

Fig. 1.—Sea focal plate for ascertaining momentary direction of translation.

## Steering Air Craft at Sea

### Some of the Difficulties of a Transatlantic Flight

By the Staff Correspondent of the Scientific American at Hammondsport

Photographs of Lieut. Porte's Instruments by F. J. Weyman.

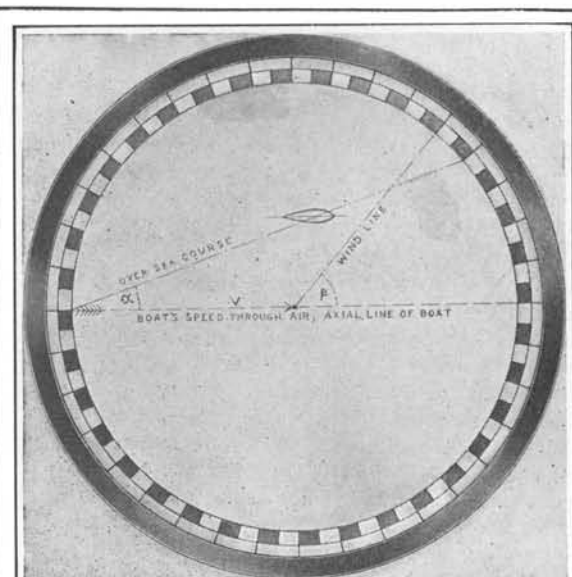


Fig. 2.—Velocity board for determining the momentary speed of the craft.

THE general art of piloting air craft, buoyant and unbuoyant, involves manifold tasks requiring manipulative skill, experience, and technical knowledge. The pilot, or his aid or crew, must keep the craft in structural and running adjustment; must maintain her poise and evenness of travel; must choose the most favorable air stream and altitude; must avoid perilous or impossible conditions; must navigate geographically, that is, determine the geographical position, and direct the course.

The geographical navigation of air craft without a map—the subject of the present inquiry—is of especial interest now, because of the approaching transatlantic flight. As applied to ocean flying it presents three questions; how to steer when only the sea is visible; when only the firmament is visible; when neither is visible. We may omit the case in which both sea and sky are clear, as this is but a combination of the first and second cases.

To be more specific we shall assume that the pilot is seated beside a qualified aviator, in a closed flying-boat with suitable windows, and provided with navigating instruments of his own choosing. He will want instruments for determining his boat's orientation, inclination, altitude, speed through air, momentary direction and speed over the water, hourly position on the globe, and hence the hourly course and speed, besides auxiliary instruments, such as a clock, hydrographic chart, weather instruments, astronomical and trigonometric tables, etc.

#### Determining the Direction of the Course.

The flying-boat's orientation referred to the earth's magnetic meridian, and thence, by chart or table, referred to the earth's meridian, can be determined by the ordinary mariner's compass. This can be read either by looking down upon its level face, or by looking horizontally into an inclined mirror or a prism. As the poise and motion of the boat can usually be kept quite steady the magnetic compass can be read truly to one half a degree. A specially light gyroscopic compass also may be used to indicate the true north independently of the earth's magnetism.

#### Measuring the Dip of a Machine.

The dip and tilt of the aeroplane can be measured with an inclinometer. A spirit level serves very well, especially for the more even conditions of the air at sea. When the billows or swells increase, the poise cannot, near the ocean surface, be maintained even, and hence can not be so accurately determined. An increase of altitude gives an even poise, and will naturally be taken when the wind blows approximately with the vessel. In fair conditions the inclination can, with such a spirit level, be maintained and measured truly to a fraction of one degree, at least for a brief period of time. A short damped pendulum with a long pointer is also accurate, but less simple in structure.

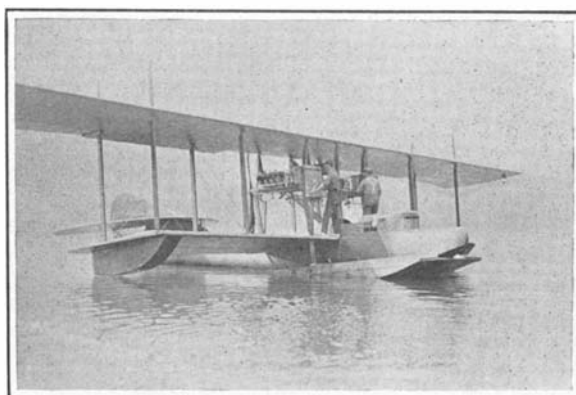
#### Altitude Indicators.

The altitude of flight, when very small, can be measured with a plumb-line or an optical range finder; when great, with a barometer or barograph. When the sea is very smooth the plumb-line measurement may be made accurately to within less than a yard in one hundred feet; when quite rough the height cannot be measured accurately by any known method. The altitude may be satisfactorily determined with an aneroid barometer if the sea level pressure be first measured, and if the barometer readings be not vitiated by the rush of air past the barometer case. Means have been devised for obviating or minimizing errors from this source.<sup>1</sup>

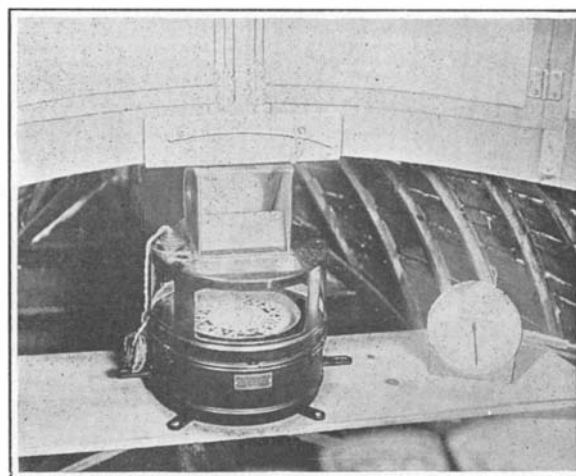
#### Determining the Speed of the Craft.

The speed of the boat through the air can be measured

with anemometers of various types, as the screw, the revolving cup instrument, the wind-tube, the pressure plate, and numerous other kinds. All, however, must be placed and used with some skill. It is important that they measure the speed of the undisturbed air at some distance from the hull, unless, by special calibration, errors due to local modification of the gen-

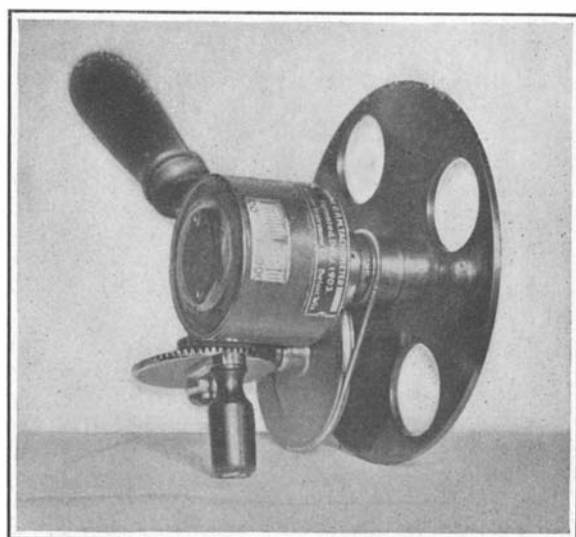


Preparing to test the side floats.



Fore part of "America's" cabin, showing compass, etc.

At left end of shelf is a bar magnet to correct deviation of needle due to iron and steel in airboat. Their compass was brought from England by Capt. C. Osborne, R.N. Note the hinged celluloid cabin windows above the instrument.



Stroboscope suggested for finding the speed of sea's image across a ground glass, to serve in estimating the overseas speed of the airboat.

eral air speed can be obviated. If the shaft of the screw or cup anemometer have its outer end well away from the hull, and before the wings and propellers, while its inner end connects with a rotation counter, or common "speed indicator," or a very good tachometer, the number of turns per minute can be read truly to one per cent, and the speed of the undisturbed air flow past the craft can be measured with like precision. It is well to calibrate such instruments, in their working positions, by actual flight through air for a known distance, or by comparison with standardizing instruments. The wind-tube may be either a Venturi air tube calibrated by trial, or a coaxial wind-tube. The latter is sometimes, though erroneously, called a Pitot tube. It consists of an inner tube pointing its open end into the wind, an outer coaxial tube having a series of side holes around it, well back from the point, and a manometer and connecting hose for measuring the difference of pressure in the two tubes. From this pressure difference the air speed is calculated in terms of the air density, which must be known or found, say from the observed temperature, barometric pressure and humidity. If the density be neglected, an error of several per cent in the speed may be made; in fact, an error of about one per cent for each 5 deg. Fahr. change of temperature, and each three tenths of an inch change of the barometric height.

The pressure plate anemometer receives the impact of the air, and by the force of this duly indicated or recorded, shows the air speed in terms of the density. All such impact instruments, or "pressure anemometers," after collecting the air pressure, require that it be measured, then that the speed be determined from the density, either by calculation or by use of tables. For accurate use they are not ready instruments; for ready use they are less accurate than the "velocity anemometers," such as the screw or the rotating cups, etc. These, after calibration, require only that their angular velocity be taken, either with an instantaneous tachometer or with a speedometer and stop watch.

An aerial log line, consisting of a toy balloon and thread unwinding from a reel may be used, sailorwise, to measure the speed of the flying-boat, or to calibrate other anemometers. A Crocco anemometer also could be used to standardize others more convenient for practical navigation.

#### How the Direction of Translation is Ascertained.

The momentary geographical direction of translation of the craft over the ocean surface, regarded as stationary, may be determined by noticing the apparent line of transit of wavelets or floating objects past the boat, or across the field of an optical instrument therein, such as a camera or telescope. Such passing objects will appear to describe streaks or stripes along the focal plane, especially if the focal length of the objective and the height above the water be so chosen as to cause the images to cross the optical field quickly. If the objects have but slight speed across course, say one per cent of the boat's speed on her course, the resulting deviation of the stripes may be neglected. By sunlight the distinct objects on the ocean surface, more especially white caps, are usually numerous; by night luminous objects may be projected on to the water, preferably ahead of the aeroplane, and along its true course. Wooden balls coated with potassium will flash on striking the water. Sodium-tailed arrows or flaming torches, cast quickly upon the ocean face and remaining bright for a few seconds, may be used to sight back to, and thus indicate the course as compared with a compass needle. Under favorable conditions, the direction may thus be determined to about one degree. Whatever the visible object, if its image cross the plate quickly, say in one tenth of a second, it will appear as a stripe or streak all across, and may be

<sup>1</sup> Zahm, Measurement of the True Pressure in a Moving Fluid, Jour. Frank. Inst., 1913.

determined in direction by comparison with an adjustable line or lines of reference; if it cross slowly its position on entering and leaving the field may be noticed, thus giving the direction approximately.

Practically a lens may be inserted in the bottom of the hull and bring the sea's image to focus on a level ground glass or celluloid plate above it, or on a vertical or oblique plate if an oblique mirror be inserted between the lens and the image plate. Reference lines and a graduated arc on the plate may serve to measure the direction of travel referred to the boat's axis or the needle of a compass. The compass needle can be mounted just under the focal plate, if this be level, or reflected upon it if oblique or vertical.

For example, in Fig. 1 the lens *L* may bring the sea face to focus on the frosted plate *A*, preferably turnable in its plane and circularly graduated, while the compass needle is supported just beneath on a transparent plate. Again, the light from the same lens may be reflected by a mirror to focus on a vertical plate, while another lens may bring a compass needle to focus on the same vertical plate, by reflection from a transparent mirror placed before the other one.

#### The Speed at Any Given Moment.

The momentary speed of the flying-boat over the water may be determined in many ways. If her altitude be unknown, or disregarded, her speed over the water, and incidentally the wind speed, may be found as shown in Fig. 2. The speed *V* of the boat through air and her inclination  $\alpha$  to her over-sea course are read; then she is turned into the wind line, or so that wavelets seem to move fore and aft, and the angle  $\beta$  of her turn is noted on the compass. From these three observations a triangle is determined giving the over-water speed of the boat, and incidentally the true wind speed. To simplify the process, transparent millimeter scales pivoted at the ends of *V* in the diagram can be set at the angles  $\alpha$  and  $\beta$ , and read at their crossing to give, in terms of *V*, the over-water speed of wind and boat. Thus if *V* be 100 millimeters, and 40 be read on the wind scale at the crossing, the wind speed is 40 per cent of the boat's observed speed through air. The scales can be read truly to less than one per cent; the speed *V* to one per cent, more or less; the angles  $\alpha$  and  $\beta$ , to about one degree. Hence the over-sea velocities of boat and wind can be determined to a corresponding degree of accuracy. The graduated disk and pivoted scales constitute in fact a mechanical device for solving any case of plane triangles, without the aid of trigonometry.

If the boat's altitude be known, her over-water speed may be found from the speed of the ocean's image moving across the field in an optical instrument, say a camera or telescope, or the sea focal plate just described, which, with the keel lens, is the equivalent of a camera. If this plate be large, and the altitude of flight be considerable, the period of transit of the image of a well-defined sea object can be taken with a stop-watch truly to one or two per cent. On a horizontal image plate the image speed is constant if the over-sea speed be constant. Hence the speed of travel of the image, multiplied by the ratio of the distances respectively from lens to sea and from lens to plate, gives the boat's over-sea speed. This ratio may be made some easy multiplier, say 100, by suitably adjusting those two lens distances. If the angular displacement through 45 degrees be taken with a rotating telescope or camera, and timed with a stop-watch, the over-sea velocity equals the boat's altitude divided by the observed time.

If, however, the sea's image crosses the plate or field of view too quickly, its speed cannot be found by a stop-watch. In this case two optical methods are available to find the over-sea speed of the boat; either halting the image, or diverting its course. To halt the image, it may be viewed either through a stroboscope or in a mirror rotating backward or in a like rotating telescope; to divert the image, the said rotation may occur perpendicularly to the path of the image, so that its lateral speed may be proportional to its direct speed, thus making the image travel at an angle to its natural course across the plate. The speed of telescope rotation, or half the speed of mirror rotation, that causes either halting of the image or diversion through 45 degrees, has only to be multiplied by the altitude of the boat to give the over-sea speed.

If the ocean face be too thickly fogged, the foregoing methods are unavailable to determine the over-water speed of either the boat or the wind. In this case, by flying moderately low, a light log line can be dropped into the sea and paid out while trailing due fore and aft of the boat temporarily turned into the wind line.<sup>2</sup> Thus observations of the log line and compass give the boat's over-sea velocity in the line of the wind. From this and the observed speed through air, the navigator, by using the velocity board, shown in Fig. 2,

<sup>2</sup> If the over-water course be oblique to the wind line, the log line tends to trail fore and aft, due to the air rush past the boat. A fine wire trailing from a low flying-boat, with good water drag, tends to indicate the true course over water even when flying obliquely to the wind.

can immediately turn the boat to her desired course, and read off her over-sea speed along this course, palled though it be in fog or darkness. Also from the tracings of a pressure plate anemograph, which shows greater pulsations of speed in the wind line than when traveling across wind, and proportionately greater pulsations as the wind increases, it is claimed that the speed and direction of the wind can be judged even in the dark. But this claim is mentioned more for its novelty than for its validity.

#### Finding the Hourly Speed and Course.

The hourly speed and course can be found by astronomical means familiar to the marine navigator. The pilot can, with his watch and sextant, read respectively the time of day and the altitude of two heavenly bodies, say the pole star and another one, and from these data, by aid of his astronomical tables, he can determine his geographic position, i. e., his latitude and longitude. The change of position from hour to hour determines his course and hourly speed.

In practice several devices are available for finding the altitude or the zenith distance of a heavenly body. If the sea be clear the sextant's telescope, held freely in hand, is pointed straight at the horizon, while the angular distance of the heavenly body is measured with the sextant index. Ordinary swaying of the craft will not thwart this. In case the flight be moderately high, a correction can be made for the consequent depression of the horizon; if very high, the horizon blurs or disappears. With a clear horizon, an expert navigator can, it is claimed, thus locate his position on the globe truly to one mile or one minute of arc.

Another device is to use an artificial horizon. Astronomers measure the angle between the star and its image reflected from the surface of still mercury, and divide by two to get the true altitude. This method is available on land at any elevation and without clearness of horizon. To apply it in an air craft the mercury would have to be supported so as to remain level and smooth. In lieu of mercury a rigid plane reflector kept horizontal may be used, say a polished plate floating on a liquid, or supported on gimbals. Also a polished plate fixed to the aeroplane frame and kept level for the moment by the aviator, who can usually choose a favorable atmosphere several times a day, and hold his craft level to within less than one degree by means of the controls and inclinometers.<sup>3</sup> If the image of the star sway to and fro a degree or so during this leveling of the craft, the navigator can take the mean position, as is done in scores of laboratory instruments. Greater accuracy, however, is claimed for the sextant and plumb-line. By this combination experienced seamen claim to be able to locate their position truly to three miles, or three minutes of arc.

A third device is to focus the sky on a graduated chart kept horizontal and having its center vertically under the lens, fixed say in the top of the cabin. During the moment that the aviator holds the craft level, the zenith star or point of the sky can be focused on the center of the chart, and the other stars will have their images at distances from the chart center or zenith image, which are measurable on the chart itself by suitable graduations. The chart can be either plane or spherical, say concave upward like a dish, and the graduations for zenith distance can be made accordingly. If the center of the plane or concave chart be called the pole, lines radiating from it mark the longitude referred to it; circles about the pole space off the latitude. The positions of any two stars on this chart, preferably at some distance from the zenith, enable the navigator, by use of his watch and tables, to determine his true geographical position. The sea image plate already described, if suitably enlarged, may serve for the plane sky chart here considered, provided the sky lens be chosen of the right focal length. To obviate the need of holding the aeroplane level, the chart and lens can be rigidly mounted on a frame supported so as to maintain their proper poise automatically, or steadied by the observer with spirit levels. Instead of reading the star's position on the chart it may be recorded on a sensitive photographic plate or film graduated by photography or otherwise. The altitude of the sun and moon can be taken instantaneously. The star's record may require a large lens and considerable exposure; but there is little objection to a long exposure if the craft be kept from turning, or if the shutter be closed during undue oscillations, provided allowance be made for the drift of the image due to the earth's rotation. Thus, during a minute's exposure the star and its image travel one quarter of a degree due to the earth's rotation, and about 1/69 of a degree due to the boat's over-sea speed, if this be one statute mile per minute. The images of several bright stars can also be marked on the chart with a pencil, so that their zenith distance can be read at leisure. If, for example, the focal length of the sky lens be 57 inches or centimeters, the degree measured on a concave chart is one inch or one centimeter; so that if the chart be held

<sup>3</sup> It is still an open question as to how nearly dead level an aeroplane can be held for a brief time, say half a minute, in smooth air.

level to a fraction of one degree, the zenith distance of the star can easily be read to a fraction of one degree.

In case the sky be long obscured, the pilot may compute his position from his continuous record of speed and direction since last taking his position with the sextant. An excellent method, if applied without excessive weight, would be to use two gyroscopic compasses inclined to one another, say one set parallel, the other perpendicular, to the earth's axis; the first indicating the true north and the latitude, the second indicating the longitude. The pilot, plotting his course from frequent readings of this apparatus, would have a good indication of his average momentary progress over sea, and thence could correct his steering, or find the average wind velocity by use of the velocity board already explained. The ordinary gyrostatic compass is graduated to single degrees and may be read to about one quarter of a degree, or 15 nautical miles. Such a check on the drifting of air craft at sea would, in the present state of the art, be very satisfactory, and especially in fog and darkness. Determinations of position by wireless, as practised in Germany, or by report from passing ships, may be disregarded here.

Unaided observation of the waves enables an experienced navigator to judge the speed and course of the wind to a degree of accuracy not despised by sailors. The well-known Beaufort scale of wind speeds is based on this principle. It is a primitive way of estimating the wind velocity, but may, when the wind is light, enable the air navigator to steer without greatly increased length of course. A good sailor can, by inspection of the waves, judge the direction of the wind truly to within ten degrees, and its speed truly to 30 per cent. With equal or greater accuracy the skilled aviator can judge his over-sea direction and speed by mere inspection of the passing water near at hand.

The effect of errors in steering may be minimized by timely correction. If in sailing from *A* for *B* one really follows the course *AC*, making a small angle with the true course, say 5 to 10 degrees, no serious increase of course ensues, provided the departure be corrected well before *B* is approached. The hypotenuse of a plane triangle is half of one per cent longer than the base, if the angle between them is 5 degrees; 1½ per cent longer if the angle be 10 degrees. The main objection to such errors of direction is the missing of the port, or place aimed at, rather than the lengthening of the course. But if the geographical position can be determined truly, the navigator can always correct his defects of steering, and finally arrive near his goal. One degree error on a great circle is a linear error of 60 nautical miles, or about 69 land miles. Hence, if the navigator is sailing for a large conspicuous coast, he need not miss it because of an error even so great as one degree in taking the stars, nor very materially lengthen his course by an error of 5 to 10 degrees in steering, more especially if he has merely to reach the coast and not any specified point thereon.

As we have seen, the errors in direction when steering with the compass, aided by instruments for estimation of wind velocity, can, under fair conditions, be kept well under 5 or 10 degrees. Suppose, however, that the wind be judged by the eye alone; say the speed truly to 30 per cent, the direction truly to 10 per cent; what then is the likely range of error in steering by compass an air craft having a natural speed of 60 miles an hour? As a particular case, suppose a wind of 20 miles an hour blow squarely across her desired course. The pilot, misjudging the wind speed by 30 per cent, will think it 6 miles faster or slower than it really is. When he has pointed his course to the best of his ability he will be advancing toward his goal at 60 miles an hour and drifting sidewise 6 miles an hour. The error in steering is thus an angle whose tangent is one tenth or an angle of 5¾ degrees. The lengthening of course due to this error is about one half of one per cent, and the drift off course about 60 miles in a voyage of 600 miles. If the whole direct course be 1,200 miles, and no correction for drift be made during the first half of the voyage, this half is lengthened out by the error to the extent of about half a per cent of 600 miles, or about three miles.

From the foregoing discussion of the navigating devices and of the consequences of error in steering, it appears that no grave evil is to be expected from steering over any length of sea course terminating on a liberal coast line, say of 2 degrees, or 120 nautical miles, provided that a powerful and long sustained storm be not encountered. For example, in the proposed flight of Lieut. Porte and Mr. Hallet from Newfoundland to the Azores, an habitual error of half a point, or 5½ degrees, corrected by the heavens from time to time, would entail an increase of course of about six miles, or an increased consumption of fuel of 6 pounds. This is small compared with the increase of load that may be had from slight improvements of design. For example, an increase of one per cent in the propeller thrust means an increase of 50 pounds in the useful load.

Lieut. Porte's instruments and methods of navigating

have not all been made public, if indeed they have all been fully and finally decided upon. He has, however, announced that he will have a sextant, a mariner's magnetic compass, watches for solar and sidereal time, an anemometer for measuring his speed through air, and possibly an instrument for giving his instantaneous or momentary speed and direction over water. The latter, commonly called a "drift instrument," is of considerable importance, as it enables him to allow for the wind in laying his course. He expects also to secure from passing ships information as to their momentary distance from his proper course, to be conveyed by special flag signals according to a prearranged code. In case of need, carrier pigeons and rockets will be used to convey information, or to call for assistance.

### Further Changes in the "America's" Bottom

By Our Staff Correspondent at Hammondsport

WHEN Mr. Curtiss, by use of the planing fins devised by himself and Dr. Zahm, and described in the SCIENTIFIC AMERICAN of July 18th, had made the "America" leap bodily out of the water at less than 20 miles an hour, he suddenly halted that promising series of experiments. He did not, as originally planned, proceed to make the angles of the planing fins adjustable, so as to regulate at will the amount of lift; but, yielding to the urgency of Lieut. Porte, he reverted to the pontoons, so as to secure greater flotation and possibly a stancher construction. The lieutenant was positive that large flat floats, lashed to either side the "America's" hull, must enable her to plane and rise promptly from the water with the desired 5,000 pounds total weight. From the data so obtained, the hull could

In the first trial of the sea sled bottom the airboat rose quickly to the water surface and planed neatly, with its load of three men, Mr. Curtiss, Lieut. Porte, and Mr. Hallet. When skimming on her heel, or step, she showed a tendency to nose forward and scoop water, a tendency not difficult to correct. The men returned smiling, and with evident confidence in the future of this type of planing board.

### Phosphorescent Air Craft

NIGHT flying is now indulged in so systematically by military officers that the European governments have cast about for some means of guiding airmen. As might be expected, the Germans were the first to attack the problem and to offer a practical solution. Many of the more important military flying grounds of the German Empire are now provided with aerial lighthouses—beacons which are analogous in function to the lights which guide the mariner when he nears land. Each German beacon has its characteristic flash, so that the airman may know a particular lighthouse by its flash. The vision which Kipling presented in his "Night Mail"—a vision of a planet studded with queer structures which send out intermittent flashes or sweep the sky with long, finger-like searchlights—is in a measure realized only ten years after aviation became a reality.

The German system of employing lighthouses and searchlights, efficient though it is, is undeniably expensive. It involves the construction of suitable towers, the installation of lighting apparatus, and the maintenance of a staff of lighthouse keepers. In a most interesting lecture which was recently delivered before the Aeronautical Society of New York, Mr. William J.

used. Since many of the coal tar dyes have a marked fluorescent effect, it is possible to obtain a range of color which is indeed very wide.

The results are not always, and, in fact, not generally like the colors either of the fluorescent material or of the phosphorescent substance which is mixed with it, and which forms the main basis of the luminescent when excited. Hence the art which Mr. Hammer has discovered, resembles in its practical application more the art of china painting, in which the artist uses colors of most incongruous appearance, which are entirely changed by the process of firing.

Of all the results which Mr. Hammer obtained, perhaps his white phosphorescent paint is most remarkable. Here we have a glow which is all but free from the usual greenish blue that is so characteristic of phosphorescence and that is usually so weirdly unpleasant. This phosphorescent paint is obtained by combining a mixture of phosphorescent zinc and calcium sulphides with alcohol, or with a trace of tincture of stramonium or uranin in alcohol and making a paint with oil.

The possibilities of Mr. Hammer's discovery are wider than may at first be imagined. Not only may aeroplanes and airships be painted entirely or striped in parts with luminous paint of various colors, but hangars, tents, and buildings may be coated in a distinctive way. Moreover, the paint may be applied not only to the structures of an aerodrome, but to buildings along the route between two points. Indeed, there would be no difficulty in mapping a very clear track for an aviator, between two cities—a track which it would not be hard to follow if the aviator is low enough.



Photo. by Benner.

### Lieut. Porte and Mr. Hallet in the "America's" bow.

Here the planing fins may be seen which were tested at an earlier period. Subsequently, side floats attached to the hull were used. These, while more successful, did not give the desired result.

be remodeled quickly to a compact, efficient form, and sent without further delay to Newfoundland.

Accordingly the pontoons of the Langley machine, which measure each 10 feet long by 3 feet wide by 10 inches deep, were lashed to either side the bow, flush with the bottom. But, though they had enabled the "America" to carry her largest load previously, when under the middle of the lower plane, they now gave much less lift, owing perhaps to the disturbed state of the water about the bow. They were at once replaced by larger pontoons, each measuring 13 feet long by 3 feet wide by 16 inches deep, lashed firmly to either side the bow and nearly flush with its outer bottom edge, being a trifle higher. The craft, so equipped, failed to rise with two men at first; then, after careful adjustment and trial, she planed well over the water, but would not lift so well as she had previously done with the smaller Langley floats under the middle of the lower plane. The big pontoons beside the bow were then discarded as being neither efficient nor promising.

In the meantime Mr. Curtiss, with little faith in the big pontoons, was studying and planning new varieties of planing boards. The most promising of these was an inverted V bottom fixed under the boat of the "America," and measuring about 16 feet fore and aft by 7½ feet wide between its parallel bottom edges. The sides of this inverted V bottom were steep under the prow, but practically horizontal under the step at the rear. This arrangement of the planing surface is known as the sea sled, and has the merit of gathering the bow wave underneath it and riding on the same, while throwing little water off at the sides. When properly rounded upward at the front it further tends to damp the pitching of the craft. Trials made with the sea-sled proved so encouraging that the hull of the "America" will be remodeled to the sea-sled bottom. Then the trials at Hammondsport will be virtually finished.

Hammer expressed the opinion that phosphorescent paint might be used with great advantage for the same purpose.

Now ordinary phosphorescent paints, consisting chiefly of calcium sulphide contained in various vehicles, such as linseed oil, are not well adapted for the purpose. They give a ghastly greenish blue. There must be some means of varying the color of the luminous paint which is employed—a means which it has remained for Mr. Hammer to discover.

To be sure, it is possible to number machines or to apply even the ordinary calcium sulphide luminous paint in characteristic patterns. But a machine thus adorned would have to approach very closely indeed before it could be recognized. What is obviously wanted is a method of making phosphorus paint in different colors.

Before we can explain how Mr. Hammer has succeeded in attaining this result, we must clearly keep in mind the distinction between phosphorescence and fluorescence. A phosphorescent substance is one which continues to glow in the dark after it has been stimulated by sunlight or electric light; a fluorescent material, such for example as resorcin blue, responds to stimulation only so long as it is within the influence of excitation, and becomes inactive as soon as the source of excitation is removed.

Mr. Hammer has found that by combining phosphorescent material with fluorescent liquids of various kinds, he can obtain a large variety of luminous paints. The fluorescent material can be dissolved in alcohol or ammonia and then thoroughly mixed in the phosphorescent material, so that each particle of the calcium sulphide is coated and impregnated with the fluorescent material. When the resultant mixture is stimulated by the mercury arc or other means, it glows with a most brilliant color, depending upon the fluorescent material

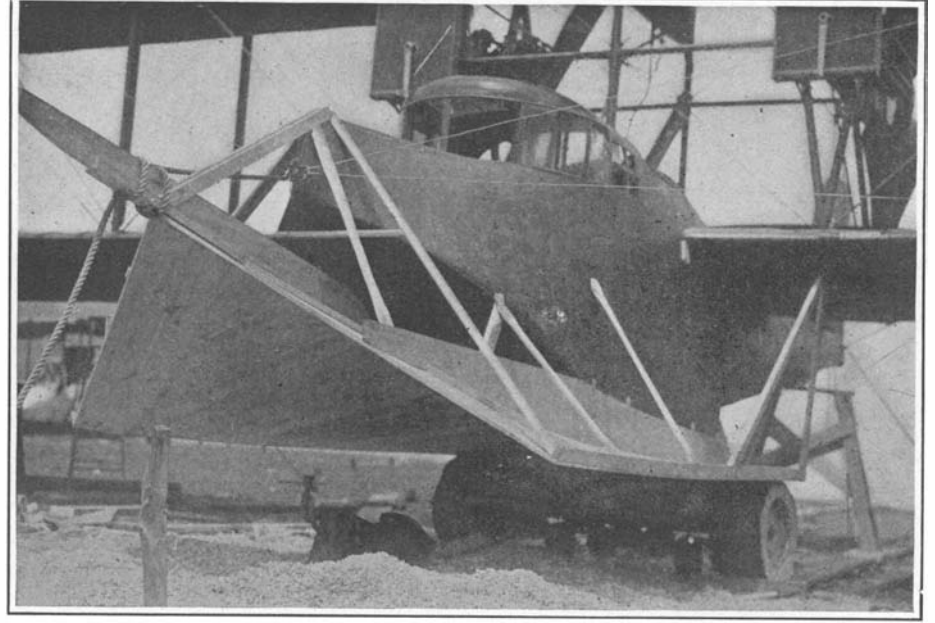


Photo. by F. Weyman.

### Sea-sled bottom under the "America," to make her skim the water with full load.

The lower front corners were curved upward to prevent scooping water when the boat dipped or met a billow. The truck supported the craft softly till she was launched in sufficient depth of water.

The practical applications of the discovery are, of course, far wider. The theatrical effects which can be obtained are at once obvious. The paint may be applied to draperies or to solid objects—indeed to any surface. Moreover, pictures may even be painted with these luminous paints—pictures which under excitation would possess an intensity most remarkable.

### Did Prof. S. P. Langley Invent the First Practical Flying Machine?

By C. Dienstbach

THERE seems to be good reason for determining the real merits of Prof. S. P. Langley's ill-fated man-carrying aeroplane of 1903 from the viewpoint of the most recent progress in flying machines, because the recent criticism by Mr. Griffith Brewer, in the face of the demonstration at Hammondsport, shows glaringly how the subconscious effect of ancient press derision is still liable to impair the memory of a great pioneer.

The only difficulty experienced at Hammondsport was in the machine's ability to lift the weight and overcome the air resistance of the pontoons and their framing, added for starting from the water. The power of the motor constructed by Mr. Manly has been established by tests of the same irreproachable scientific accuracy that distinguished the mechanical part of Langley's work from previous experiments with flying machines to be exactly 54 brake-horse-power—far in excess of the famous so-called 50 horse-power Gnome motor, which still easily lifts two men. Langley's propellers were tested equally well. As the total area of the wings was far more ample than in modern machines, a rather low carrying efficiency is obtained, which can be attributed only to Langley's plan of depending for longitudinal stability partly on wings in tandem. Of these wings, the rear pair are deliberately dis-

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