apparatus about 20°, the stern being the lower. The screw is 4 meters in diameter and has 12 wings, appearing to cover $\frac{3}{4}$ of its circle. The pitch is 12 meters. The wings seem to have about 50 square meters surface, and the tail 12 square meters; the car being 4 square meters in plan. According to the author a force of 6 horses is necessary to propel the apparatus (which weighs 1,000 kilogrammes) at a rate of 9 meters per second.*

The third plan, trying to imitate the flight of birds, is yet in the theoretical stage.

It may be well in choosing among these three systems to look into the principles of flight, and first into the action of the air on a moving plane.

The pressure of the air on a plane depends solely upon the relative velocities, no matter what the absolute velocities, of the air and of the plane. We shall consider a horizontal plane and a horizontal direction of the wind.

If a plane heavier than air, and remaining horizontal, be abandoned in the air, it will fall, whether it has velocity horizontally or not; for nothing, under these conditions, can annul the effect of gravity. For a plane heavier than air to be sustained therein it must be oblique and have a certain horizontal movement (or else be sustained by an upward force).

To find the resistance of the air to the movement of a plane inclined to the direction of its movement, it suffices to know this resistance for the translation,† at the same speed, of a plane perpendicular to its motion, and to apply to this resistance a certain coefficient. Omitting minor considerations of friction, air-currents, etc., it has been shown that the work of translation in air is proportional to the surface, to the cube of the sine of the angle of incidence of the wind, and to the cube of the velocity of the wind. Also, that, providing that the angle of a plane moving in the air is maintained at the minimum necessary to sustain its weight, the work of translation diminishes as the speed increases; and that there is an advantage in making the planes of an "aviator" as large, and their angle as small, as possible. The resistance to translation of a sphere is half that of its great circle; and that of an equilateral half spindle is only $\frac{1}{4}$ that of its great circle. Dupré has stated that for high speeds a half-sphere or a half-spindle bears the calculated pressure on only part of the surface; there being even a vacuum or aspiration on part of it, due to a conical film of air following the advancing body. It is thus

*Really, with a surface of about 66 sq. meters, this aëroplane would require, with an angle of 20°, a speed of 33 meters to sustain it, and the propelling force would be about 154 H. P. At a speed of 9 meters, and an angle of 20°, it would need to sustain it 826 sq. meters of surface, and a propelling force of 43 H. P.

†The word translation is employed, to save circumlocution, to denote motion from place to place.

NEW FRENCH STEEL FIELD GUN.

desirable so to shape the aviators as to avoid these eddies.

To compare the work of translation in different systems we must take as a common base a common weight of apparatus and a common speed—at least equal to that of an ordinary wind, say 10 meters per second. With a device weighing 1,000 kilogrammes the following results are found:

Velocity of Wind.	Pressure per Square Meter.
10 meters per second.	13 kilogrammes.
15 " " "	30 "
20 " " "	54 "
30 " " "	122 "
45 " " "	277 "

An ordinary spherical aërostat weighing 1,000 kilog., filled with hydrogen pure enough to support 1 kilog. per cubic meter, should have for diameter

$$\sqrt[3]{\frac{1000 \text{ cu. m.} \times 6}{3.14}} = 12.40 \text{ meters.}$$

The work of translation of the balloon alone (not counting the car) would be

$$\frac{1}{2} \times \frac{3.14 \times (12.40)^2}{4} \times 13 \text{ k.} \times 10 \text{ meters;}$$

or about 104 H. P.

Two equal aërostats, of length six times the diameter, would require a diameter of

$$\sqrt[3]{\frac{12000}{106.76}} = 4.83 \text{ meters each; *}$$

and the work of translation would be

$$\frac{1}{2} \times \frac{\pi \times (4.83)^2}{2} \times 130 = 2380.71 \text{ kgm.,}$$

or about 31 H. P.

Two aërostats, of ten diameters in length, would require † a diameter of

$$\sqrt[3]{\frac{12000}{58\pi}} = 4.03 \text{ meters;}$$

and the work of translation would be

$$\frac{1}{2} \times \frac{\pi \times (4.03)^2}{2} \times 130 = 1657.71 \text{ kgm.,}$$

or about 22 H. P.

For reasons of construction two symmetric aërostats are recommended, although one requires less power. A simple aërostat of ten diameters in length would require a diameter of

$$\sqrt[3]{\frac{12000}{29\pi}} = 5.09 \text{ meters;}$$

and the power to work it would be, instead of the 22 H. P. of the last example of twins,

$$\frac{1}{2} \times \frac{\pi \times (5.09)^2}{4} \times 130 = 1321.96 \text{ kgm.,}$$

or only about 17.6 H. P.

Ease of construction would also point to a hemispherical cap. Now if, preserving the same diameter as in the last example, the length were so modified as to have it in form of an equilateral half-spindle, the work of translation would be only

$$\frac{1}{2} \times 1321.96 = 771.14 \text{ kgm.,}$$

or only about 10.28 H. P.

We will now suppose an aëroplane weighing in all 1,000 kg., and moving horizontally with a velocity of 10 meters per second. To have the least dead weight, it must work at an angle of $54^\circ 44'$; and then the work of translation would be

$$* 1000 \text{ cu. m.} = 2 \left\{ \frac{\pi d^2}{6} + \frac{5\pi d^3}{4} \right\} = \frac{34}{12} \pi d^3$$

$$† 1000 \text{ cu. m.} = 2 \left\{ \frac{\pi d^3}{6} + \frac{9\pi}{4} \right\} = \frac{58}{12} \pi d^3$$

$$1000 \times 10 \text{ meters} \times \frac{\sin. 54^\circ 44'}{\cos. 54^\circ 44'} = 14,088.69 \text{ kgm.,}$$

or about 187 H. P.

This aëroplane would have for aviating surface

$$\frac{1000}{13 \sin. a \cdot \cos. a} = \frac{1000}{13 \times 0.385} = 199.98$$

square meters (say 200 sq. m.).

To move at an angle of 14° (of which the tangent is about $\frac{1}{4}$) it must sustain a horizontal pressure of

$$\frac{1000 \text{ k.}}{200 \text{ sq. m.} (0.0568 = \sin. 14^\circ \cdot \cos. 14^\circ)} = 88 \text{ k.,}$$

corresponding about to a speed of

$$\sqrt{\frac{88 \text{ k.}}{10^3 \cdot 13 \text{ k.}}} = 26 \text{ meters; and the}$$

work of translation at this speed would be

$$26 \text{ m.} \times 88 \text{ k.} \times 200 \text{ sq. m.} \times (0.0142 = \sin. 14^\circ) = 6497.92 \text{ kgm.} = 86.63 \text{ H. P.}$$

But if one had made the aëroplane with a surface sufficient to sustain it at an angle of 14° , at a speed of 10 meters a second, the power required at that speed would be only

$$1000 \text{ k.} \times 10 \text{ m.} \times \frac{\sin. 14^\circ}{\cos. 14^\circ} = 0.242 = 2494 \text{ kgm.}$$

about 33 H. P.

This surface would be

$$\frac{1000 \text{ k.}}{13 \sin. 14^\circ \cdot \cos. 14^\circ} = 1354 \text{ square meters.}$$

Now while this angle of 14° is not very small, it is evident that it would not be practicable on account of the immense surface required.

Not only the aëroplane, but the oblong balloon terminating in a spindle, necessitate too much power to be practicable, not only with known motors, but even with those which it is hoped to build. We will then consider the "mixed aëroplane."

Suppose we have a rectangular aëroplane carrying a prismatic aërostat so that their vertical projections in the direction of travel are one; that is, an aërostat comprised between a horizontal plane cutting the upper edge of the aviator plane and three vertical planes cutting the three other edges. In this way the aërostat would present no resistance proper to translation; that resistance being entirely utilized to sustain it.

Suppose an aviator plane with a surface $S = n c^2$, mounted on a prismatic balloon as just explained; p be the total weight, a the aviating angle and d the weight lifted by a cubic meter of the gas—say $p = 1000 \text{ k.}$, $p_a = 13 \text{ k.}$, $d = 1 \text{ k.}$, $n = 2$, $a = 54^\circ 44'$; then $500 \text{ k.} = 5.005 c^2 + 0.472 c^3$; and c (the side of the plane) would be about 7.62 meters; the power required would be $2 c^2 (0.543 = \sin. a) \times 13 \text{ k.} \times 10 \text{ m.} = 8197 \text{ kgm.} = \text{about } 109 \text{ H. P.}$ If, other things being equal, $n = 4$ (that is to say, $S = 4 c^2$), $1000 \text{ k.} = 5.005 \times 4 c^2 + 0.472 \times 4 c^3$; and c (or the length of the plane) = 5.06 meters; the power would be $4 c^2 \times 0.543 \times 130 = 7228 \text{ kgm.} = \text{about } 96 \text{ H. P.}$

It is easy to see how rapidly the power required diminishes with n (n being the oblique area of the plane). Now suppose the cube of the prismatic aërostat doubled by such a symmetric increase that the vertical projection opposed to the wind is not altered. Then $1000 = 5.005 \times 4 c^2 + 0.472 \times 16 c^3$; and $c = 4.35 \text{ m.}$ The power required would be $4 c^2 \times 0.543 \times 130 = 5342 \text{ kgm.} = \text{about } 71 \text{ H. P.}$

All the above examples are for a speed of 10 meters per second. An increase of speed would bring about a lessening of power required and of the weight of the motor. This is true for the simple aëroplane, but is it for the mixed one? For, increase of speed implying diminution of angle, there would be needed a prismatic aërostat smaller than that calculated, so that a downward pressure of the air above should not be produced when the angle is closed; and in consequence the final result could not be bettered.*

The difficulty might be practically obviated by allowing a certain liberty of diminishing the aviating angle without a downward pressure being produced—making the prismatic aërostat with a horizontal lower face and an oblique upper face, without changing either its volume or (very much)

* A proper solution of this question requires an equation of the sixth degree; hence test cases are used here.

the position of its center of gravity. It then follows that for a speed of 10 meters, suitably formed aërostats are better than aëroplanes. If the speed increases beyond 10 meters, the advantage approaches to the aëroplanes, up to the limit exacted by their fixed elements. But either system would demand a propelling force much greater than is possible with known or probable motors; for the figures above are rather under than up to those which practice would give.

The "mixed aëroplane" is much better than either of the pure systems, and appears practicable with known motors if made extraordinarily light.

What can American inventive genius and practical skill do in this important direction?

THE NEW FRENCH STEEL FIELD GUN.

The French are now introducing a new steel gun for field service, in which are embodied the principles now adopted by most powers—that is to say, the gun is very long; the bore is small; the chamber is enlarged, and the cartridge has a considerable air space round it—the effect of these features being to allow of a very high velocity being obtained at the cost of the waste of some powder, a large charge being employed, which acts on the shell in a way which we may describe as being as much of a push and as little of a blow as may be. The gun by this means is subjected only to a comparatively low pressure, but will recoil very much if not checked by means of brakes. The gun being a breech-loader, the above arrangements can be carried out more completely and perfectly than in the case of a muzzle-loader, for the chamber can be enlarged to any desired extent without necessitating any such device as an expanding cartridge, which would, beyond a certain point, be a necessity in a muzzle-loading gun with an enlarged chamber. The shell also in a breech-loading gun is always driven up to the same distance when rammed home, being stopped when it is gripped; whereas in muzzle-loading a projectile is generally simply forced home on the cartridge, which may set up more at one time than another, either from harder ramming or other causes. This insures the powder being always burnt in the same sized space in a breech-loader, and consequently under more uniform conditions than in a muzzle-loader. Hence there is an advantage in accuracy on the side of the former.

The following are the details of the French piece in question, as given in an official translation by Major Owen, R.A.: The gun is made of cast steel, strengthened by six rings of puddled steel shrunk upon the inner tube. The second ring from the muzzle carries the trunnions, and the first ring is shrunk not only over the tube, but also over a securing ring. This arrangement gives much more power than the mere grip of the ring by shrinking to resist the tendency of the trunnion rings to slip forward upon the shock of discharge. The securing ring is embedded for half its thickness in a groove cut round the exterior of the steel tube, and for the other half in the front strengthening rings. It is put on in two pieces. The several strengthening rings are shrunk on in the following order: First the fifth, then the fourth, third, second—carrying the trunnions—the first, and finally the sixth.

The vent is of hardened copper, threaded on the exterior, screwed through the fifth ring and inner tube at right angles to the axis of the piece, and in such a position as to strike the powder chamber near the center. The lower portion is plain, and is compressed or set up into a conical recess, undercut in the wall of the chamber.

The bore, 3.74 ins., may be divided into the following portions: 1st, the rifled portion, 77 ins. long, rifled with 28 grooves, the latter being right hand and increasing; 2d, the shot chamber, 4.372 ins. by 3.82 ins; 3d, the conical part leading from shot chamber to powder chamber; 4th, the powder chamber, 12.38 ins. by 4.13 ins.; 5th, the truncated conical part of the "obturator;" 6th, the part taking the breech screw.

The breech mechanism need hardly be described in much detail. It closely resembles that of several guns recently made by the Elswick Ordnance Company. There is a screw hinged on to one side of the breech, which by means of slots cut through the threads can be entered and then turned round on its axis—which coincides with that of the bore—so that the threads enter those of the unslotted portions of the gun and engage and force home the breech piece. The general form may be seen in Fig. 1.

The "obturator" (vide Fig. 5) is a device for closing the