disk and provided with an indicator *I* for use on the circular scale in reading the same. A battery current of 3 to 8 volts is utilized, the force of the current being determined by a galvanometer.

The piece of steel to be tested is placed in the instrument after the indicator *I* has been placed at zero, and then the current is sent through the solenoid, and they are moved away from the magnetic needle or toward it until it rests at zero, when the current is reversed by the switch *E*, the instrument being tested for true balance.

In the center of the solenoid *B* the piece of steel or projectile is inserted, and when the current is turned on, the needle will move on account of the test piece disturbing the balance of the instrument by becoming magnetized. It is then necessary to move the electro-magnet *A*, so as to establish a magnetic equilibrium by bringing the magnetic needle to the zero. A record is made of the reading, and the current is reversed through the solenoids, a second reading being made when the electro-magnet is moved in the opposite direction, to bring the magnetic needle back to zero.

The magnetic capacity of the test piece of steel or projectile is obtained by adding the two readings on the indicator *I*, but in determining the magnetic capacity by passing the current through the piece direct or reverse, it must not have any of the artificial magnetism given to it by tempering or by forging.

It is stated that the locks on gun barrels have been tested by this instrument in Europe, more than one hundred pieces being tested per hour. It is held that by means of this instrument degrees of temperature for tempering and hardening were determined which practically abolished the faults before encountered, where a great many pieces were split and broken, causing great annoyance. In Europe the testing of projectiles by means of this instrument has been successful, a sliding carriage being provided for inserting the shell into the solenoid. Of course, this instrument is limited to testing the hardness of iron and steel, and cannot be used for determining this quality in metals of a non-ferrous nature.

THE EFFICIENCY OF AERIAL PROPELLERS.

A NEW INVESTIGATION AND ITS RESULTS.

BY W. R. TURNBULL.

In the December 19th, 1908, issue of the Scientific American Supplement, Mr. Sidney H. Hollands writes of a new form of aerial propeller in a rather misleading way. He states, "The propeller tested was of 6 feet diameter, and as little as 1 brake-horse-power sufficed to drive it at 370 revolutions per minute. The carefully measured thrust at this speed was 26½ pounds. The volume of air displaced was 40,000 cubic feet per minute, and the linear velocity of the air column was 1,400 feet per minute. *Let it be borne in mind that this was at a speed of only 370 revolutions per minute, a low speed for a 6-foot propeller of this type.*"

The italics are mine, for it is just at this point that Mr. Hollands's remarks are misleading. If he had given us the efficiency of his propeller at double or triple the speed the efficiency would show a thrust of about 18 pounds and 12 pounds respectively per brake-horse-power.

This is a very good screw indeed, but the average 6-foot two-blade aerial propeller, with concave blades of about 1/12 curvature, the chords of the concavity showing a true screw, is quite capable of giving 22 pounds thrust per brake-horse-power at 370 revolutions, as will be clearly seen from the accompanying curve (see figure). It is hardly fair for Mr. Hollands to compare his 26½ pounds thrust with the 9 pounds of Maxim's propellers, the 7 pounds of Langley's, the 6 pounds of Farman's, etc., without giving their speeds of rotation. Mr. Hollands does not tell what the efficiency of his propeller is at 1,000 revolutions per minute (for instance) and does not point out the crux of the whole question of the efficiency of all aerial propellers of rational design.

The whole question of efficiency of two-blade aerial propellers is one of diameter and speed.

Speaking always of properly designed concave propellers, a propeller of large diameter and slow speed is always the most efficient (other things being equal). Reduce the diameter and increase the speed and the efficiency steadily drops from about 50 pounds thrust per horse-power to about 6 pounds per horse-power (to use concrete examples within the range of ordinary experiments).

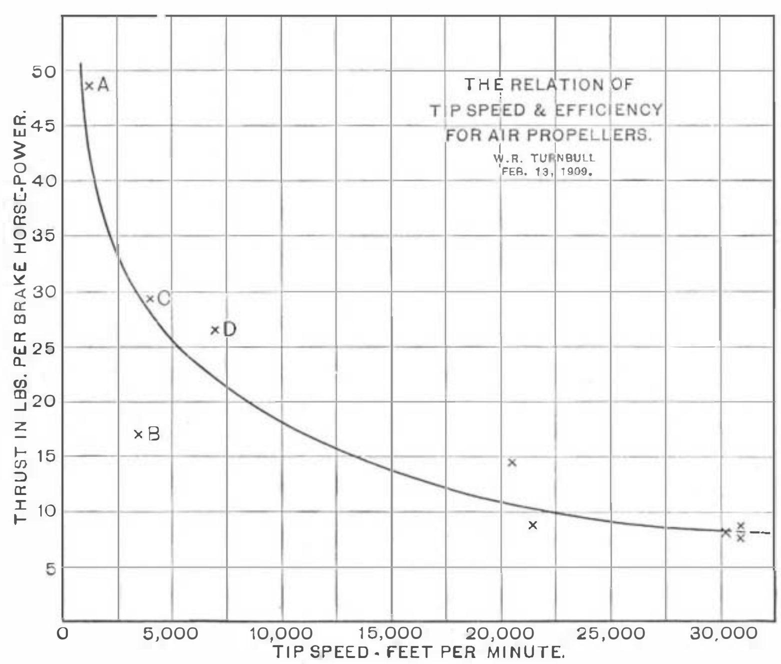
The Frenchmen have constantly erred on this point, using a single propeller of 6 to 7 feet in diameter at about 1,100 revolutions per minute and 50 horse-power, as against the Wrights' two propellers turning up about half that speed with 25 horse-power; and it is just in this vital point of design that the higher efficiency of the Wright machine has been demonstrated.

Theoretically, an aeroplane or dirigible should have propellers of very large diameter turning at a comparatively low speed, but in the case of the aeroplane especially the diameter of the propellers must be reduced to conform to the general design and it is this serious compromise that is the greatest drawback of the present-day aeroplane machine.

Langley demonstrated that 1 horse-power, properly applied, could carry 200 pounds at 40 miles per hour. But what machine approaches this?

Theoretically, according to this, the Wright machine should be supported by a 5-horse-power engine (instead of a 25-horse-power one) or say 7 horse-power to overcome the resistance of the necessary supports, but this would entail propellers of large diameter and pitch, turning at a slow speed, and they are not compatible with the rest of the design. If they were, what a tremendous saving would be effected! The engine weight would be reduced to one-third and the "steaming radius" of the machine increased threefold.

I can quite indorse Mr. Hollands's remarks concerning the advantages of the two-bladed propeller for aerial work, but from my own experiments I feel confident that if the blade area is from 10 to 15 per cent of the area swept, if the blades are made with a concave curvature (of about 1/15) and with a slightly increasing pitch, if the ratio of diameter to pitch is from 1 to 1.25, and if the diameter of the propeller is made large and the speed of rotation small, we will have a propeller that approaches the maximum possible efficiency.



The curve shown herewith gives the whole thing in a nutshell. For any propeller, of rational design, the higher the speed the lower the efficiency, and for any type, the larger the diameter the greater the efficiency.

In the curve abscissæ are tip speeds in feet per minute, and the ordinates represent the thrust in pounds per brake-horse-power, thus we have a measure of the efficiency at different speeds. (Note: Diameter in feet multiplied by 3.1416 and by revolutions per minute gives the tip speed in feet per minute.)

Points *A* and *B* are the figures of Renard, published in 1889, for the same propeller of 23 feet diameter, at two different speeds; point *C* is the result of Breguet (1907) for a helicopter screw of 26½ feet diameter, and point *D* Mr. Hollands's propeller. All the other points are for modern high-speed screws of about 5 to 7 feet in diameter, driven at much too high a speed for good efficiency.

The falling off in efficiency at the higher speeds is most remarkable, for while it seems possible with the most efficient screws to get thrusts of 40 or 50 pounds to the horse-power, the modern aeroplane has a screw of one-sixth this efficiency, or about 7 pounds per horse-power.

This particular compromise of using a small-diameter, high-speed screw to suit the rest of the design has cost the present-day aeroplanes an enormous toll, and it is right at this point that the present design is decidedly poor, for it means we have to carry an engine six times heavier than it should be, and that means much larger aeroplanes (with their additional weight) to carry the extra weight of the motor, etc.

Sooner or later we will be forced to study this subject of efficiency if we are to arrive at a practical solution of aerial navigation, and the present indications are that the air-screw is not the ideal means of propulsion, at least for aeroplane machines of the present type.

SAFEGUARDING WOOD AGAINST ANTS.

A new process has been discovered for warring against white ants, the pest of the tropics. These termites, as they are called, destroy the woodwork of the finest building within six months. Their action is insidious, inasmuch as the outward appearance of the wood does not betray the rottenness within, and their ravages, if not discovered in time, lead to the total collapse of buildings. No wood except eucalyptus and teak resist the termites. If soft wood is used in tropical countries it must be saturated with kerosene.

After a somewhat practical trial, news has been received from the Madras Presidency that the specimens sent there have successfully resisted the attacks of white ants. The great importance of this new process to India, Australia, South Africa, and other tropical regions can scarcely be overestimated.

The process is extremely simple and adds very little to the cost of the timber. To those who are technically interested in the new process it may be explained that it is one which rapidly seasons newly cut timber, and unlike other systems improves, toughens, and strengthens the wood, enhancing the appearance and resisting the attacks of dry rot, which in temperate countries is the equivalent of termites. This is accomplished by boiling the timber in a saccharine solution, which extracts the air and coagulates the albumen in the sap. In cooling, the air spaces are filled with saccharine matter, which in large measure is analogous to the fiber of timber. The timber is then rapidly dried in fairly high temperatures and becomes a homogeneous vegetable substance which does not expand, warp, contract, or split like ordinary timber.

Preserving Medium for Valuable Printed Matter.—Upon the objects to be protected (stamps, engravings, rare prints, etc.) a 3 per cent collodion solution can be applied without injurious consequences.