NEW DEVELOPMENTS IN MARINE LORAN RECEIVING EQUIPMENT

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Through electronic developments, which received a great impetus during the last World War, the measurement of time in millionths of a second became possible. This scientific achievement gave birth to a new and entirely different navigational aid known as loran — an abbreviation for *LO*ng *RA*nge *N*avigation.

A description of the operating principles and technical details of the Loran system of navigation are contained in the *Hydrographic Review*, Volume XXIII, 1946 (pages 9-30 inclusive). Therefore only a brief description of the loran system is contained herein. The purpose of this article is to review the improvements in loran receiving equipment made since 1946 which are of interest to the navigator.

Advantages of the Loran System.

Growing interest in loran is undoubtedly attributable to the several inherent advantages of the system.

Loran enables the navigator to find his position on the high seas, or in the air, at any time in darkness and fog. Fixes are obtainable over water at distances up to 750 nautical miles in daylight and 1400 nautical miles at night from shore-based loran transmitting stations of known position.

A fix can be obtained in from 2 to 6 minutes and its accuracy is comparable to that obtainable with celestial observations under favorable conditions. Loran lines may be used in combination with terrestrial bearings obtained by visual or radio means and lines of position obtained with a sextant.

The ship's navigator can depend on loran in the stormiest weather when knowledge of the ship's position is most urgently needed and when poor visibility prevents the use of a sextant.

This new navigational aid is free from ambiguity. It is unaffected by changes in ship's structure and is completely independent of other data, such as ship's heading and dead reckoning. Furthermore, its use does not depend on any other navigational device, such as the compass, chronometer, or directional antenna.

Growth of the System.

Loran was first developed in the United States of America at the Radiation Laboratory of the Massachusetts Institute of Technology and was undergoing its first tests in December 1941. By the autumn of 1942, U. S. Naval vessels were carrying out trial operations in the stormy north Atlantic, where convoying and anti-submarine opeiations required the best possible navigation. The system became fully operational in the spring of 1943. During 1944 and 1945 loran coverage was extended rapidly over the combat areas and long supply lines of the central and western Pacific. By the end of 1945 over 3,000 surface vessels and 30,000 aircraft were equipped with loran receivers.

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The benefits of this new navigational aid, which played an important role in the last World War, are now being enjoyed by both merchant ships and commercial airlines. Of 37 loran stations now in continuous operation, 24 are in the Pacific and 13 are in the Atlantic—providing a total of 26 loran rates or lattices of lines of position. The U. S. Coast Guard operates most of these stations. Three are operated by Canada while the United Kingdom, Denmark, and Iceland each operate one station. Service is provided over most of the important ocean routes of the north Atlantic and Pacific Oceans.

Basic Principles of the Loran System.

The fundamental principle of loran lies in the reception by a navigator at sea of radio signals emitted continuously by a pair of loran stations usually from 200 to 400 miles apart. The two stations are held in synchronism by a radio link.

By means of a special receiver which functions as an electronic stop watch, the navigator is able to identify the stations and measure the time which elapses between the arrival of the signals from the two stations.

By consulting a loran navigational chart, or book of tables, the navigator determines from this time difference that he is somewhere on a particular line of position on the earth's surface. From a second pair of stations he determines that he is on a second line of position. The ship's position is at the intersection of these two lines and the latitude and longitude are read from the coordinates of the chart.

No knowledge of electronics or any computations are required to obtain a fix. Either charts or tables may be used depending on the navigator's preference. The charts containing superimposed lattices of lines for several pairs of stations and the tables are obtainable from the U. S. Hydrographic Office. The U. S. Coast and Geodetic Survey have introduced the practice of placing on the back of their sailing charts a similar chart complete with loran lines, thus combining information on all navigational aids on one chart.

A fixed relationship exists between the time of travel and distance traveled by radio waves which propagate at the speed of light. In one millionth of a second, known as a microsecond, a radio wave travels 983.2 feet. The loran receiver is capable of measuring time in millionths of a second which is a direct measure of the distance traveled by a radio wave during that time.

The loran measurement evaluates the difference in the distance from the ship to each of two transmitting stations and not the distance to either station. There are many points on the earth's surface where the difference in these two distances remains the same. These points fall on a smooth curve which is but one of a family of spherical hyperbolas with the transmitting stations as the focal points. Because of the constant difference in distance the same time difference is obtained everywhere on each loran line of position.

Loran transmitting stations operate on a frequency of 1750, 1850, or 1950 kilocycles. All thirteen stations in the Atlantic operate on 1950 kilocycles. Each pair of stations emits pulses at a different rate (such as 25, 25 1/16, or 25 1/8 pulses per second) and the receiver makes it possible to identify the stations by their pulse recurrence rate. The signals from the two stations are viewed on a cathode-ray tube (scope) and appear as two vertical lines of light. The measurement of time difference is accomplished by manipulating knobs on the control panel to superimpose the two signals.

Method of Indicating the Time Difference.

After the two signals were superimposed or "matched" on the various loran receivers available during the war it was necessary to compute the time difference from the scope. This was usually done in three steps and required counting, multiplying and adding time markers (small vertical lines) on the scope traces. Although this process of obtaining the time-difference reading was not very difficult, it was somewhat laborious and was subject to the possibility of human error.

There are now available to ship's navigators loran receivers of the direct-reading type in which the time difference can be read from numerals on a meter the moment the signals have been matched. This advance in the art has been very favorably received by navigators on ships of all types. The direct-reading feature, developed and first introduced by the Sperry Gyroscope Company, has simplified the operation considerably as it eliminates the need for any mental computations and greatly reduces the chances of human error.

Development of the Direct-reading Loran.

Sperry engineers undertook the job of developing a loran which would be fully automatic, and by the end of 1943 had produced a receiver which automatically gave a continuous indication of the time difference. Representatives of the U. S. Navy witnessed a demonstration of a working model in a station wagon in February 1944.

At one time during a heavy fog, the engineers were returning to the factory laboratory in the station wagon and made a wrong turn onto a highway. They thought they were headed toward the laboratory, but the numbers on the loran meter kept increasing and indicated they were traveling in the wrong direction. It turned out that the loran was right.

Loran signals may be received at night by direct transmission along the earth's surface and as one or more reflections from the ionosphere. Hence, several separate signals may appear on the scope. Some judgment must be exercised by the operator to insure that the proper signals are matched.

The automatic loran was not sufficiently developed to justify placing it in production, and it was feared that with an automatic loran the wrong pulses might be matched with erroneous results.

However, as a result of the progress made, the manufacturer was asked to develop a loran in which the pulses could be selected manually but in which the time difference could be read from numerals on a meter.

A redesigned model of a direct-reading loran was demonstrated exactly one month after the demonstration of the automatic model. In April 1944, the company was awarded a contract by the U. S. Navy to produce six experimental direct-reading loran receivers. Several units were undergoing trials the latter part of 1944. The design was approved and placed in production, but as a result of the war's termination only 200 Model DBE direct-reading lorans were actually produced for the U. S. Navy.

In November 1945 the Chief of Naval Operations granted permission to advertise and sell to commercial customers loran receivers similar to the Navy Model DBE units. To investigate the peacetime possibilities for the new device a quantity of commercial lorans were built and sold under the designation Mark 1. At first, commercial customers were somewhat sceptical. However, those who tried the direct-reading loran found it very dependable and easy to use, and they soon gave it their hearty endorsement. It was apparent to the manufacturer that additional lorans would be required, and early in 1947 work was started on the development of an improved version of the

Mark 1 loran which would be smaller and better suited for commercial vessels.

Preliminary models of several different designs were tested out at sea in the summer of 1947. Pre-production units of one of the designs were built to check manufacturing drawings before the new Mark 2 loran was actually placed in production.

Features of the Mark 2 Loran Equipment.

The new Mark 2 loran retains the direct-reading feature and possesses a number of advantages over its predecessor. The size has been reduced through the use of miniature tubes and by separating the power supply from the receiver-indicator. It is particularly suited for installation in smaller vessels where space is limited.

The receiver-indicator is designed primarily for mounting on a table or shelf at a convenient height. The trunnion mounts permit tilting the control panel to any angle desired by the operator. The unit can be suspended from the overhead and by turning the trunnion mounts 90° it can be mounted directly against the bulkhead. A cast aluminum pedestal is available for deck mounting, as shown in the illustration n° 7.

In general, the same type of phase-shifting circuit, which has proved so successful in the Mark 1 loran, has been retained. However, in the Mark 2 loran the phase shifters and time-difference meter are motor driven, which simplifies and speeds up the operation. In the new loran the coarse and fine delay controls, which position the lower pedestal, can be varied smoothly and continuously throughout the entire range of measurement. Because these controls do not operate in steps and never come up against a stop, no trial adjustments of the coarse and fine delays are required in making a reading.

Readability has been improved through the use of larger numbers on the time-difference meter. The 1,000's and 100's appear on a counter and the 10's and units are read from an adjacent dial, the microsecond reading appearing as a series of four or five numbers.

The time-difference meter and station selector characters can be read in the dark, as they are illuminated by a source of "black light" (ultra-violet) which does not interfere with night vision.

A further improvement is the addition of automatic frequency control, whereby the frequency of the oscillator in the indicator is synchronized by the received signals. This aids in positioning the pulses on the operating portions of the sweeps and prevents the pulses from drifting to the left or right.

The equipment requires very little attention and service facilities are provided by the manufacturer in principal ports. The test switch on the control panel, in combination with a chart, enables the operator to check the equipment and assure himself that the readings obtained are dependable and accurate.

Use by Commercial Vessels.

The first loran installation in a commercial vessel was made in New York City by Sperry on January 2, 1946, in the Swedish-American lines *M/S Gripsholm* and this was followed one week later by an installation in Boston in a General Seafoods trawler *M/V Calm*. Mark 1 lorans are now in use in numerous commercial vessels of various types and include those carrying flags of the United States, the United Kingdom, Sweden, Norway, Canada, and the

Netherlands. The U. S. Coast Guard has found loran invaluable in keeping their weather ships on station.

Because of the simplicity of operation of the direct-reading loran receivers they are proving very popular in the United States with fishermen. The loran helps them locate and remain on the best fishing grounds.

One of the most dramatic uses of loran is found aboard the trawler *Deep Sea*, which fishes for the giant king crab in the Bering Sea. In this area, where normal aids to navigation are of little use, Capt. Lowell Wakefield depends almost solely upon loran, not only to locate the most profitable habitat of this tasty catch, but uses loran lines in making good parallel courses over the characteristic crevasses where the best crab are found. Capt. Wakefield states that loran has been especially useful in navigation from Seattle to Unimak Pass which is the entrance to the Bering Sea. Using the stations in the Bering-Aleutian network he is able to "home", or run down a loran line, directly to and through Unimak Pass — regardless of weather, wind, and tide.

Loran is being used regularly by merchant ships in sailing great-circle courses from the west coast of the United States to the Orient. The Western Union Telegraph Company has found loran especially useful on their cable ship the *S/S Lord Kelvin* in locating submerged cable. The master of this vessel, Capt. Richard Beadon, reports that in one instance near Long Island it was necessary to postpone work on a cable when the repair was on a shipping lane and it was imprudent to leave a buoy on the grounds. A mile of stray was paid out on the end of the cable and was laid at right angles to the 1LO loran lines. The Captain reported that it was possible to tow for this stray by "homing" on the loran line to within an accuracy of 500 feet, or with at least six times greater accuracy than is possible with the aid of good celestial observations.

Indications of increasing confidence in loran are much in evidence in recent months. For example, commitments for the Mark 2 loran, even before the new design was placed in production, included a contract from the U. S. Signal Corps for the U. S. Army Transportation Service for 175 lorans and a contract from the U. S. Coast Guard for 20 lorans.

A recent Notice to Mariners (U. S. Hydrographic Office weekly publication) states that "The need for increased loran coverage is recognized and plans exist for establishment of stations to serve additional areas." The U. S. Coast Guard have announced that some of the existing stations are to be relocated to provide better coverage for merchant shipping.

Electronic engineers are already looking forward to even more remarkable achievements in the form of improved loran which will provide positional information automatically and steer a plane or ship on a prescribed course.

Sperry Gyroscope Company, Division of the Sperry Corporation, Great Neck, New York.

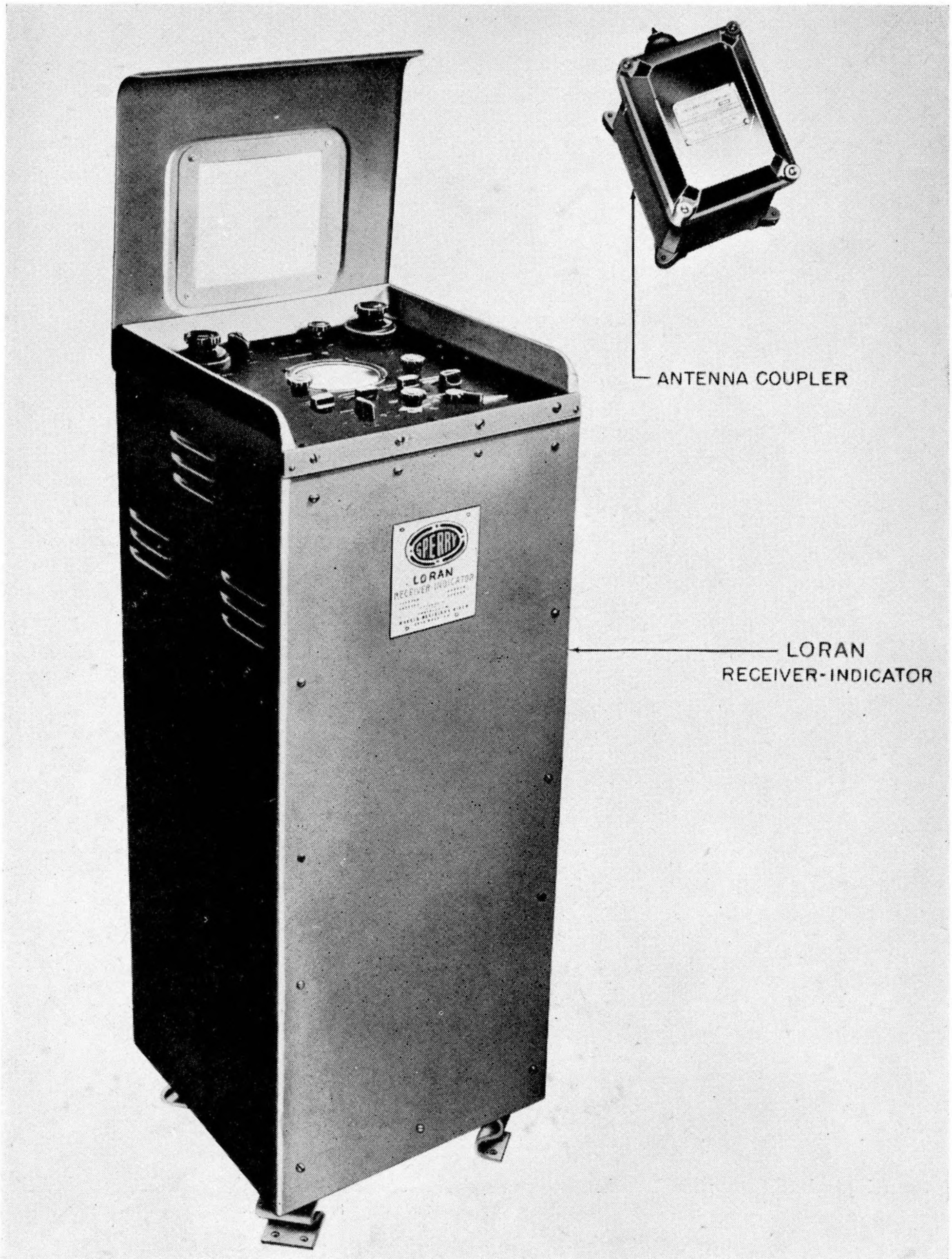

FIG. 1

Sperry Mark 1 Loran receiver-indicator designed for shipboard use. This is the first Loran receiving unit produced in which the time difference appears in numerals on a meter.

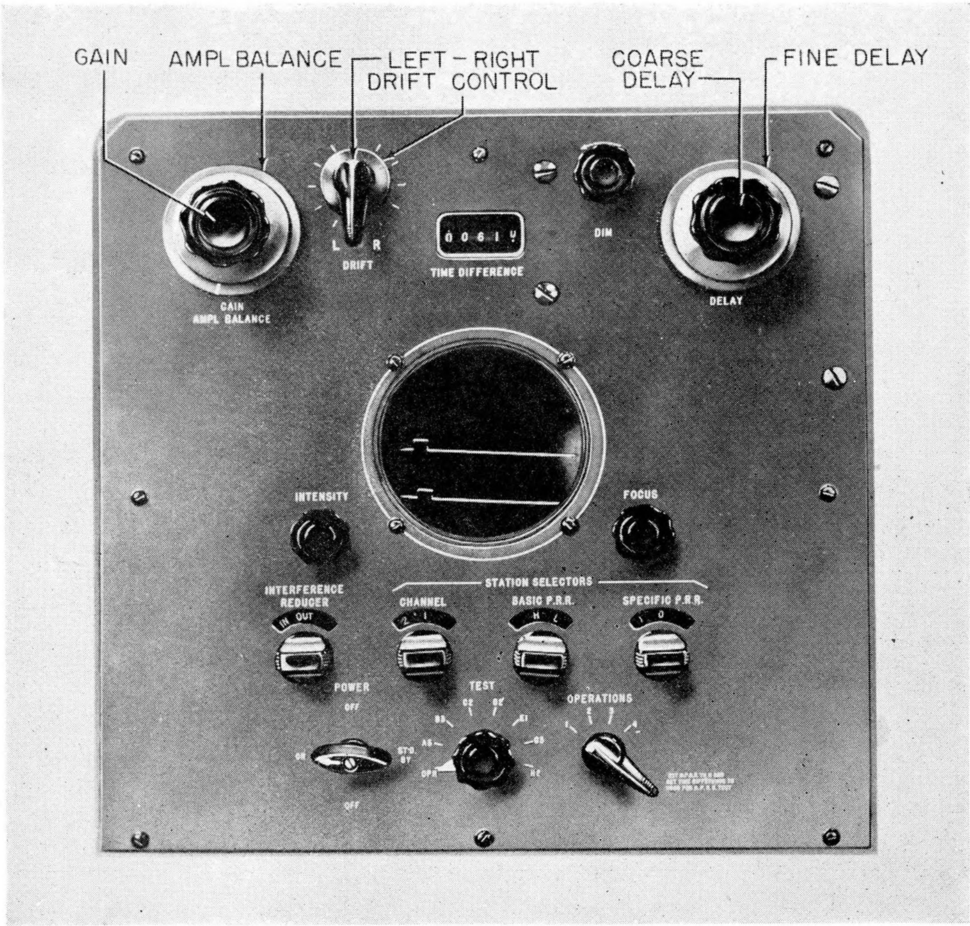

FIG. 2

Control panel of Sperry Mark 1 Loran. When signals are matched on the cathode-ray tube, the time difference can be read from the numbers on the time difference meter.

FIG. 3

New Sperry Mark 2 Loran can be table-mounted as demonstrated by Capt. W. R. Griswold who tested the device at sea aboard Sperry's floating laboratory M/V *Wanderer*.

FIG. 4

The Sperry Mark 2 direct-reading Loran receiver-indicator can be mounted on a shelf or table. Trunnion mounts permit tilting to suit the operator.

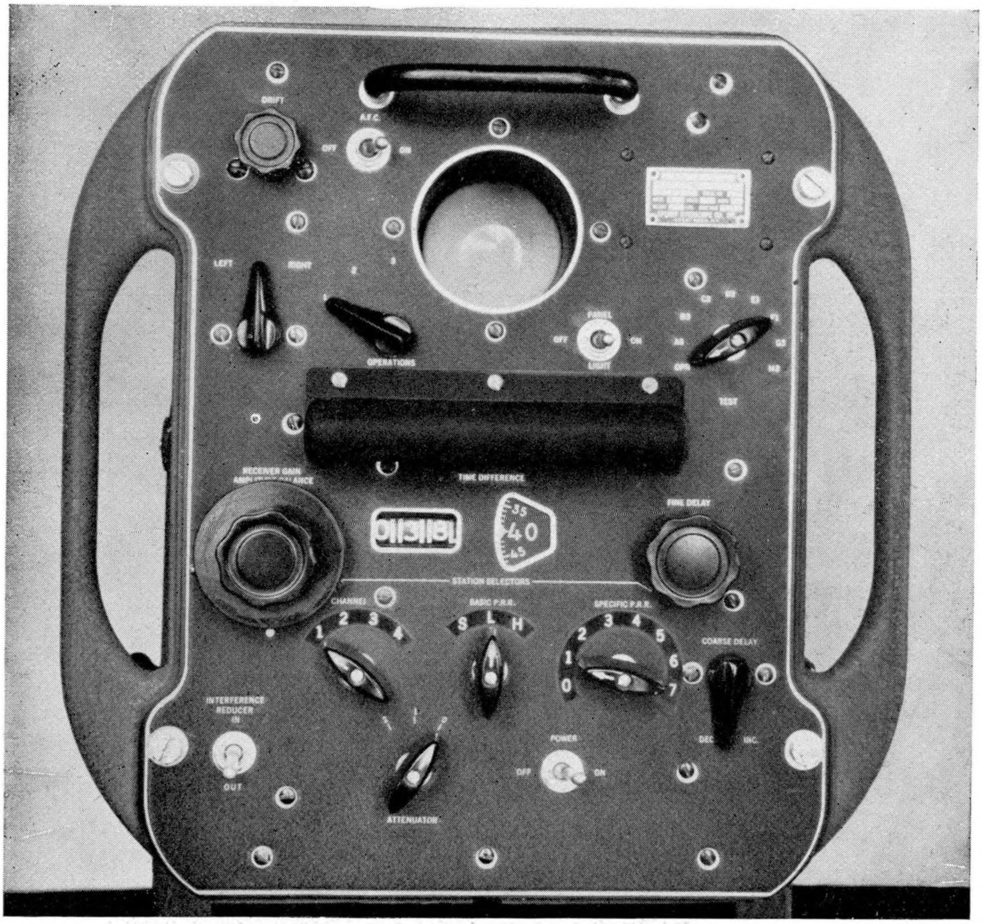

FIG. 5

Panel of receiver-indicator of new Sperry Mark 2 Loran includes controls and cathode-ray tube. Time-difference meter, designed whith large numbers for ease in reading, and station selectors are illuminated by "black light".

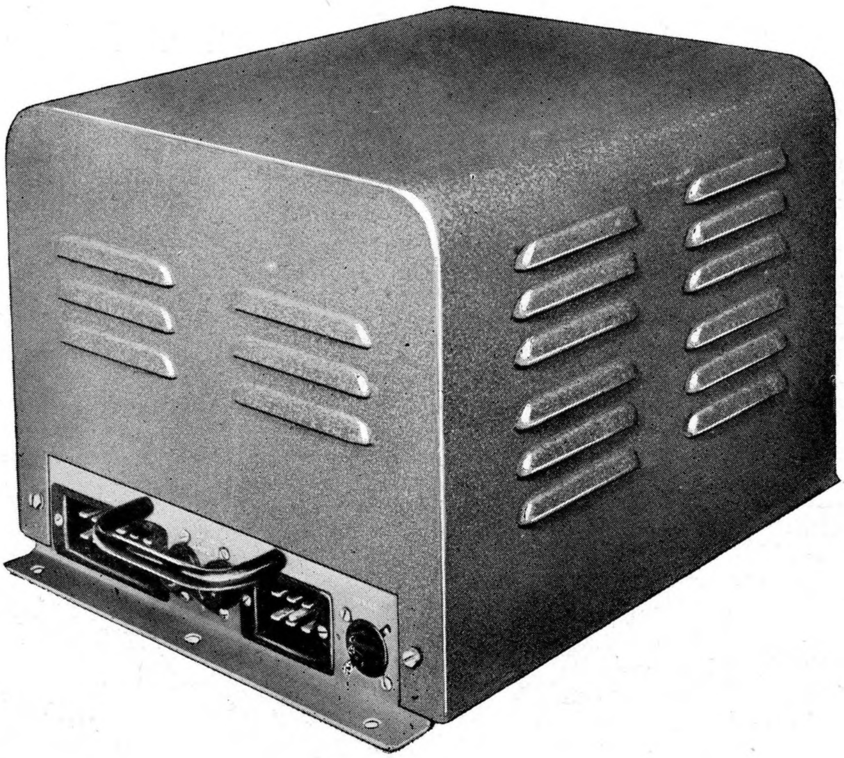

FIG. 6

The new Sperry-Mark 2 Loran has a separate power supply unit, shown above, which is connected to the receiver-indicator through a multiconductor cable. The equipment requires 60-cycles, single-phase, 115-volt power and draws approyimately 250 watts.

FIG. 7

The new Sperry Mark 2 Loran receiver-indicator with pedestal for deck mounting. Note trunnion design permits tilting to suit the operator.

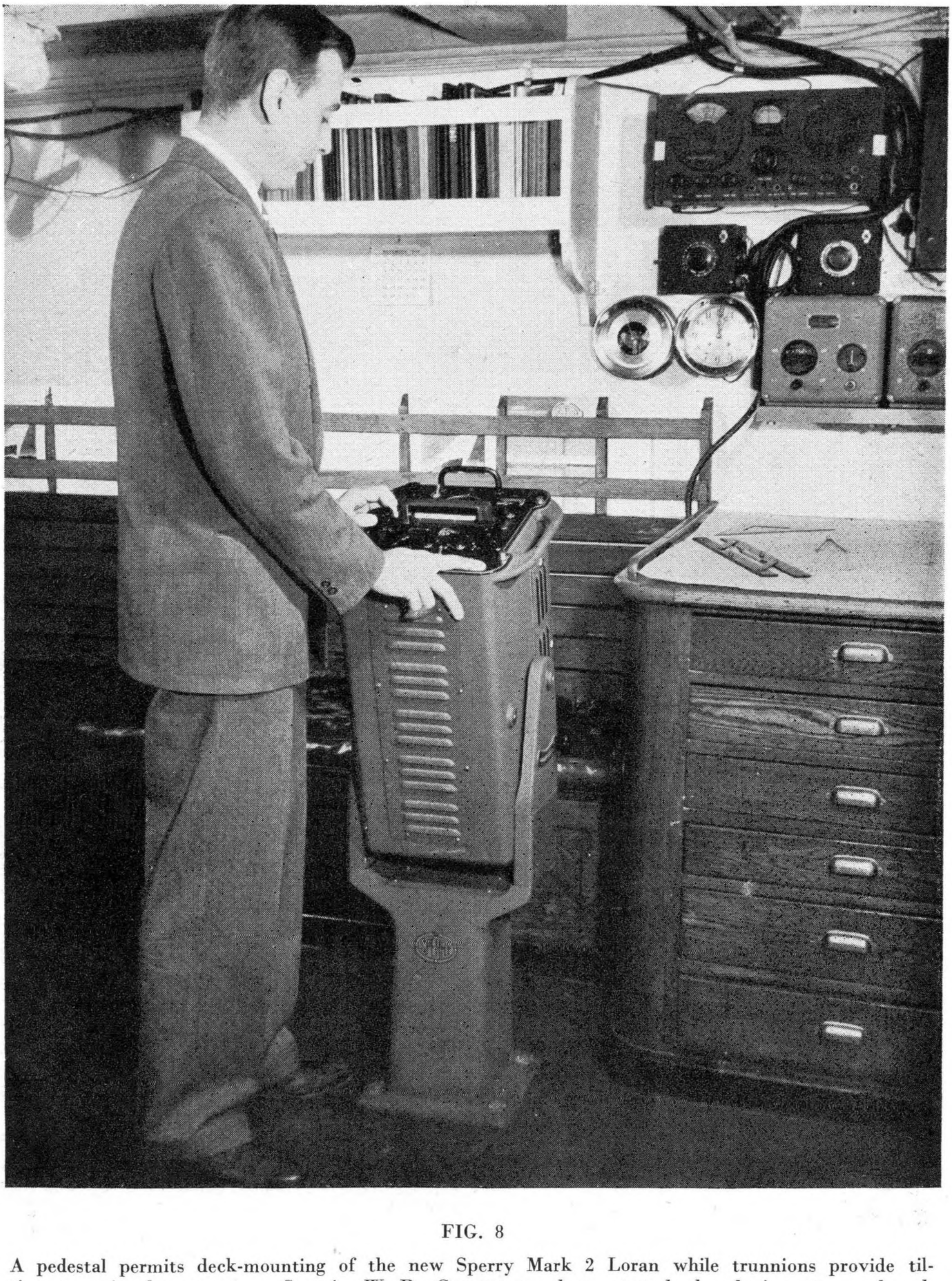

FIG. 8

A pedestal permits deck-mounting of the new Sperry Mark 2 Loran while trunnions provide tilting to suit the operator. Captain W. R. Griswold, above, tested the device at sea aboard Sperry's floating laboratory M/V *Wanderer*.