DEPARTMENT OF COMMERCE

BUREAU OF AIR COMMERCE

SAFETY AND PLANNING DIVISION

REPORT NO. 2

REPORT ON

125 MEGACYCLE AIRPORT TRAFFIC CONTROL TESTS

AT INDIANAPOLIS

By

W. E. Jackson
and
J. C. Hromada
Radio Development Section

January - 1938

REPORT ON 125 MEGACYCLE AIRPORT TRAFFIC CONTROL TESTS AT INDIANAPOLIS

By

W. E. Jackson
and
J. C. Hromada

SUMMARY

With a view to the application of ultra high frequencies to airport traffic control, a 125 megacycle transmitter and antenna were installed at the Indianapolis airport. The experimental ground station equipment and the receiving installations in two airplanes, in which flight tests were conducted, are described in this report.

As a result of the flight tests, it is concluded that these frequencies have definite application to airport traffic control and should prove much more satisfactory than 278 kilocycles due to their freedom from atmospheric disturbances and minimization of interference from traffic control transmitters at other airports.

INTRODUCTION

At the Fifth Meeting of the Radio Technical Committee for Aeronautics, which was held in Washington, D. C., on February 8, 1937,[1] there was considerable discussion relative to airport traffic control, particularly with regard to the numerous cases of interference on 278 kilocycles and the apparent inadequacy of this frequency for airport control work. With the thought of finding an ultimate solution of this problem in the use of ultra high frequencies, it was decided that some

[1]Reference, "Minutes of Fifth Meeting of the Radio Technical Committee for Aeronautics", Washington, D. C., February 8, 1937.

651

experiments should be carried out immediately to determine the usefulness of the ultra high frequencies for airport control. Accordingly, the Bureau of Air Commerce volunteered to build and install an ultra high frequency transmitter and antenna system in the control tower of the Indianapolis airport for a series of cooperative flight tests by the Bureau, airlines and manufacturers over an extended period of time. The frequency chosen for these experiments was 125 megacycles (2.4 meters wavelength). The Bell Telephone Laboratories cooperated by furnishing an aircraft receiver for use in the Bureau of Air Commerce airplane NS-62. RCA Manufacturing Company also equipped their Waco airplane with a receiver for the tests, which took place between May 28 and 30, 1937. The results of these tests proved very gratifying. Later, further tests were carried on by a group from the War Department Aircraft Radio Laboratory, Wright Field, Dayton, Ohio, in a Ford tri-motored airplane. It is the purpose of this report to describe the equipment used in the tests made on May 28-30, 1937, by the personnel of the Radio Development Section, Bureau of Air Commerce, the Bell Telephone Laboratories and RCA Manufacturing Company.

EQUIPMENT

A Type TXI, 100 watt, crystal controlled transmitter capable of being fully modulated by either voice or a 1020 cycle tone was used. The TXI transmitter was originally designed for operation on 60 to 65 megacycles, and for the purpose of these tests was modified by the utilization of recently developed transmission line tank circuits of high

651

efficiency for operation at 125 megacycles at the Silver Hill Experimental Radio Station. An output of 100 watts was also obtained at this frequency without the use of additional tubes. A block schematic of the transmitter is shown in figure 1. A photograph of the transmitter installed in the control tower at Indianapolis Airport is shown in figure 2.

The antenna consisted of a vertical copper tube approximately one-half wavelength long, fed by the transmitter by means of a 3/8 inch coaxial cable through a quarter-wave, open-wire impedance matching transformer. The antenna and matching section have an overall length of 5 feet - 3 inches. This was installed on top of an iron pipe above the airport beacon light, about 50 feet above ground. Two views of the antenna system are shown in figures 3 and 4.

The Bell Telephone Laboratories receiver, shown by block diagram in figure 5, was a crystal controlled superheterodyne and was installed in Bureau airplane NS-52. A vertical rod antenna approximately 1-1/2 feet long was erected above the fuselage of the airplane.

The RCA Manufacturing Company equipped its Waco airplane with a crystal controlled superheterodyne receiver, shown in block diagram figure 6. The antenna consisted of a half-wave vertical wire, suspended from the horizontal transmitting antenna, such that one-half of it was above the fuselage and the other half was inside the fuselage. A twisted pair feeder was run horizontally from the center of the antenna to the receiver. The RCA installation was equipped with a meter, calibrated to read microvolts input to the receiver.

Both receivers used in the tests were equipped with automatic volume control.

681

FLIGHT TESTS

Numerous flights were made with both airplanes, particularly along the four courses of the Indianapolis radio range and directly over and in the vicinity of the antenna. During each flight, transmissions were made in alternate half-minute periods using voice modulation and the 1020 cycle tone.

The results obtained in both ships were similar, with the exception that the signals could be heard somewhat farther in the RCA Waco than in NS-62, due to less ignition noise and considerably less directivity of the receiving antenna. The antenna on NS-62 was somewhat directive, being particularly effective over both wings and slightly less to the rear. It is believed that this directivity was in the main due to reflection effects from the four foot standard radio range antenna mast located a few feet behind the 125 megacycle rod antenna.

Flights in NS-62, over the transmitting antenna and within a radius of one-half mile, indicated the presence of several high angle lobes in the field pattern. These lobes are to be expected, since the transmitting antenna is a number of wave-lengths above the ground. During all the flights the 500 watt Lorenz glide path transmitter (33 Mc), the Bureau of Air Commerce glide path transmitter (91 Mc), and marker transmitter (75 Mc), were all in operation. At no time during the tests was any interference noted in either of the two airplanes.

The curve of figure 7 shows the computed optical path distance from the transmitter. On this curve sheet, the cross-points mark

657

distances and altitudes in all directions from the transmitter at which good quality speech reception was possible in NS-62. The circle-points represent similar reception conditions in the RCA Waco airplane. It is seen from figure 7 that good reception was obtained in the Waco at slightly below line-of-sight distance from the transmitter as indicated by points between 45 and 62 miles distance. Due to the high ignition noise in NS-62, higher altitudes were necessary at the same distances.

Several days previous to these tests, the 15 watt, 278 kilocycle airport control transmitter and high frequency receivers were installed in the control tower, which made it possible to obtain a direct comparison between 278 kilocycles and 125 megacycles during the flights. Under normal conditions of static, the 278 kilocycle signals could be heard up to about 15 miles with good intelligibility, whereas the 125 megacycles could be heard with excellent strength up to 45 miles at 1000 feet altitude or higher.

On May 29, 1937, a flight was made in NS-62 on the Terre Haute leg of the Indianapolis radio range under severe static conditions. The 278 kilocycle airport control signals were satisfactory for 2 to 3 miles from the airport, and became unintelligible at 10 miles distance. Beyond 15 miles, it was impossible to detect the presence of any 278 kilocycle transmissions. The radio range, which has an output of 1000 watts, could be followed out to 15 miles distance, when course signals became obliterated by static. The 125 megacycle voice signals were received with absolute clarity, free from any static disturbances to Putnamville, Indiana,

651

a distance of 42 miles, at 2000 feet altitude. The flight was not extended beyond this point due to a very heavy thunder storm.

One flight was made in the Waco at a constant altitude of 1000 feet, toward Richmond, Indiana. Readings of signal input to the receiver were made at various distances from the transmitter. The results of this test are shown in figure 8. Very good quality speech could be received down to 100 microvolts input to the receiver, corresponding to about 45 miles distance at 1000 feet altitude. This same input was received at 62 miles by increasing altitude to 1500 feet. However, intelligible speech through considerable ignition noise could be received at the same distance at 1000 feet altitude. The computed optical path altitude for 62 miles is approximately 1900 feet.

RESULTS

The results obtained in the flight tests on 125 megacycles at Indianapolis indicate that frequencies in this neighborhood are very suitable for airport traffic control, and should provide a much better service than 278 kilocycles. Of greatest importance is their freedom from atmospheric disturbances, particularly under bad weather conditions when the 278 kilocycle frequency fails. This was amply demonstrated in the flight to Terre Haute during a storm, when the 266 kilocycle signals from a 1000 watt radio range transmitter and the 278 kilocycle signals from the 15 watt traffic control transmitter were both obliterated at less than 15 miles from the airport, whereas the 125 megacycle signals of the 100 watt transmitter were clear up to 42 miles at 2000 feet altitude.

657

The results of the constant altitude flight show that with the equipment used in these tests good voice quality reception may be obtained within or slightly beyond optical path distances up to altitudes of about 1000 feet. At higher altitudes, indications are that good reception can be obtained considerably beyond the optical distance. The limiting factor in these observations was the ignition noise due to imperfect shielding, which permitted good voice reception down to about 100 microvolts input to the receiver in the case of the Waco installation, and somewhat less in the case of the NS-62 installation.

CONCLUSIONS

It is concluded that:

(1) Further flight tests should be made by the Bureau, particularly under heavy rain static conditions.

(2) Attention should be directed toward the improvement of aircraft antennas and receiver installations to eliminate antenna directivity and reduce ignition noises to a minimum. Indications are that the shielding and bonding requirements of apparatus in airplanes at ultra high frequencies is of somewhat greater importance than at low frequencies, but no great difficulty with ignition noise is anticipated.

(3) The Bureau should consider taking steps to encourage the use of frequencies in the band 129-132 megacycles for airport traffic control and discourage the further use of 278 kilocycles for this service. Due to the propagation characteristics of the ultra high frequencies, the interference problem between ground stations at various airports should be minimized, since it is known that these frequencies are not

651

reflected from the Heaviside layer, and follow an essentially optical path. Although a 100 watt transmitter was used in these tests, it is quite probable that 25 watts will be sufficient and should materially reduce the interference zones between airports. However, until sufficient experience is gained at a number of airport installations, this power should not be reduced below 100 watts.

651

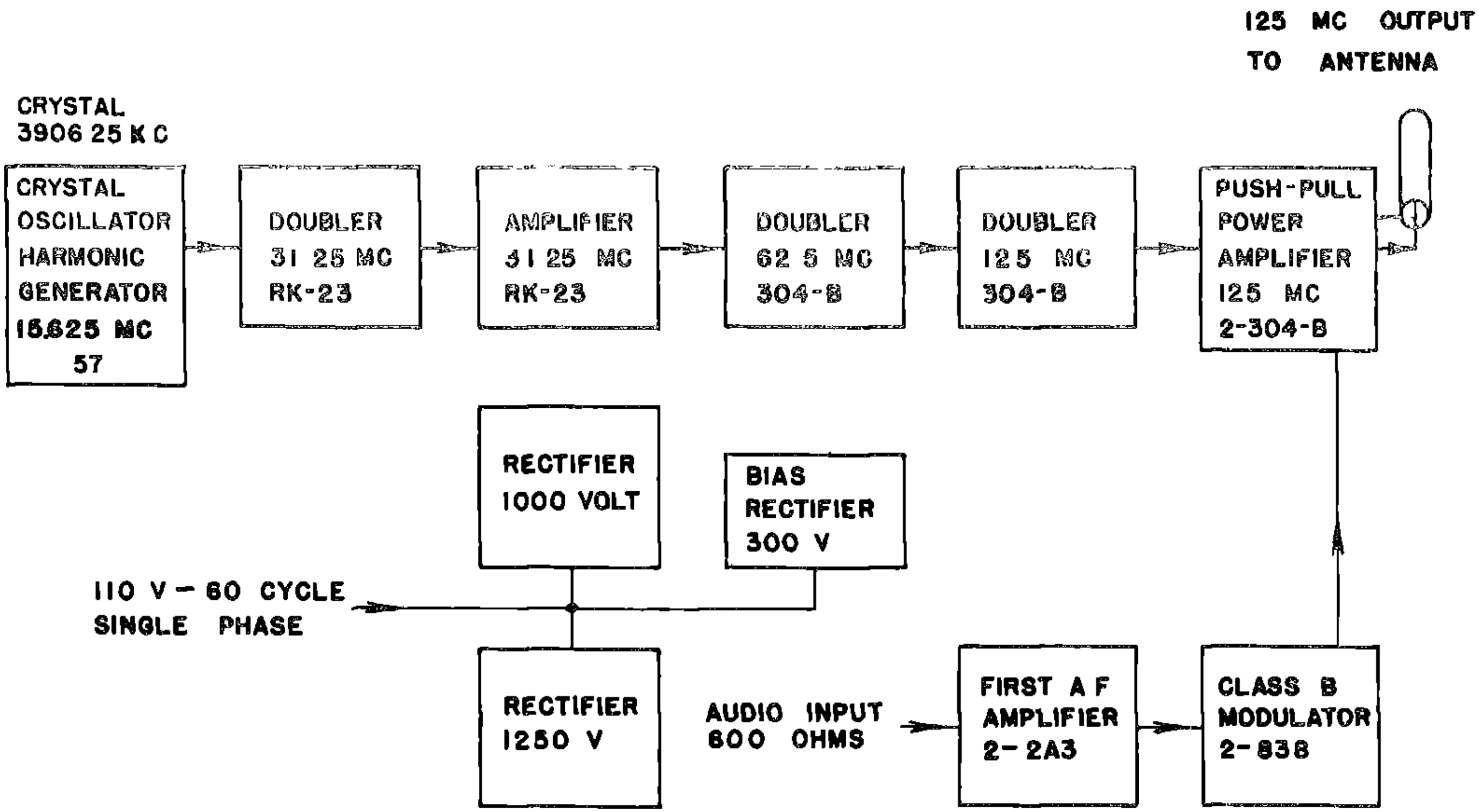

Fig.1- Block schematic diagram of the 125 Mc. transmitter.

#19052

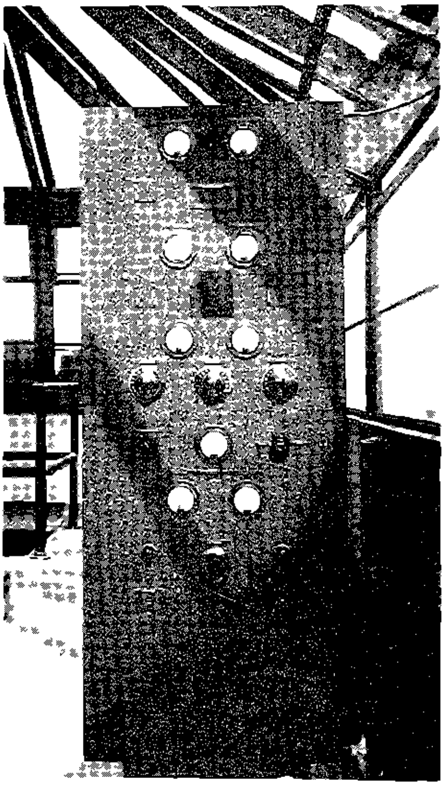

Fig. 2 - The transmitter installed in the control tower at the Indianapolis Airport

#651

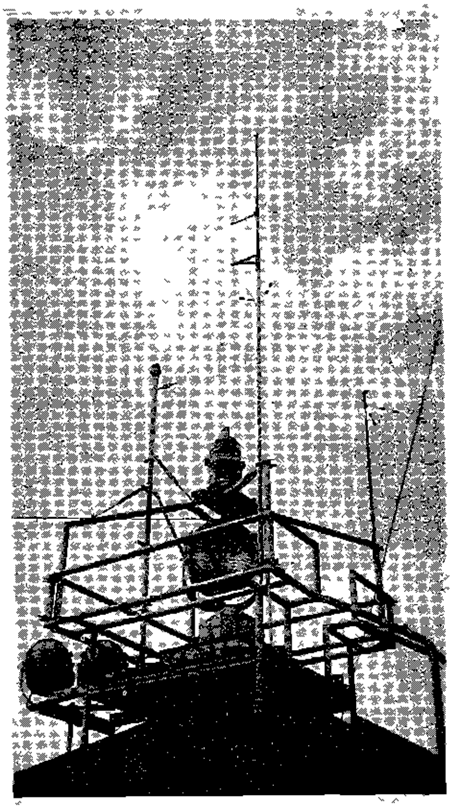

Fig. 3 - Vertical antenna installed above control tower

651

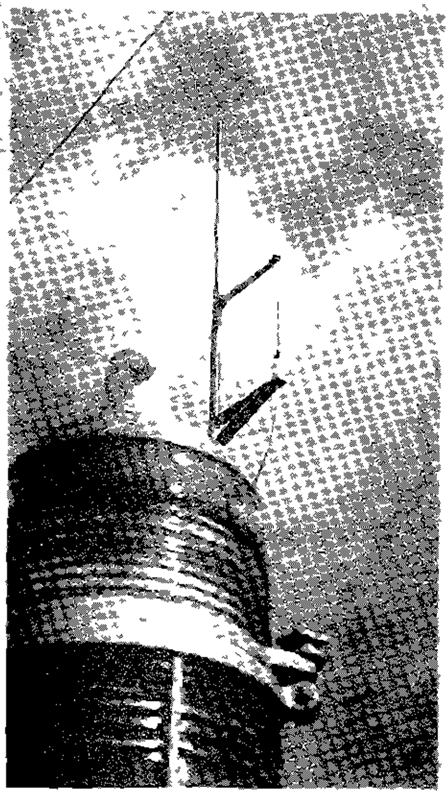

Fig. 4 - Close-up view of the antenna and matching section

651

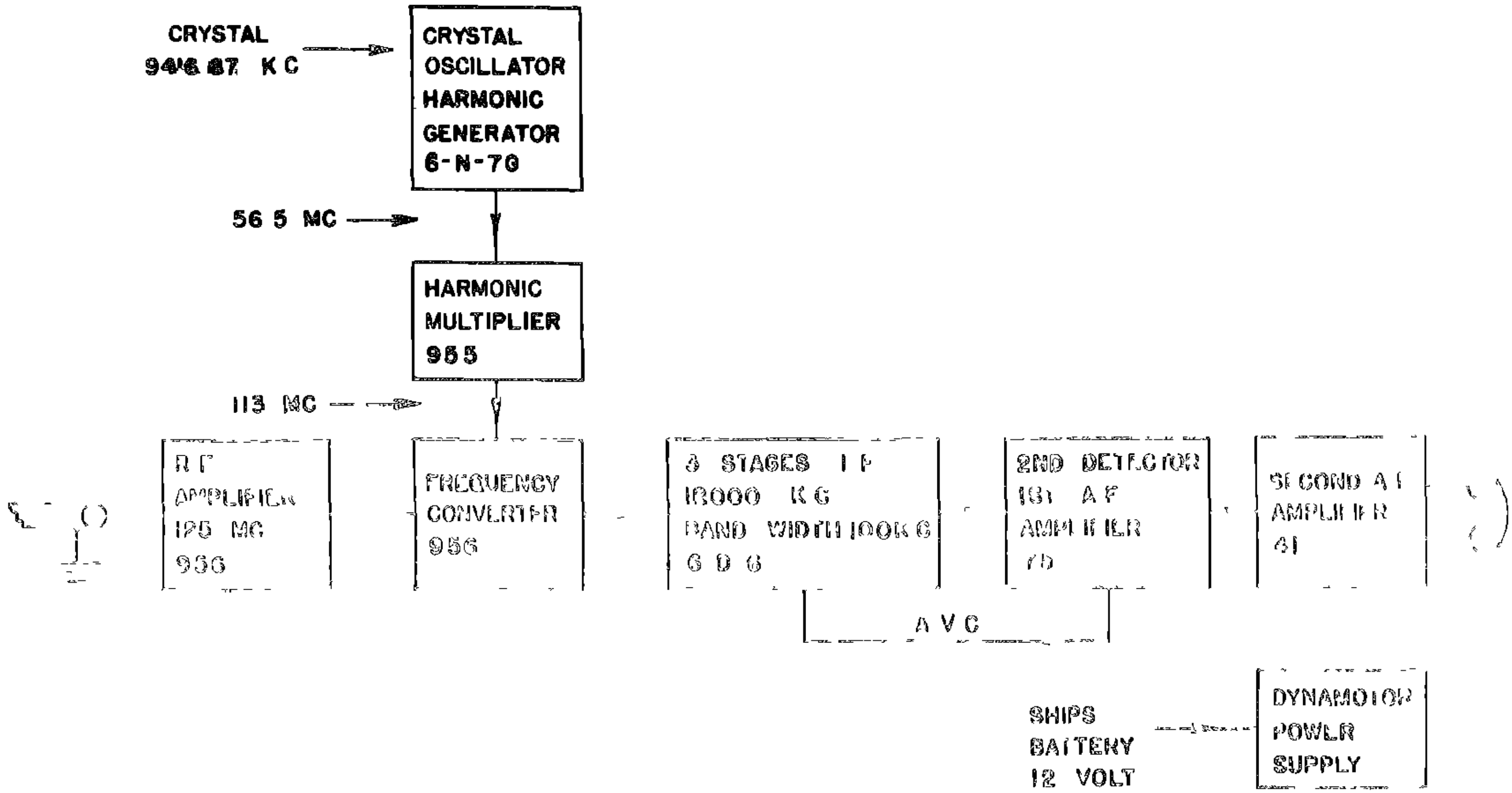

Fig.5- Block schematic diagram of the Bell Telephone Laboratories aircraft receiver.

#19052

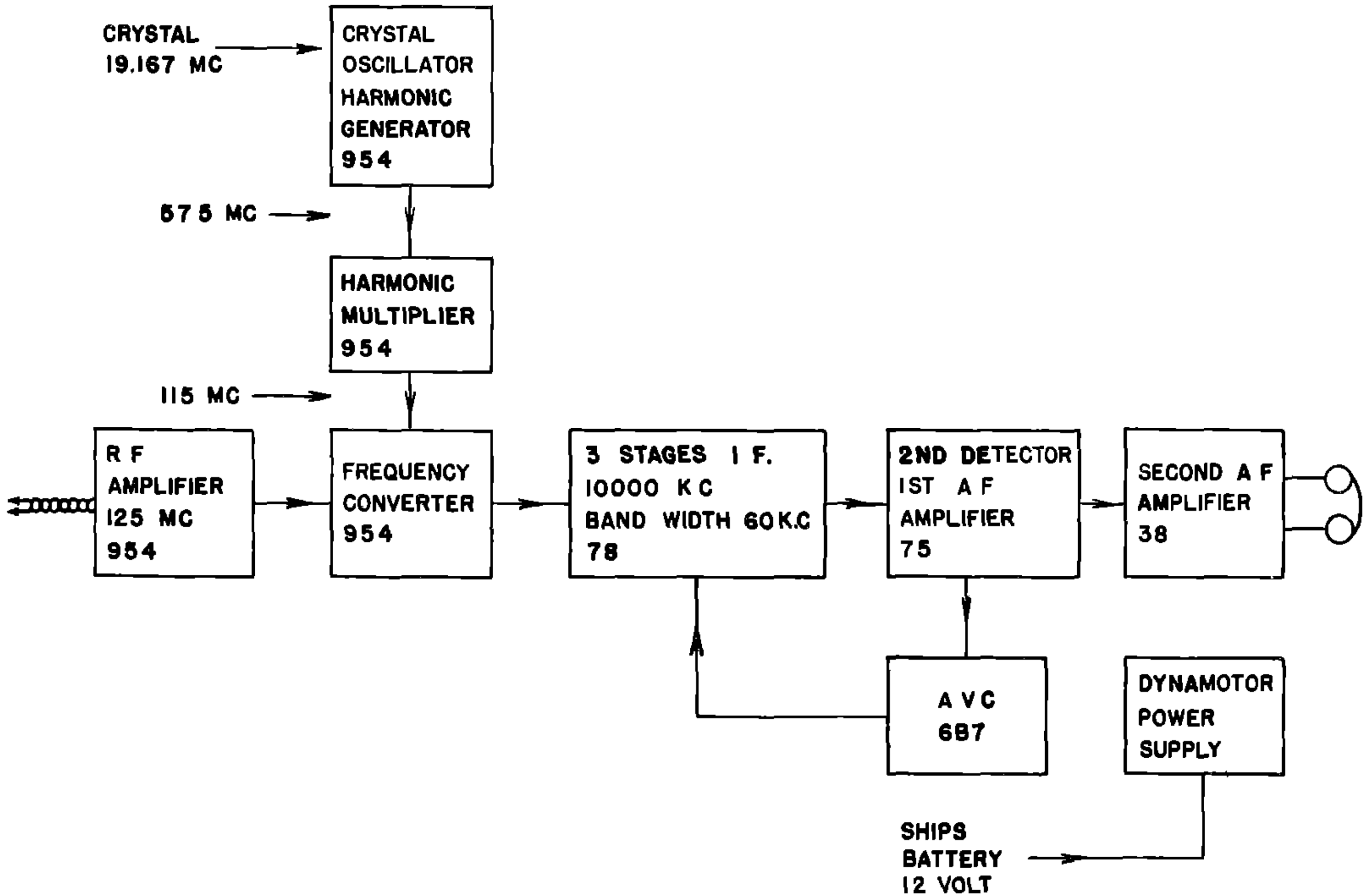

Fig.6- Block schematic diagram of the RCA Mfg. Co. aircraft receiver.

#19052

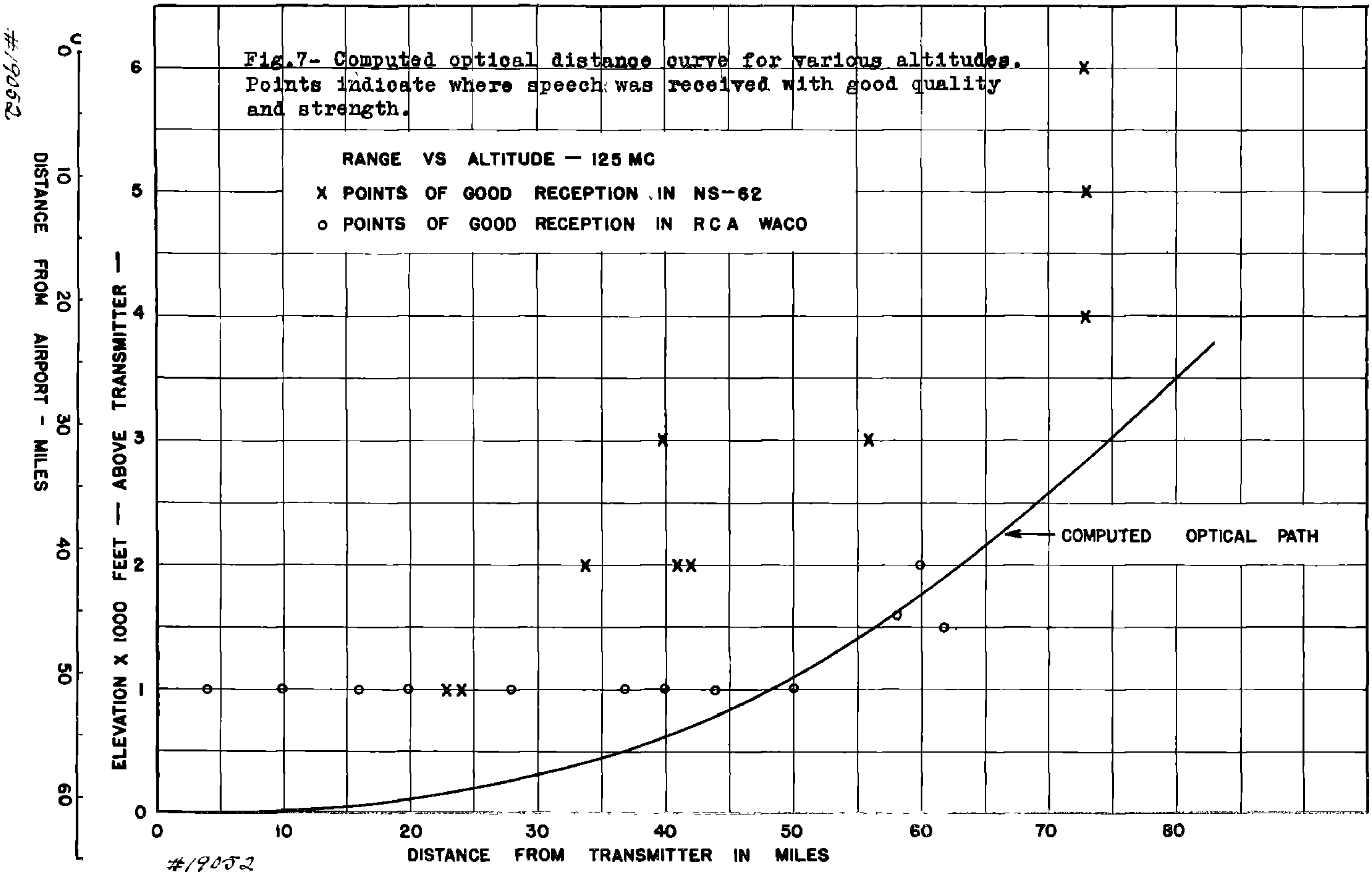

Fig.7- Computed optical distance curve for various altitudes. Points indicate where speech was received with good quality and strength.

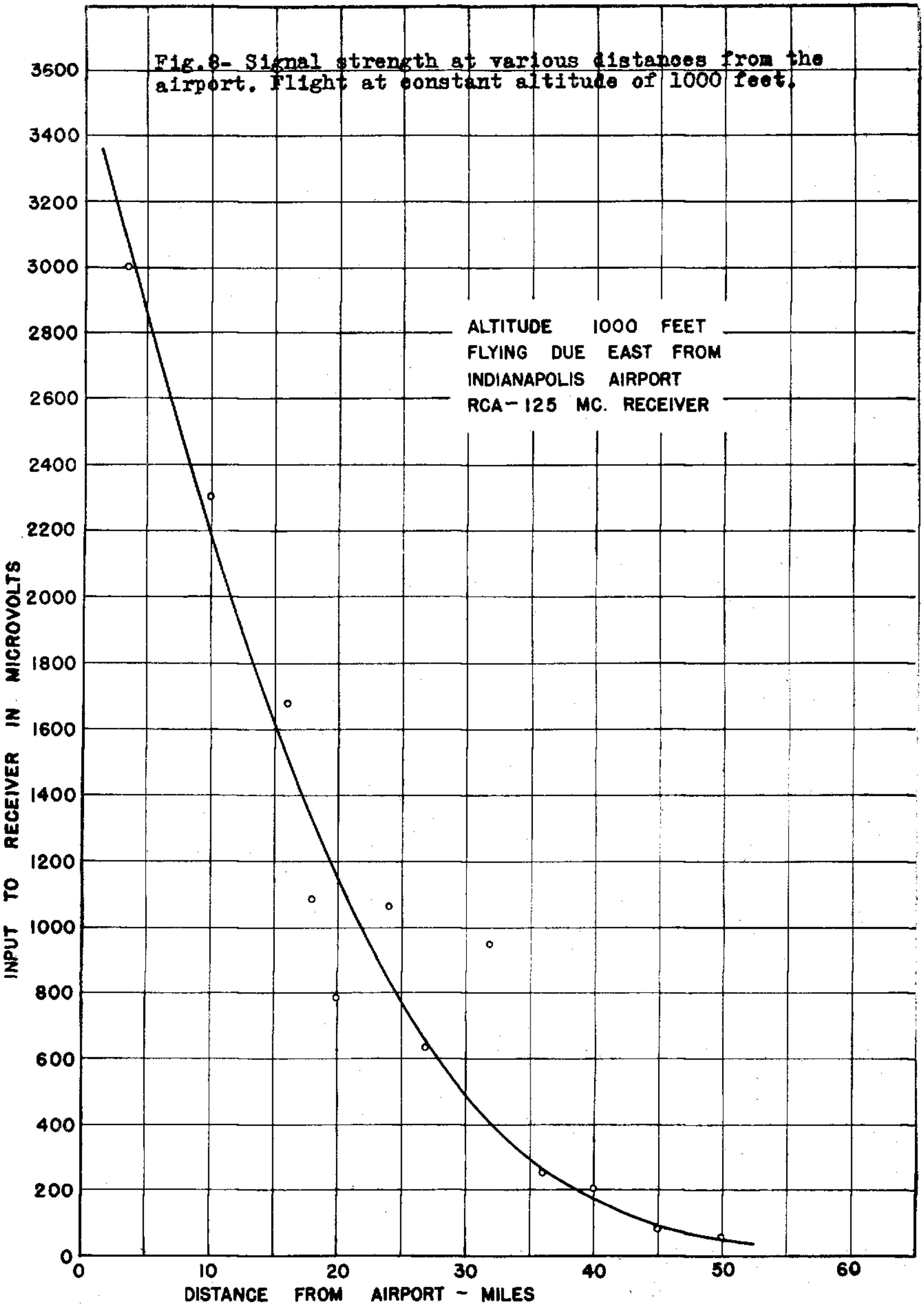
Fig.8- Signal strength at various distances from the airport. Flight at constant altitude of 1000 feet.
ALTITUDE 1000 FEET
FLYING DUE EAST FROM
INDIANAPOLIS AIRPORT
RCA-125 MC. RECEIVER
INPUT TO RECEIVER IN MICROVOLTS
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
10
20
30
40
50
60
DISTANCE FROM AIRPORT - MILES