The flight of airplanes around the world was not possible until aeronautical engineering had advanced to a point where equipment could be constructed that would withstand such a journey. As a military campaign is worked out beforehand on paper, so was the world flight mapped, figured, and the essential engineering problems done in blueprint before even the personnel was chosen to make the flight.

The problem of equipment was by far the most stupendous task confronting the World Flight Committee. This committee was appointed to work out the details of the flight, and, while matters of finance and supply presented an enormous task, the most important consideration was the selection of an airplane that would withstand the strain of flying 27,000 miles through the varied and extreme changes in climate necessarily encountered in a flight entirely around the world. The problem of selecting the personnel was a particularly difficult one, not because, as may be supposed, of the lack of properly qualified and experienced pilots in the Air Service, but because of the great number of such men who were eager for the opportunity. It was only after long and careful study that it was possible for me to decide upon the men for the job.

Planning the route itself was the first task to be considered. Engineering air routes is a new occupation. It is the youngest of all the professions and is yet in its swaddling clothes, but it had to be pressed into service to accomplish a feat never undertaken before in this country. There is very little experience upon which to build an air route. The great essential to success in flying is the ground work, and, with the entire world laid out to fly around, the problem of ground preparation was not easy. In order to minimize the number of long over-water flights, the route was laid over as much land as possible, and this led to flights over and landings in areas where accurate maps were very hard to obtain. Maps of over a score of countries had to be minutely studied, while the intervening seas had to be charted for currents and winds. Wind directions were determined, the rainy seasons noted, the percentage of fog-free days in Arctic countries figured, and the eccentricities of barometric pressures studied. It was discovered in making meteorological studies that a mean condition of weather could not be expected for a greater distance than 600 miles, due to the recurrent regions of high and low barometric pressure. It was, therefore, advisable to establish landing places at intervals not greater than this distance.

Advance officers were sent ahead to make preparations with local officials to receive the flight. The supplies were then sent to the selected stops or bases by any available means of transportation. Boats were the usual method of distributing the spare motors and other supplies, as most of the stops, especially those in foreign countries, were on or near the water. This phase of the problem was also worked out on paper long before a single wing or spare motor was crated for shipment to the bases.

The mechanical engineering, which has to do with the airplanes and their motors, was one of the most important phases of the task. The proper functioning of an airplane is dependent upon the perfect operation of every part that goes into the ensemble. If one of these small parts fails, the entire machine may stop and flight will be brought to an end. As stated by the engineer officer in his official report, the minor things are often of the greatest importance. This is shown in the following excerpts from the report of the engineer officer of the world flight:

**Engines**

"The engine situation is always the most serious one in any undertaking of this nature. Regardless of how good the planes are, or how well everything is planned and organized, or the ability of the pilots, when the engine stops, in most cases, the flight ends. It is seldom that a forced landing can be made in a strange country and over bodies of water without damage to the plane. Not only the lives of the personnel were at stake, but also the honor of the Service and the whole nation, and no effort could be spared in preparing the engines to insure success of the project. Usually, it is the small thing that causes a forced landing and not a big one. Care in assembling the engines will obviate the necessity of a lot of work on the part of the airplane crew. The work of cleaning up the engine and plane after a flight, because of oil leakage from the different joints of the engine, such as crank-case joints, the cylinder hold-down flanges and camshaft housings, is very tedious. It can be avoided in most cases if the proper care is given to the assembling of the engines. The flight took full advantage of the spare motors at the various bases along the route and every plane had installed a new motor while at the main supply base in each of the six divisions. These changes were not made because the engines had become sufficiently worn to make imperative the installation of a new motor, but for the same reason that an owner of an automobile has the carbon removed from the cylinder heads of his motor when a diminution of power be-
comes noticeable. The installation of a new engine was easier, more rapid, and less expensive than the usual top overhaul necessary to place the engine in excellent mechanical condition again. The great strains placed on the power-plants of the airplanes of the World Flight during the time that they were equipped as seaplanes and passing through the tropical heat of the countries near the Equator made the frequent engine change a very excellent precaution.

When the world cruisers were using the water for alighting, the work of maintenance was particularly difficult because of the necessity of working on the motors with the airplanes pitching to every swell. But, throughout the entire undertaking, the Liberty engine fully vindicated its selection as the power-plant for the airplanes that succeeded in establishing the record of flying around the world for the first time.

**Ignition**

**Battery**—The 12-volt system used was very satisfactory with few exceptions. The batteries stood up well under all climatic conditions and gave very little trouble. The battery on Plane No. 4 went from the factory to Ivigtut, Greenland. The only reason for changing was that one of the cells would not come up to full charge. As new batteries were available, it was decided not to take chances with an old battery. The old batteries on Planes Nos. 2 and 3 went as far as Bagdad and Calcutta, respectively, the failures resulting from shorts by wires falling across the terminals.

**Generator**—These gave some trouble and at times would go dead for no apparent reason. One went out on Plane No. 2 at Rockwell Field before the flight left. When disassembled, the separate parts were tested by all the electrical experts, both from the Army and Navy, and also from the City of San Diego. Everything tested O. K. but, when assembled again, no current could be obtained from the generator. This trouble occurred on several occasions but, on examination, no trouble could be found that would explain the generator failure. Several of these generators were shipped to the Engineering Division, McCook Field, so that the trouble can be found and eliminated on future productions.

**Starter**—The starters and hand-starting attachments worked well, except in cases where they had been assembled without being packed with grease, as a result of which they would bind and stick and a fully charged battery could not turn the engine over. In such cases, the hand-starting attachment was used with satisfactory results. On disassembling these starters, they were found to be dry from lack of lubrication, but nothing else was wrong. After this, whenever mounting a new starter, it is always disassembled and inspected before installation. Hereafter, an alemite attachment will be mounted in the starter housing, so that it can be lubricated without removing and disassembling the starter. The hand-starter attachment was well worked out and, without it, it would have been impossible to start the engines on a good many occasions, especially in cold weather when the batteries were low and would not turn the engines over. The following method was used in starting the engines in cold weather: first, the engines were turned over by the hand crank several times to break up the cold oil; a few injections of ether were fed in with the primer, and then from about six to ten shots of gasoline, depending on the temperature. The engine would usually start on the first few turns of the electric starter. A good many times, however, when the batteries were low, only the hand starter was used. A small can containing ether was hooked up to the primer so that it could be used for priming with ether and gasoline.

**Distributor Heads**—The carbon rotor was installed in the right distributor head and the jump spark rotor on the left. The right switch was used for starting because it was found easier to start the engine using a carbon brush than with the jump start in cold weather.

**Spark-plugs**—The type of spark-plugs used throughout the flight were satisfactory. They were set with a gap of .012 and remained in the engine until a new power-plant was installed. Throughout the en-
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The tire journey, it was unnecessary to remove a single spark-plug for fouling or any other cause of failure.

Cooling System and Gasoline System

The cooling system worked very satisfactorily with practically no trouble. The method of mounting the radiator was most satisfactory; it was very accessible and the radiator and shutters could be quickly removed if necessary. The only trouble experienced was due to the small bracket on the radiator used for fastening the cowling support, vibrating loose in one place. This was remedied by fastening the cowling support to the engine and cutting off the brackets on the radiator.

The larger type radiators were mounted at Tokio, Japan, the smaller size having functioned excellently without leaks and with the same water with which the planes left Seattle.

The larger radiator gave excellent cooling under all conditions met in tropical climates. At times, the planes were on the water, with the engine wide open for over an hour, trying to take-off, and the temperature of the water in the motor never exceeded ninety degrees Centigrade. At Multan, India, the temperature was one hundred and sixteen Farenheit in the shade. While flying close to the ground, to find the way in a sandstorm, the motor temperature did not exceed eighty-five degrees Centigrade. These radiators were used as far as Brough, England, without giving any trouble. From England to the terminus of the expedition, the planes used two flexo types and one cartridge-core radiator, respectively, both types giving excellent results, although the latter type was about twenty-five pounds heavier. A mixture of alcohol and glycerine was used with good results in freezing temperatures.

The radiator filler necks should be improved. It is difficult to keep them from leaking water around the cover, which causes a fine spray to fly back, covering the wind-shields. This was very annoying when using the non-freezing solution and flying close to the water in snow or fog with poor visibility, making it necessary to wipe off the wind-shields every few minutes. This was remedied by wrapping the caps with friction tape.

Gasoline System—The engine-driven gear pump C-5, mounted level with the bottoms of the gasoline tanks and driven by a flexible shaft from the engine, proved satisfactory. One pump failed after three hundred hours, due to the sticking of the gears against the housing and causing the drive shaft to shear; one pump was still functioning after four hundred and fifty hours, a truly remarkable performance.

At Karachi, India, after a Flight with Broken Connecting Rod

Both wind-driven and hand pumps worked very satisfactorily. Trouble was experienced with air locks in the gasoline lines. This was eliminated by opening the pet-cock on the line strainer for a few seconds. It is believed this trouble was caused when starting the engine on the “gravity” fuel tank and turning the indicator to the “run” position on the three-way valve without turning on the gasoline from one of the main tanks.

Flying with the 3-way valve on the “both on” position, when the main tank began to empty, the engine would not get sufficient gasoline from the gravity tank and would cut out. It was then necessary to run on “gravity” until the other main tank was cut in before turning back to the “both on” or “run” positions, on the three-way valve. No trouble was experienced with three-way valves, by-passes, strainers, gasoline lines, solid or flexible connections.

Oil Pumps

Every oil pump had to be adjusted and the low-speed adjustment closed. It was found that it was not safe to use the low-speed adjustment, because, when used, the pumps would function properly for a considerable length of time and, when least expected, the oil pressure would drop. The pressure also varied too much with changes of temperature and it was found safest to close the adjustment tightly.

The world cruisers were equipped with two ignition systems, three gasoline fuel systems, five gallons of extra water for the cooling system, but with no emergency pump of any kind in case of an oil pump failure. I do not know that it would be practicable to equip airplanes for a mission of this kind with emergency oil pumps, but I do believe that it would
be worth while experimenting to the end of devising an appliance which can be used as an auxiliary in the event of failure of the engine-driven oil pump, during a long flight.

**Airplanes**

The airplanes performed splendidly throughout the entire flight. The workmanship was excellent and two of the airplanes completed the flight with practically the same equipment with which they left the manufacturer, except the engines. The only changes were some control wires and two vertical wires on No. 4 and one removable panel on No. 2. These airplanes have now four hundred and fifty flying hours to their credit.

**Pontons**—The construction of the pontons was the source of a little worry due to the fact that the decks were made of ply-wood and not built up by two layers of wood laid at an angle of forty-five degrees to each other, with a thickness of canvas between. This is the usual practice, but it was thought that the former would stand up better in severe weather, as the built-up decks were more liable to leak, also to warp and blister in hot climates. The construction used gave some very good results, except that it was necessary to exercise considerable care in mooring the planes, or, when leaving or getting aboard, not to puncture the deck. The pontons withstood landings in some very rough water and also rode out heavy weather and sea at anchor. On several occasions, some difficulty was experienced with the spreader bars working loose. This was due to weave of the pontons in rough water. Very little difficulty, however, was experienced from leaks, it being possible to leave the planes in the water for days without the necessity of pumping out the pontons. Many times, the weather was too rough even to attempt boarding the planes, yet, it seldom took over ten or fifteen minutes of work to pump them entirely dry.

While at Dutch Harbor, Alaska, one of the world cruisers was blown from the skids upon which it had been drawn during a severe squall, in which the wind reached a velocity of about thirty-five miles per hour. It was thought at the time that the pontons could not escape injury, but they fortunately came through without any damage whatsoever.

Metal pontons would have been desirable for several reasons; first, the weight would have remained constant because they would have been free from water soakage experienced in wood-covered pontons; they would also have stood more rough treatment during their handling and would not have been so easily damaged by floating wood, ice, etc. The metal ponton had not reached a stage of development before the start of the expedition, which would have warranted its use, on such an important trip.

The port-holes of the present pontons will have to be redesigned to allow greater access to the different compartments for repair, inspection and draining of water. The port-holes should be larger and placed in better-suited positions for doing this work when planes are at anchor on the water. The screw type ports should be changed to a type very quickly removed and replaced. Considerable time was lost making inspections using the present screw type. Good varnish properly applied will help greatly in keeping pontons dry and clean.

**Landing Gears and Tail Skids**—No trouble was experienced with the landing gears, one of the airplanes being forced to land near San Francisco, landed in a very rough field without any damage. It would have been impossible for any others of our present service type of aircraft to have landed there without serious damage. The tail skids were also very satisfactory. One failure occurred on Plane No. 2, due to faulty workmanship in welding. This was called to the manufacturer’s attention, with recommendations for a change of design so that faulty welding would not cause complete failure of the tail skid assembly.

**Fuselage**—The metal fuselage construction withstood a great deal of rough treatment without a failure in any of the airplanes of the flight. When on water, all metal parts were covered with Noxide. This was to protect them against salt-water spray thrown up when it was necessary to take-off
or land on rough water. Inspections after the termination of the undertaking showed the fuselages of all airplanes to be in good condition, with hardly any traces of rust.

Wings—The only part of the construction of the wings that gave any trouble was the fairing at the opening for the ailerons. The supports were a little light and, after the wood had been subjected to the different atmospheric conditions, the fabric pulled the fairing strips away from the supports, which were too light to withstand the strain. New fairing strips were constructed at Brough, England, and no further trouble was experienced. It was noticed during damp weather that the fabric on the wings would wrinkle badly and, as it dried, tighten again. It was necessary to dope the inside of the fuselage covering upon Plane No. 2 upon reaching England. This was very satisfactorily accomplished by an application of a coat of pigmented dope on the inside. The Royal Air Force have discontinued the use of clear dope and now use three coats of olive drab pigmented dope as a primer and finish, with two coats of olive drab pigmented aluminum dope. In India, instead of using olive drab dope as a primer, they use a rose-colored dope which has been found more satisfactory in tropical climates.

Tail Surfaces—The construction of the tail surfaces proved very satisfactory, and on no occasion was it necessary to make any changes. The whole assembly was just as rigid after four hundred and fifty hours of service as when new. Waves often buffeted the lower side of the elevators and stabilizers, but no damage was suffered because of this fact.

Gasoline Tanks—The fuel tanks were constructed entirely of aluminum. One failure occurred on Plane No. 3 at Constantinople. This failure occurred in the bead along the side of the tank and consisted of a very fine crack. None of the other planes of the flight had any trouble with their fuel tanks.

The aluminum gasoline tank commended itself very strongly for use in the world cruisers, because of its lightness when compared with the turnplate type that has heretofore been used in army aircraft.

Considerable anxiety was felt, however, toward the use of this new type of fuel tank construction on an undertaking of the nature of the flight around the world, and it was only after exhaustive research that their utilization was decided upon. Their success has opened up the question of using this construction in all other service types of army aircraft.

Anchor—Standard navy type, 60-pound stock anchors were carried for emergency. These anchors were strapped between the front struts on the left ponton with the stock folded. One hundred and eighty feet of 2½-inch rope was carried in a box on the left wing close to the fuselage.

Moorings—The flight experienced some trouble at first when large drums were used as mooring buoys. This proved very dangerous when approaching to moor the planes, or when at anchor with the tide running in the opposite direction to the wind, because this condition would cause the plane to drift up against the buoy and the drum would pound against the pontons. This, however, was overcome by snubbing the drum between the two pontons so that it could not strike the sides of either. After the first two flights, cork life buoys were substituted for the metal drums and, thereafter, the only trouble experienced was when a landing was made in rivers, the tide would sometimes be running so fast that the buoys would be submerged and very difficult to pick up by the plane when mooring. The planes were moored without aid of boats at all harbors around the world except at Saigon, French Indo-China, and at Calcutta, India.

When the world flyers arrived at Boston, Massachusetts, I was surprised at the splendid condition of the airplanes. It was hard to realize that these same machines had passed through the rigorous climates of the near Arctic and the steaming heat of the equatorial regions; they looked almost new. This same thing was noticed with great interest by all the pilots who saw these machines land. The tales of hardship through the Alaskan snows, the forced landings in the ocean, the heavy rains of the tropics were supposed to turn the color to at least a drab gray, but for the moment we had forgotten that the planes had been redoped in England. But, at that, the stories that came from the Orkneys, Iceland and Greenland in which long periods of waiting took place led everyone to expect to see the airplanes partaking of the color of the bleak coasts of Greenland and Labrador.

It was only in the drawn faces of the personnel that I could see how much these men had given and how zealously they had husbanded the powers of the aircraft, which made it possible to bring the honor of this great achievement to the American people.