Proceedings

of the

Radio Club of America

Incorporated

January, 1932

Volume 9, No. 1

RADIO CLUB OF AMERICA, Inc.
11 West 42nd Street + + New York City

The Radio Club of America, Inc.

11 West 42nd Street - New York City

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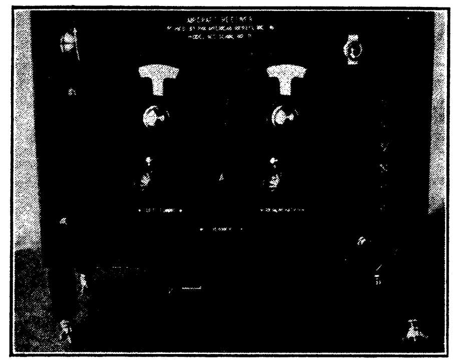
PROCEEDINGS
of the
RADIO CLUB OF AMERICA

Vol. 9 — JANUARY, 1932 — No. 1

Radio communication on the international airlines of the United States†



Model ACC aircraft receiver. View of front panel, set closed.

By H. C. Leuteritz*

Route Traffic Between Airports

Where an organized air route between fixed points is established, it is of the utmost importance that an efficient system of communications should exist, in order that messages concerning the departure and arrivals of aircraft, instructions to land at intermediate airports or emergency landing fields, information regarding transport of passengers and goods, and the thousand and one messages which are a part and parcel of an efficient air transport organization may be rapidly and accurately communicated without unnecessary delay.

The Department of Commerce under the Air Commerce Act of 1926 has undertaken to handle part of these details, using wire line facilities where they exist and radio service in other locations. However, the service which is rendered is rather limited in extent so that all the points covered in the above paragraph are not handled by them, particularly on international routes, in which cases the airline operator is necessarily compelled to provide his own facilities.

Experience has shown that the circulation of all meteorological information and all route traffic messages, is best handled by means of radio telegraphic signals.

Meteorological information is usually circulated in the form of code messages, while the normal route traffic messages consist of information concerning number of passengers, letters defining the airplane and such details regarding the aircraft in particular. It is generally agreed that this class of service is more easily dealt with when using the telegraph code. This insures a permanent record being kept of the actual text of the messages dispatched and received for future reference.

The location of any aircraft on an airway at any particular instant must be available to the flight control officer usually designated as the operations manager. This is most important so that he may keep in close touch with the meteorologist at all times to be in a position whereby he can issue the necessary advice to cancel any flight if in his opinion such flights will jeopardize the safety of the passengers and crew.

Aircraft Communications

Turning to the question of the system to be employed from and to the planes while in flight, it is now accepted that where the pilot of the machine himself has to operate the radio equipment, then the *only* system that can be efficiently operated is radio telephony. The pilot of a modern airplane has so much to occupy his mind while flying the plane and watching the multitudinous "gadgets" which are an integral part of all modern types, that he cannot possibly be expected to concentrate on the reception and writing down of telegraph signals. Consequently the spoken word is essential for such cases.

In the case of large transport planes carrying passengers, it becomes necessary in most cases when employing telephony, to repeat a message two or more times before it is clearly understood. This delay is normally due to static and other contributing noises. This statement is based on experience both here and abroad and on more than one occasion the use of telegraphy copied by an operator aboard the plane has demonstrated that the speed of transmission is greater by use of the telegraph code. On several tests conducted, using both types of communication, it was possible to deliver a message pertaining to the safety of life and property in one-twelfth the time required by telephony.

In our operations, we not only have to contend with the inherent noise which exists on all aircraft, but the problem of static is decidedly more prevalent and over greater portions of the year in the tropics than elsewhere. This is only natural as the climatic conditions

†Presented before the Club, January 13, 1932.
*Chief communication engineer, Pan American Airways, Inc.

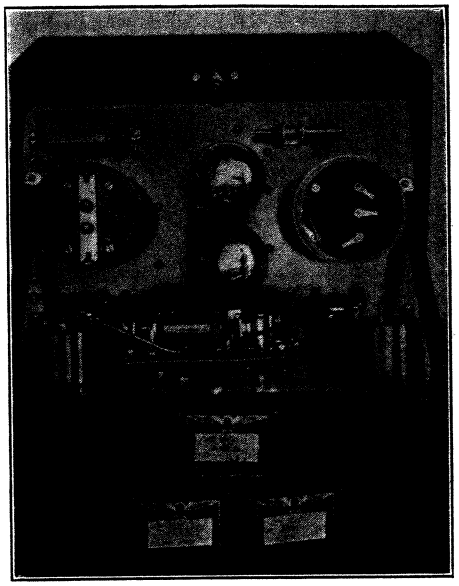
are such as to be conducive to development of electrical storms, etc.

Aircraft communications are carried out in the following manner. The pilot is required to send a message every half hour giving his position on the route. This position uses for its basis given landmarks where same are visible, or a latitude and longitude position when flying over water routes. This report is based on a dead reckoning and is dependent for its accuracy on the experience of the pilot. It is rather surprising to note the accuracy attained by pilots as checked against direction finder bearings. The radio operator, however, is required to contact airport stations every fifteen minutes and maintain a continuous watch so that ground stations and aircraft can contact each other instantly. As an illustration of how this works, a plane on the ramp at Washington heard the Miami station working an airplane in flight between Havana and Key West. When the contact was finished, he called Miami on the same frequency and got an immediate answer to his call and several messages were handled. This was done without any preliminary schedules or advice to the Miami station. This method of operation insures service to all aircraft so that in cases of emergency the situation can be met.

Direction Finding and Radio Beacon Operation

One of the prime uses of radio for aircraft is the possibility it affords of ascertaining the exact position at any instant of an aircraft in flight. While the ordinary methods of navigation can be used with a reasonable amount of success in the air, yet certain conditions of weather may be encountered where these methods may not only become almost totally useless, but actually misleading and in some cases dangerous.

For instance, suppose an airplane is flying in bad weather and is suddenly surrounded by thick fog which can neither be flown over or under. It is evident that the ordinary methods of flying by visual observations on the sun, stars or beacons immediately become useless, and reference has to be made to the compass and on dead reckoning. The aircraft compass, as is well known, is liable to be misleading, since under certain conditions it begins to swing, due to the yawing of the aircraft, and owing to the lag due to mechanical inertia, the pilot may over compensate again until the compass card may actually begin to spin. A turn and bank indicator helps here, but no other method of navigation will enable the pilot to determine his exact position except by radio direction finding, as if there is either a wind causing a drift, or an error on the compass, the machine may become many miles off its course, without the pilot having any indication. If the fog belt extends for many miles over the course, it is quite evident that the pilot may become totally lost under such conditions.



Transmitter.

Several methods of direction finding for aircraft have been employed to date, viz., (a) Direction finding systems on the ground. (b) Direction finding equipment carried on the plane. (c) Directional transmitter on the ground (radio range system).

A certain amount of discussion has taken place as to which method is preferable, and as a matter of fact there are many pros and cons for each system. Therefore, let us briefly summarize the advantages and disadvantages of each system.

Direction Finding on Aircraft

Advantages. (a) Secrecy; (b) Responsibility for correct position rests with the pilot or navigator on the plane.

Disadvantages. (a) Extra training and work of navigator; (b) Extra weight of apparatus; (c) Wind resistance in the case of a rotatable loop on the plane; (d) Turning of plane in flight when using fixed loops in order to check correct position; (e) Lack of direct contact with ground stations; (f) Lack of check with known ground points; (g) Lack of ground control; (h) Interference from ignition, etc., due to high sensitivity of receiver.

Direction Finding on the Ground

Advantages. (a) Saving of weight of equipment; (b) No extra wind resistance; (c) No extra personnel required; (d) Greater accuracy of bearings due to absence of noise and ignition interference; (e) Direct contact with ground stations at all times; (f) Direct control by ground stations; (g) Accurate check from ground points; (h) Accurate means provided for keeping aircraft on a predetermined course between airports; (i) Installation cost very low; (j) Air crashes avoided.

Disadvantages. (a) The pilot has to rely on bearings from the ground stations; (b) Slight delay between time of request for position and the time it is received from the ground station. However, this time can be reduced to less than one minute by efficient operation and training of ground crew.

Radio Range

Advantages. (a) Pilot flies a given course; (b) Theoretically any number of planes can follow same course; (c) No extra wind resistance; (d) No extra personnel required.

Disadvantages. (a) Lack of direct contact with ground stations; (b) Lack of direct control by ground stations; (c) Installation costs high; (d) Air crashes are possible between planes following the same course; (e) Responsibility of correct position rests with pilot; (f) Turning of plane in flight in order to check correct position; (g) Confusion of course due to noise and ignition interference; (h) Confusion of course due to other interfering ground transmitters caused by ships, etc.

Although much stress has been laid on the necessity of rapid communication between airports and airplanes in flight, the aid to navigation rendered by directional means is no less important.

Due to the many advantages by the use of direction finders on the ground the Pan-American Airways has adopted this system in preference to all others. A system has been worked out which is very economical and efficient in operation.

Aircraft Telegraph and Telephone Apparatus

The design and manufacture of aircraft radio equipment is an art in which the radio problems are complicated by the restriction of weight and space. Definite limitations are placed on these two facts and it is only by careful design and arrangement of the circuit parts that it is at all possible to combine compactness with efficiency.

1. The following data is compiled as a result of experience gained in the equipment and operation of radio apparatus on many commercial planes. It is intended to serve as a guide to the technical engineer well acquainted with modern radio practice.

2. Aircraft radio communication has many problems associated with it which do not come into prominence in connection with ground or ship stations. The various systems employed have been developed by no means because they

were the simplest and easiest to apply to aircraft communications, but because it is not always economical or practical to carry a radio operator capable of giving his undivided attention to the transmitting and receiving of messages, except on very large passenger machines such as we use in our own services. In the case of single pilot mail or express planes or in the case of limited payload machines and under favorable conditions it is essential to employ telephony, since it forms the only solution to the problem, for it provides a practical means of linking the airplane with the ground or with another machine and can be used by a pilot or navigator without special training.

3. The destructive effect of constant vibration, and the conditions of extreme noise under which telephony has to be carried out, coupled with the fact that in most cases the apparatus is not available for inspection under working conditions except when a test flight is made, constitute the chief difficulties which are experienced. In the new large cabin planes the pilot does not wear a helmet and this further handicaps the use of telephony.

4. The efficiency of the radio installation on an airplane will depend largely on how the initial fitting is carried out, and too much attention and care cannot be given to this subject. Unfortunately provision is not always made in the modern airplane for radio equipment, consequently the disposal of the apparatus (including, as it does, the main set, controls, generator, antenna reels and fairlead) is a matter which often taxes to the utmost the ingenuity of the radio engineer.

In March, 1929, work was started on the construction of a 200-watt transmitter for airport operation and which utilized one UV-204A tube in an oscillating circuit feeding a doublet antenna.

The plate power supply was furnished by a full-wave rectifier using two UX-866 tubes and delivering from 1,500 to 2,500 volts. The plate voltage transformer was arranged with taps in the primary circuit for voltage control. The entire unit operating from either a 110 or 220 volt, 60 cycle, single phase supply.

These transmitters were later equipped with a wavechange switch to permit operation on two frequencies, and erected at each of the airports along the route for communication both with airplanes in flight and between airports.

In April of 1929 some of the new 100-watt transmitters were delivered and installed aboard aircraft and operated on telephone by pilots. Telephone tests in regular scheduled operation again demonstrated the need for better and more efficient service as the length of time required to deliver messages was considered too great for safe operation. By July 1 these transmitters had all failed from one fault or another and the entire lot were therefore rejected.

On the basis of this experience, complete new aircraft apparatus was designed including both transmitter and receiver.

The aircraft equipment can be divided into the following classification and each part will be considered separately:

(a) transmitter; (b) power supply; (c) receiver; (d) antenna systems.

Aircraft Transmitter

The output of the transmitter is 12 watts cw. telegraph only. The circuit is a standard master oscillator-power amplifier connection employing one 7.5 watt type UX-210 tube as the oscillator and one of the same type tubes as a power amplifier. The amplifier circuit is neutralized and the oscillator circuit is a straight "Hartley." All resistors are of the moulded type to insure reliability.

Plug-in inductances are used so that a quick change of wavelength can be made. The tank circuit capacities are constructed as integral parts of the plug-in coils so that in changing wavelengths, no adjustment is required in the transmitter other than retuning the antenna (by increasing or diminishing its length) for maximum radiation at the new frequency. Standard installations contain plug-in coils for 32, 54, 97, 600 and 900 meters. The latter waves being necessary because of our international flights part of which are over water. Keying is accomplished by biasing simultaneously both the grid of the master oscillator and the power amplifier.

The set is mounted in an aluminum

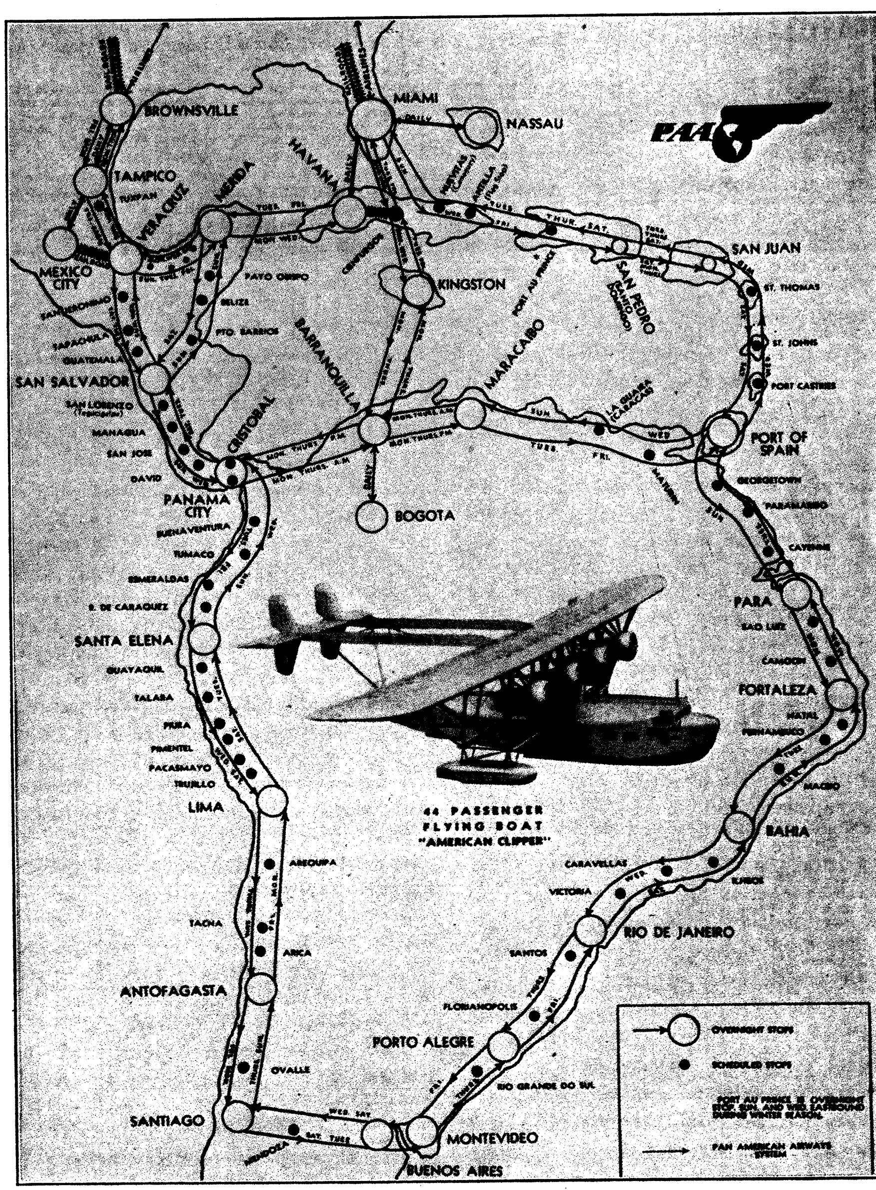
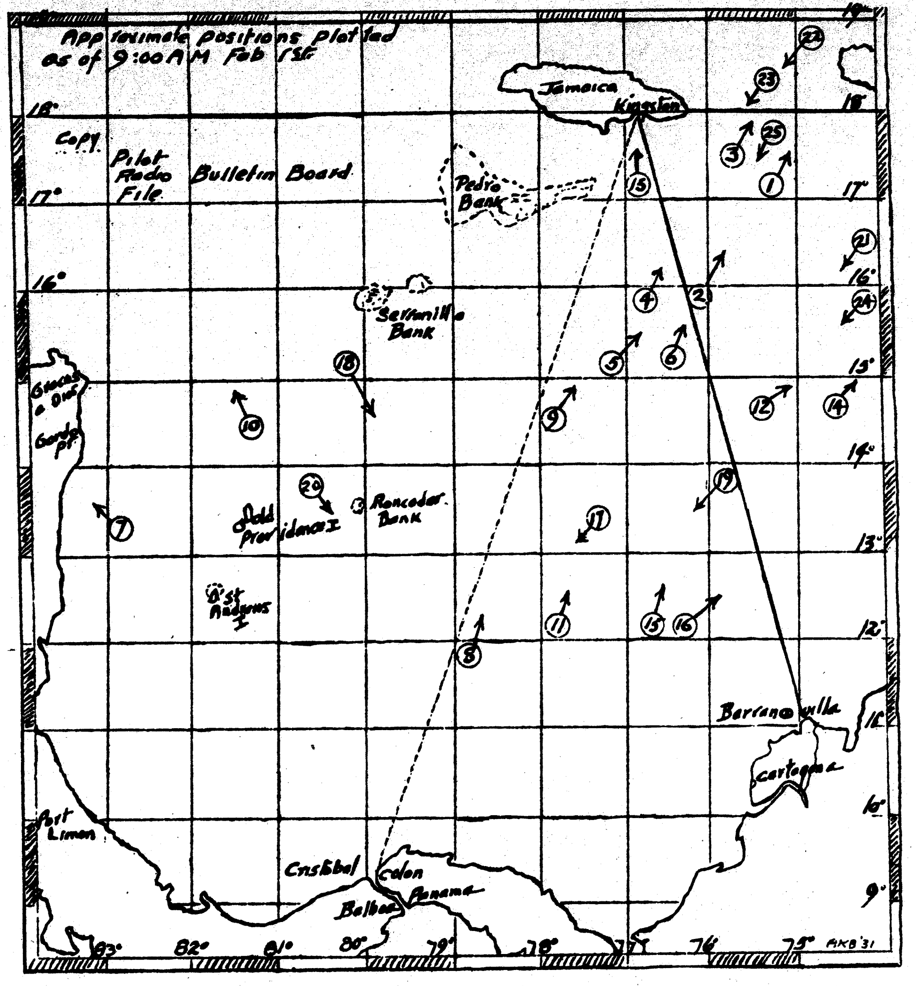


Fig. 1.



Chart, Fig. 2.

cabinet with a hinged front panel which tips outward disclosing in full view all of the component parts which are mounted either directly on the front panel or on a sub-panel. The front panel contains three meters; a plate current meter showing total plate current for both tubes, an r-f. ammeter for antenna current and a zero center ammeter showing the charge and discharge current in the main storage battery. The cabinet dimensions are: width 13 inches, height 9¼ inches, depth 8⅛ inches. A special break-in relay is also incorporated in the cabinet which permits faster communication between the plane and the airport stations. All resistors are of a moulded type and the entire transmitter assembly, including the cabinet, are especially treated with a coating impervious to heat and moisture. The set is also equipped with an antenna tuning arrangement consisting of a tapped inductance and a variable condenser in order to permit rapid tuning of the fixed antenna on amphibion and boat type aircraft. The radio transmitter complete with coils, vacuum tubes and cabinet weighs 12 pounds.

The filaments of the tubes are fed from a 12-volt aircraft storage battery while the plates are supplied from a small dynamotor rated at 400/12 volts, 70 MA/8-A. No filtering is required.

Aircraft Power Supply

It was at once realized that communication would be necessary in the event of forced landings. To accomplish this, the 12-volt, 65-amp. hour aircraft storage battery was standardized as the source of power instead of a wind-driven generator. With the 8 amp. input into the transmitter dynamotor and also feeding the filaments of the transmitting and receiving tubes, it is possible to maintain continuous communication for at least eight hours (and longer if used sparingly) without recharging the battery. On aircraft not equipped with engine driven charging generators, a wind driven generator rated at 6,500 r.p.m. 14 volts 5 amps. is used to continually charge the battery so that the source of power is kept up to full capacity at all times. The storage battery also supplies lights for the instrument board and cabin of the ship.

The dynamotor weighs 16 lbs.

The storage battery weighs 59 lbs. and the W/D charging generator 11 lbs.

Aircraft Receiver

The aircraft receiver is enclosed in an aluminum cabinet of the same construction and black crackle varnish finish as the transmitter. The exterior dimensions are: width 13 inches, height 9¼ inches, depth 6½ inches. The circuit consists of one screen-grid stage of radio-frequency amplification with tuned output only; a screen-grid detector; one space charge screen-grid audio tube and a low impedance output tube. All of the tubes are of the a-c. heater type and all of the filaments are in series. This receiver has a fairly high gain permitting the reception of weak signals over long distances. Ignition interference is not so bothersome as to preclude the reception of airport station signals over distances of four and five hundred miles even though shielded spark plugs are not employed.

The front panel of the receiver contains two dials, the right one for controlling oscillation and the left for tuning. The dials are indirectly lighted each with a small six-volt lamp. One inductance composes the tuning circuit. This inductance is of the plug-in type and each receiver is supplied with coils to cover the 32, 54, 97 and 600 meter wavebands.

The input to the receiver is controlled by means of a variable potentiometer and oscillation is controlled by a condenser. The plate voltages are supplied by a 135-volt aircraft "B" battery tapped at 67½; 22½; —4½volts. A six conductor cable supplies all the battery connections required.

In the audio-frequency circuits all the coupling resistors are of the moulded type and all grid resistors likewise. The entire assembly is coated to make it impervious to heat and moisture.

The receiver complete weighs 10½ lbs. and the plate battery 9½ lbs.

Antenna System

Due to international regulations and flights, the frequencies of 500 and 333 kc. must be available. Therefore both the transmitter and receiver are equipped with plug-in coils for operation on these frequencies. Each airplane therefore must necessarily be equipped with a trailing wire antenna of sufficient length which can be resonated to these frequencies.

The airplanes (Fokkers-Fords) are equipped with trailing antenna only and in case of forced landings on safe ground, communication can be maintained by unreeling the antenna to the correct resonance point and suspended a few feet above ground by anchoring it to a stick or tree. In cases of this kind, communication has been maintained with airport stations by using the frequency on which the last contact was made.

In the case of amphibions and boats, both a trailing wire and a fixed antenna were utilized. In most cases, the fixed antenna is suitable for all communication and also permits contact while on the surface of the water. As an illustration of the efficiency of this type of antenna, communication has been maintained between a boat on the ramp at the Naval Air station at Anacostia and the Miami station using 5680 kc.

LIST OF STEAMSHIPS ON CRISTOBAL-KINGSTON ROUTE

Date—January 31, 1931

Nr.	Steamship	Company	Knots	D.F.	Sails	Bound For	Radio Call Let.
			Out-Bound From Cristobal				
1	Point Breeze	At;-Refg.	12	Yes	3PM-30th	Philadelphia	KJEI
2	Henderson	U. S. S.	14	...	10PM-30th	H. Roads	NESD
3	Pear Branch	F. & W. Ritson	13	No	4PM-30th	S. Thomas	GDZJ
4	Arizonan	Williams	12	Yes	9PM-30th	New York	WACX
5	Hendon Hall	Inter-Frtg.	13	Yes	3PM-31st	Norfolk	GMZL
6	Albion Star	U. C. S. Ltd.	12	...	Mdt.-30th	Norfolk	GCBD
7	Amapala	S. F. & SS. Co.	14	...	2PM-31st	New Orleans	......
8	Baracoa	U. F. Co.	15	No	12M -31st	Kingston	KEDN
9	Volendam	Holl.-Amer.	16	Yes	3PM-31st	Kingston	PIHP
10	Tela	U. F. Co.	16	No	1PM-31st	Castilla	HRAM
11	Buchanness	W. R. Smith	12	No	7PM-30th	London	GKXY
12	Monique	Cie. Aux.	12	Yes	5PM-30th	Le Havre	FOEG
13	Barrwhin	C. Crom. Co.	13	Yes	6PM-30th	Jamaica	GDYK
14	Queen Maud	E. I. DuPont	12	No	5PM-31st	Baltimore	GKFR
15	Bolivier	Cie. Mar. B.	12	Yes	5PM-31st	S. Thomas	ORVA
16	Serantes	Cie. Nav. V.	12	No	5PM-31st	S. Thomas	EAKT
			In-Bound for Cristobal				
					Due*	From	
17	Trojan Star	Amer.-Hawa.	12	No	12M -2nd	Liverpool	GKMV
18	Caledonia	Cunard	16	Yes	9AM-2nd	W. Indies	GFJY
19	Canada	Johnson L.	15	No	7AM-2nd	Stockholm	SDQN
20	Heredia	U. F. Co.	15	Yes	7AM-2nd	New Orleans	KDAH
21	Parrakoola	Tr's.-Atl'c.	13	Yes	9AM-3rd	Europe	SMLA
22	Gisla	Can. Trans.	12	No	9AM-3rd	Philadelphia	LCLD
23	Hakushika Maru	N. Y. K.	13	No	7AM-3rd	New York	JBXD
24	Welsh City	W. R. Smith	13	No	9AM-3rd	U. K.	GKWD
25	Triton	W. W. Line	12	No	7AM-3rd	Baltimore	DDIT

*Approximate.

Direction Finders

During the early period of tests on frequencies in the order of 2500 kc. an attempt was made to construct a conventional loop type direction finder together with suitable receiving equipment for taking bearings on aircraft in flight. While the results obtained were fair, it was necessary to split some twenty or thirty degrees to obtain an approximate bearing. The accuracy of the device was such as to prevent its adoption as standard equipment. This unit, however, was used for a period of some six months and the results were carefully analyzed.

It was found that during the period of December corresponding to the shortest daylight time, erratic and rapid shifting of minima were noted at sunrise and sunset. During certain periods of the day, depending on cloud formation and weather condition, minima were entirely lacking, or shifting very rapidly.

On the basis of this work, it was decided to conduct further tests on frequencies lower than 2500 kc. and not lower than 1500 kc. The results of these tests showed conclusively by using a frequency between 2000 kc. and 1500 kc. that accurate bearings could be obtained and the signal strength indicated the possibility of obtaining bearings on signals for distances up to 400 miles.

The first unit constructed was installed at Kingston, Jamaica, for the purpose of taking bearings on aircraft flying over the largest over-water route in the world. The distance between Kingston, Jamaica and Barranquilla, Colombia, is 540 miles. This location was selected for three reasons. First, for the necessity of navigational aid; second, over water transmission, and third, possibility of making observations on signal propagation over mountains.

The City of Kingston is located on a large sheltered bay and mountains towering 4000 feet encircle the town with the exception of the seaward side. Bearings have been taken on aircraft while they were flying between Kingston and Cienfuegos, Cuba, with the results that the mountains above mentioned were intervening. Observations disclosed that reflection by the mountains affects the aircraft bearings only while the plane is in close to the island of Kingston. On the over-water route, a slight shift in signal minimum is noticed only during sunrise and sunset periods. No extensive night observations have been made, although during the short periods of darkness when bearings were attempted, fairly good results were obtained.

Bearings are taken both while regular transmission is taking place and at other times when particularly requested by the pilot. Eventually this system of D. F. will be installed on board the aircraft, in which case the operator can take his own bearings and plot instantaneous positions. The unit has now reached the stage of development where the apparatus can be installed aboard the aircraft adding only 12 pounds additional weight for the loop and its tuning unit.

In addition to this means of navigation, I wish particularly to call attention to the chart, Fig. 2. This chart with its accompanying list shows the number of steamers in this area together with all pertinent data regarding call letters, frequency, where bound for, ship's name, and its approximate position on the day of the flight. These charts are compiled each morning and supplied to the radio operator whose responsibility it is to check these reports while en route. In this way, ships are contacted on 600 meters and weather reports obtained while en route in many cases 150 miles before the aircraft arrives at and actually sights the steamer.

It is by careful attention to such details that this route has been flown with the same regularity and safety as any domestic route. Not so long ago one of the aircraft on this route between Colon and Barranquilla sighted some wreckage and persons from the S. S. Baden Baden and prompt means of communication resulted in the rescue of the unfortunates.

Conclusion

The application of radio to aircraft is of special nature and requires considerable thought and planning in order that a suitable network of stations can be erected to serve the particular demands. This must also be done as economically as possible.

It is the policy of the Pan-American Airways to maintain contact with all planes in the vicinity of any particular station at all times, plotting its course and advising the flight office of the location of any one plane on the various routes.

It is demanded that aircraft radio operation be made as reliable as engine operation and is only possible because of rigid inspection before and after each flight.

The system in use is the largest of its kind in the world and an endeavor is being made to make it the most efficient as well.