Countless designs were drawn up and considered, but only two of the systems provided an adequate solution of the problem. The first of these inventions evolved directly from a suggestion of Octave Chanute, who considered some of the plans and checked them in the light of his wonderful analytical powers. It was agreed, however, that this plan did not provide an altogether satisfactory answer to the question and so a new and absolutely unique system was tentatively presented as a last resort.

This plan seems to provide an adequate solution to the problem, but there being almost no reliable data upon which to base our calculations regarding it, I remain skeptical of its success at first trial, although the principles are perfectly sound and a few experiments will suffice to gather information for future use. As this invention is the subject of patents it will be impossible to divulge the secret at present and my only object in treating this phase of the problem is to show the importance of providing adequate apparatus for the maintenance of lateral equilibrium during variations in direction and velocity of the wind.

These disturbances are the direct result of changes in the position of the center of pressure of the supporting surfaces, this point being a rather variable quantity but generally tending toward the part of the surface which is receiving the most pressure.

Since the main trick in flying consists in keeping the centers of pressure and gravity coincident, it is evident that the designer has his choice of two methods of procedure in balancing, for he must either make the center of gravity follow the center of pressure or the center of pressure must be constantly shifted to coincide with the center of gravity.

In small machines of the Lilienthal and Chanute pattern it is quite possible to consider the center of gravity as a variable but in the heavier dynamic apparatus it is necessary to make the center of gravity constant and the center of pressure variable, depending on some system of compensating surfaces to effect the changes in the position of the center of pressure.

Some Features of Design.—Much might be written regarding the efficiency of various wing attitudes (shape of wing when viewed from front) and the importance of this feature in the design cannot be overestimated. Of the many "attitudes" which have been demonstrated theoretically and experimentally, there are two which we recognize as distinct types. The first of these is the dihedral angle in which the wings slope upward from the center to the extremities and the second is the "gull" or depressed-wing attitude, so named after the position for sailing flight assumed by the sea birds.

The dihedral angle was probably first suggested by the soaring of the buzzards and other land birds, but we find it hard to place the responsibility for its introduction to aeronautics on any one experimenter or theorist. A flyer designed with the dihedral angle is well suited to flight in a calm or light wind, but proves a treacherous proposition under any other circumstances. Its principle of operation is that the wing which becomes depressed will receive less pressure than the wing which tilts upward and that these forces will constitute a dynamic couple tending to automatically maintain equilibrium.

This has been found to work out satisfactorily in light winds and when the current blows directly toward the machine, but unfortunately these conditions do not obtain on many occasions and it is found that a flyer utilizing the dihedral angle almost invariably capsizes when struck by oblique currents. This is easily explained, for when the wind strikes the up-raised wing obliquely to the line of flight, the pressure on that wing increases tremendously, owing to the wing being placed at a more favorable angle of lift than when the wind strikes directly in front, and thus under most conditions, instead of acting as a force tending to right the machine, the dihedral attitude proves quite fatal to its stability.

The gull or depressed-wing attitude, on the other hand, is found to work equally well in wind or calm, and if the flyer is well balanced, side gusts may strike the wings without producing any disturbance other than a slight depression of the side of the machine nearest the wind.

This favorable result is caused by the wind striking the tip of the wing from above instead of below and counteracting the tendency of the wing nearest to the wind to lift unduly but yet not affecting the efficiency of the aeroplane as a whole. While this feature in the design will assure good inherent lateral stability, yet it must be remembered that exceptional conditions are liable to arise during flight in high or cyclonic winds and that adequate provision must be made to meet all emergencies.

Thus it will be found that most air currents close to the ground are rotating around horizontal axes and also more or less about a vertical axis, so that instead of a steady current the flyer must make its way through a veritable maelstrom which affects the fore-and-aft and lateral stability of the flyer in a most peculiar manner.

A very ingenious experimenter, Mr. G. A. Spratt, has investigated these phenomena and demonstrated quite clearly that "curvature" of the aeroplanes must be used as a relative term, since a plane surface flying in a rotating wind and a curved surface flying in a straight wind are operating under approximately the same conditions and call for similar propelling and balancing forces.

This hypothesis assists us materially in propounding a more rational theory of soaring and sailing flight, and the difference in curvature of wing noticed in birds which fly high in air and those which sail close to the ground (or to the surface of water) is no longer a mystery. It is now obvious that vultures which fly in the steady upper currents require deeply curved wings, while the sea birds which sail in the turbulent surface winds can extract more power from the wind if the wings are less deeply curved or are very nearly plane surfaces.

As was stated at the beginning of this paper, aeroplane designing embodies a dangerous amount of guesswork, and the various theories and features in design presented here are not yet permanently estab-

FIG. 1.—CONSTRUCTION OF MAXIMUM AND MINIMUM REGISTERING THERMOMETER.

lished, although they form the best working basis at our disposal.

Formulae and Tables.—After mastering the theory and general principles of aviation, the experimenter will undertake to apply the various tables and formulae to the calculation of aeroplane efficiency, and it might be well to outline the best course of action in carrying out this part of the work.

The standard literature on aeronautics is not overloaded with reliable tables and formulae, but it will be found that the data published by Chanute, Langley, and Lilienthal will enable the engineer to arrive at fairly accurate results.

An estimate of the speed which will be required for support in the air may be arrived at by computing the total lift which will be obtained with the surfaces at a favorable angle of attack (say 7 deg.) and at a speed which will allow a fair margin of lift over the total pre-estimated weight of the machine and operator.

After estimating the speed required for support, the engineer may then arrive at the power required for propulsion by computing the total resistance of the framing at the given speed and adding to this the horizontal component of pressure or drift of the aeroplanes. The lift and drift of aeroplanes or of plane surfaces may be estimated by the Chanute tables for planes or the Lilienthal table of coefficients for curved surfaces. These tables will be found under the head of "Aeronautics" in the Encyclopedia Britannica.

FIG. 2.—POINTER AND GRADUATED BRASS ARC OF THERMOMETER.

Having estimated the weight of an aeroplane and operator without the engine, the designer seeks a motor which will deliver the maximum of power for the given limit of weight which the machine will lift and if the thrust developed by this motor shows a fair margin over the resistances to be overcome at the speed of sustentation he will know that his machine is at least capable of supporting itself in flight.

Formula for "Effective Area."—Although the data now accessible to aeroplane designers may appear at first to be quite complete and fairly reliable, yet a more careful study of the matter reveals the true intricacy of the problem and several factors come to light which are as yet unknown quantities.

The Spratt theory, although very valuable as far as it goes, does not go far enough, and there are other similar phenomena of atmospheric currents which remain something of a mystery.

While there are reliable tables and formulae for computing the lift and drift of surfaces at various angles

of incidence, yet these tables only purport to obtain with surfaces of a given shape, and it is a well-known fact that aeroplanes having the same area but being of different shapes will differ greatly in efficiency.

Thus, a plane 5 feet long and 1 foot wide will have 5 square feet of surface, but if it be presented to the wind with the entering edge of a foot, it will be vastly less efficient than if presented with the entering edges of 5 feet.

This is an established fact and since every designer must take it into consideration in selecting the shape of his surfaces, it might be well to formulate the facts and derive a new coefficient to be used in determining the effective area of rectangular aeroplane shapes. This "effective area" must then be used instead of the real surface area of the wings in computing the lift and drift.

The following empirical formula will be found to accord fairly well with practical results and to provide a necessary link in the chain of calculation forged by aeronautical engineers. Other formulae have been proposed by Goupil and Soreau as deduced from Prof. Langley's experiments:

Let L = length of surface,
 W = width of surface,
 $M = L - W$,
 then A = effective area.

L = length of entering edge or the dimension of the surface in the direction at right angles to the line of motion.

$$\frac{W^2}{2} + \frac{W}{2} + MW = A = \text{effective area.}$$

A HOME-MADE THERMOMETER.

By A. HEATON.

It would seem at first thought that meteorology is a subject which has no connection with the generation or conservation of steam energy, but on reflection it will be seen that natural thermic and barometric conditions either assist or retard those artificially produced in a measure proportional to their extreme changes. For illustration, consider the vast sums which are paid out for more or less non-conductive substances to counteract those external effects. Again, if a locomotive will haul a given train in August with a certain amount of coal, we do not expect it to haul the same train with the same quantity of coal in January.

There are also many engines at the sea level which maintain a vacuum of 27 inches, and there is a Westinghouse-Parsons turbine in my city which shows as high as 29¼ inches on a mercury vacuum gage; on days when the barometer is high it will go as high as 29¾; and a high vacuum in a turbine installation represents money, lots of it.

But because these things are done near the sea level it does not follow that they could be also done at the summit of the Himalayas, nor even up among the Rocky Mountains, for, approximately, water boils at 1 deg. F. less for every 596 additional feet of altitude, so that at the summit of the Himalayas, the highest attainable vacuum would be less than 11 inches.

The maximum and minimum registering thermometer here illustrated consists of a circular box *A*, Fig. 1, 1½ inches diameter and ½ inch deep, with a knurled screw-cap and a flange for screwing the device to the north side of a building. Into a boss on the box are screwed or pinned two 22-foot lengths of iron ⅛-inch gas pipe which run through a series of guide supports *B* and are made fast in the cross tail-piece *C*. A 22-foot length of brass ⅜-inch pipe is made fast in the tail-piece between the two iron pipes, but runs free at the other end, entering with a reduced diameter through a dust-proof stuffing-box; it is attached to a 5/16-inch crank on a ⅜-inch shaft which goes through to the inside of the building, and it carries a pointer 18 inches long, which extends downward to a graduated brass arc, Fig. 2. On this arc are two slides which the pointer pushes along and leaves at the extreme limits of its travel.

With this thermometer it is not necessary to go outside to get the outside record, but simply take the record from the slides once in 24 hours and push them back against the pointer for the next day's record. With metals of average density, the differential expansion between brass and iron will give with 22-foot tubes and a 5/16 × 18-inch indicator an approximate travel on the dial of 1/20 inch per deg. F., but as all metals vary in density, it is safer to calibrate from a reliable mercury thermometer.—Power.

Artificial Wood Substance for Plastic Decorations.—The sawdust of soft woods is boiled with a solution of glue and water glass, and to the resultant mass so much sawdust added and thoroughly mixed by kneading as to produce a dough-like mass. This is pressed between iron plates, dried, and ground. Colors such as English red, cinnabar, etc., may be mixed with it at an earlier stage.