

moves by clock work. As the barograph would get out of order from the heavy jolting inseparable from the starting and landing of an airplane, the instrument is held in place in the cockpit by elastic cords. These absorb the shock and prevent any disarrangement of the suspended mechanism or any premature chart marks by the pen. The barograph is used in place of the altimeter only in test flights for the purpose of making official height records.

The instrument used to determine the speed of an airplane consists of two parts—the indicator proper and a pressure head, generally a kind of tube arrangement, which will be described later. The indicator is fixed on the dashboard and its function is the measurement of the differential pressure caused by the air rushing through the tube, which, in turn, is mounted to a strut, or wing brace. This pressure head usually consists of a combination of a pitot and a venturi tube. The first consists of two concentric pieces of tubing, with one end set squarely upstream to the air flow. A series of very small holes runs the length of the inside tubing. The space between the two concentrics is sealed at the end of the tube so that when the air enters the wind finds access only through the perforations of the inner concentric. This arrangement produces a suction effect on the outer tube and pressure on the one inside. The difference in pressure is then measured by a gage and the result is shown on the indicator in the cockpit. In some makes of air-speed indicators only the pitot tube is used.

The venturi tube, now so generally combined with the pitot, as mentioned above, is short, flares out at both ends and is constricted between the two openings. The pitot tube, long and narrow, on the other hand, has no variation in its diameter. An idea of the shape of the venturi becomes obvious by comparing it with an old-fashion blunderbuss, the kind that one associates with Stevenson's romances. A side tube meets the main tube at right angles at the point where the "blunderbuss" tube is the narrowest. Air passing through produces a suction effect in this side tube. As the velocity is greater at the constricted part of the main tube than at its mouth, there is considerable increase in the suction effect—in which consists the advantage of the venturi tube. The air-speed indicator is a stability instrument. By its aid the aviator is able to avoid the loss of flying speed and to keep on the safe side of excessive speed. The true speed is not shown and the aviator is obliged to make certain calculations to determine the distance being covered.

There is another instrument, however, which relieves him of this necessity and shows at a glance the number of miles traveled—the air distance recorder. On this the reading is simplified, as in the case of a pedometer used by a pedestrian or a distance indicator on an automobile. The distance indicator is operated by a rotating vane attached to a brace or wing support.

The venturi tube is used in another airplane instrument, the gyroscopic form of turn indicator, which shows any deviation from a straight line course. The air passing through the venturi tube furnishes the power for the operation of a small gyro, which spins about a lateral axis at about 7000 revolutions a minute. The well-known law of gyroscopic precession governs the operation of this type of turn indicator. When a gyroscope is affected by any motion, except motion on its own axis, it moves at right angles to the applied motion instead of in the direction of the applied motion. Bearing in mind this principle, one readily understands how the indicator works. As an airplane turns to the right or to the left the motion generated sets up a state of precession which, more intense than the motion caused by the veering of the airplane, is registered by the instrument dial. For the guidance of the aviator a white mark appears and he turns the rudder on that side to regulate his course.

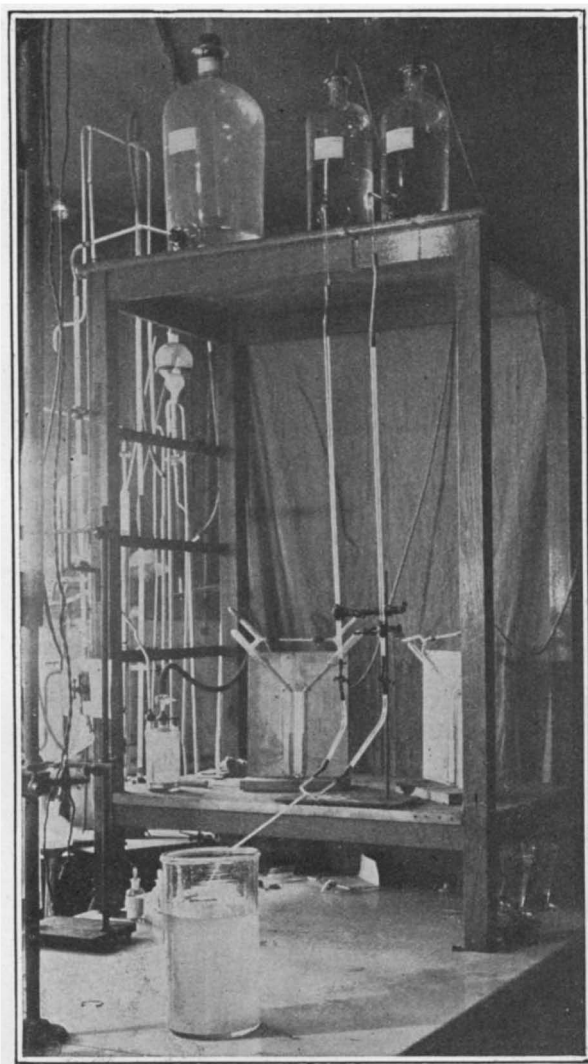
The operation of the other type of turn indicator is based on the measurement of differential pressure. In this connection a static head is fixed to each wing tip. This type, however, has disadvantages. Should the airplane strike a wide area of atmosphere also in a state of rotation, the instrument might read zero. But in the case of the gyroscopic types the absolute rotation is shown, and it measures the actual rate of turn.

Then there is the inclinometer, sometimes incorrectly called a banking indicator, which has a distinct function of its own. The tilt of an airplane, fore and aft, is shown by the inclinometer. There are two kinds. One is gyroscopic in principle, but the most common type consists of tubes filled with liquid and made to form a closed triangular circuit. The contents of the tube seek its level when the plane makes an upward climb. A scale shows the aviator the change in position undergone by the meniscus, the curved surface of the liquid column. This instrument is used only in test flights.

Banking indicators show how much an airplane rolls over on either side. There are also two kinds of these instruments. In the type which finds greater favor the familiar spirit level is modified to suit flight requirements. The other style operates by a pendulum, which is attached to a metal cross-piece on the face of the indicator.

In the upper part of some instruments white lines are to be seen which represent in the rough a transverse section of an airplane. When the machine turns on its side so that the right or the left wing tilts down—or "banks"—the pendulum actuates the metal bar, which forms an angle of greater or less degree with the small plane on the dial. The pilot knows that this condition of overbanking or underbanking has been corrected when by manipulation of the controls the metal bar and the miniature plane on the indicator become parallel. In another kind a white spot appearing at the crucial moment performs the function of the miniature indicating plane.

Connected with the vital part of an airplane, the motor, is the tachometer, which indicates the number of revolutions per minute of the propeller shaft. Thus correct engine speed may be obtained, which is par-



The Jolibois apparatus for rapid and accurate proportioning of liquid mixtures

ticularly important when a plane is driven by more than one motor, as is now generally the case. Unlike some of the other instruments on an airplane, the tachometer is not a device specially designed to meet certain conditions in aviation. The aircraft tachometer is merely an adaptation of an instrument—operating on the centrifugal principle—which, for instance, has been in use for some time on twin screw steamships for the maintenance of the same speed in both propellers.

While the centrifugal type is the most common in aviation, others have been tried out for airplanes. One kind has a clock work mechanism and counts the number of revolutions of the propeller shafts in a given interval of time. It is too sensitive to shocks, however, for practical use. In the case of those tried out during the war it was found that vibration from the big guns disarranged the delicate adjustment of parts necessary in the chronometric type. In the liquid type the angular acceleration—that is, the speeding up or slowing down rate of the propeller shaft—is indicated by a comparison of the fluctuations of two liquid columns in connection with a Bourdon gage. Other types are the elastic, the air pump, the magnetic and the air-viscosity, the latter being like a torsion viscosimeter,

which records the rate of rotation of a fluid—in this case, air; as its viscosity is almost a constant, the change made by the dial is practically in proportion to the rate of rotation.

In the rate-of-climb indicator—used only in connection with laboratory and experimental work—the upward speed in feet per second is obtained by direct reading. A manometer—an instrument which measures the elastic pressure of gases and vapors—is part of this particular indicator.

An instrument for seaplanes skirting close to the surface of rivers and the sea is the night altitude indicator, optical in principle and built on the range-finder plan. However, it is not in general use.

The side-slip—a lateral movement of a plane caused by overbanking or by underbanking—is measured by the yaw indicator. Again the principle of operation is that of differential pressure. This is another instrument used only in experimental work.

Both the magnetic and the gyroscopic compass have been adapted to airplane use and at one time the long-period magnetic was used by many aviators as it performed the function of a turn indicator. In the gyroscopic form the actual turning rate is measured. For overcoming the constant vibration of a soaring plane a jeweled spring pivot of an adjustable nature and studs of rubber are used.

Then there are a number of thermometers and gages which show the condition of the various parts of the motive unit—the gasoline tank, system of lubrication and the radiator. As to the thermometers the type is that which depends upon the vapor pressure of a liquid in a bulb. Although they cannot be seen directly because of their location, the results of their operation are placed under the eyes of the observer in the cockpit by the aid of a long-distance Bourdon tube system.

In a general sense indicators for the gasoline tank may be classified as depth gages and flow meters. The former are constructed to indicate the contents-level by either a float, like that in a domestic water-flushing box, or by a contrivance which measures the hydrostatic pressure near the bottom of the supply tank. Built in accordance with the underlying principle of the venturi tube, flow meters reveal to the pilot at any instant just how much fuel has been consumed.

In respect to timepieces they are made with special consideration of the hard usage to which they are subject from sudden jarring in "taking off" and in landing.

A species of airplane equipment necessary in seeking high altitude records is the oxygen apparatus, without which the pilot could not live in the rarified atmosphere above us. While there are three types, chemical, liquid and compressed oxygen, only the latter has been used in America. In this kind the flow of oxygen is controlled automatically for supplying the exact amount

(Continued on page 279)

Mixing Liquids by Machine

By Jacques Boyer

IN the laboratory certain difficulties are met in effecting the quick and homogeneous mixing of two liquids. M. Pierre Jolibois, professor of chemistry at the Polytechnic School, Paris, has invented a very simple apparatus for this purpose. The principle upon which it is based consists in directing, through the two branches of a Y-shaped glass tube, the two liquids which mix with each other in the end tube.

By means of faucets, the flow is regulated in order to obtain each liquid in the desired proportion in the resultant mixture.

In order to measure the flow, the admission of air in the vials which contain them, is effected through a graded venturi tube. By selecting a rapid colored reaction it is possible to ascertain the speed with which the two liquids mix. Let us put, for instance, in the left branch a solution of permanganate of potassium at 1.58 grams per liter; and in the right branch a solution of ferro-silver at 15 grams per liter and containing 50 cubic centimeters of concentrated sulfuric acid and 10 grams of sulfate of manganese per liter. The discoloration of the permanganate by this liquor is effected to the point of homogeneity in 0.04 to 1.2 seconds, according to the diameter of the tubes.

The liquid is sensibly homogeneous in those parts of the tube where it is colorless, and it is shown by this test that homogeneity is attained the sooner when the tube is thinnest. The method invented by M. Jolibois thus allows to operate very quickly, and by changing the form of the branches of the Y tube he has even been able to obtain the homogeneous mixture of two miscible liquids in the one-hundredth part of a second. This apparatus will be of great use to chemists for studying the speed of quick reactions between liquids.