1942

NBC'S INTERNATIONAL BROADCASTING SYSTEM

By

RAYMOND F. GUY

Radio Facilities Engineer, National Broadcasting Company, Inc., New York

Summary—International broadcasting as an instrument of national defense and a humanitarian service has assumed growing importance and stature. NBC stations WRCA and WNBI provide effective service in six different languages to the Portuguese and Spanish-speaking countries of South and Central America and to Europe. Recent increases in power to 50,000 watts and the development and construction of new directive transmitting antennas add to the scope and effectiveness of the NBC International Broadcasting activities. At times transmission to Latin America is accomplished with a total power of 100 kw on 9670 kc through the use of dual transmitters and antennas.

AN EXPANDING horizon of steel towers, tall wooden poles, and networks of elevated antenna wires attests to the growing international broadcasting activities of NBC stations WRCA and WNBI at Bound Brook, New Jersey. NBC has provided this service for many years.[1] International activities have been stimulated in recent years, first, in point of time, through the action of the Federal Communications Commission authorizing commercial operation, and second, by the more important contribution this service brings to National Defense.

A growing proportion of the program material consists of unbiased news broadcasts which are brought to the attention of foreign listeners with the aid of institutional sponsors and, especially to Europe, through the redoubled efforts of the National Broadcasting Company itself. Throughout Europe and the Americas there is a large and regular listening audience. In most, if not all of Europe, American news broadcasts constitute the best and often the only source of unbiased and complete news. Heavy penalties are meted out to those caught listening to such broadcasts in the oppressed countries, but there is nevertheless a substantial radio audience.

NBC has recently increased the power of the WRCA-WNBI transmitters from 25,000 to 50,000 watts and now transmits simultaneously through two separate 50,000-watt transmitters from 9:00 A.M. through the day until the early hours of the following morning and at times this service is continued around the clock 24 hours per day. A minimum of 16 transmitter hours per day are at present directed to Europe

[1] An International Broadcasting System, Raymond F. Guy, RCA REVIEW, pp. 20-35, Vol. III—July, 1938.

during the most favorable listening periods in Europe. The balance of the program day consists of programs transmitted to Central America and to the Spanish and Portuguese areas of South America during their most favorable listening periods. The manner in which most favorable listening periods vary is indicated by the differences in time of various areas served by WRCA-WNBI.

Standard Time		*City*
Noon	in	New York corresponds to
1 P.M.	"	Buenos Aires
2 P.M.	"	Rio de Janeiro and Greenland
4 P.M.	"	Iceland
5 P.M.	"	London
6 P.M.	"	Berlin
7 P.M.	"	Athens
10 P.M.	"	Central Russia

In England the clock is advanced two hours during this Summer, contrasting with our own advance of one hour for daylight saving, thus increasing the difference to six hours.

The importance attached to international broadcasting by the European powers is evidenced by the fact that Italy directs toward the United States four program hours per day, the British send us about six and one-half hours, the Germans about ten hours and the Japanese about four and one-half hours. In addition to the programs directed to North America, these countries also provide service on from one to three frequencies simultaneously to about 20 other countries in many different languages. International personalities have been developed as a result of this service, of whom the best known is Germany's "Lord Haw Haw". The German program content covers a broad scope ranging from dance music to learned discourses on anthropology, and includes the reading of the names of new prisoners of war, request programs, question and answer periods, dramatizations of war developments, personalities, etc. etc. One offer by the German government to accept collect Radiograms relating to the German programs was accepted by several thousand listeners in the United States.

The Bound Brook plant contains NBC's international transmitting facilities plus the WJZ transmitting facilities. The original property was purchased for these combined facilities in 1925 when RCA built its first short-wave broadcast transmitter, the predecessor of the present busy stations. The original site consisted of 54 acres. Recently the expanding scope of NBC's international activities resulted in the purchase of an additional 16 acres, making a total of 70 acres, most of it devoted exclusively to international transmitting antennas. The majority of these antennas are horizontal broadside units and any future extension will probably include the replacement of other types

with broadside units. They are economical of property requirements, less vulnerable than other types to damage from sleet and ice, and are very efficient. They have the added advantage that the systems can be

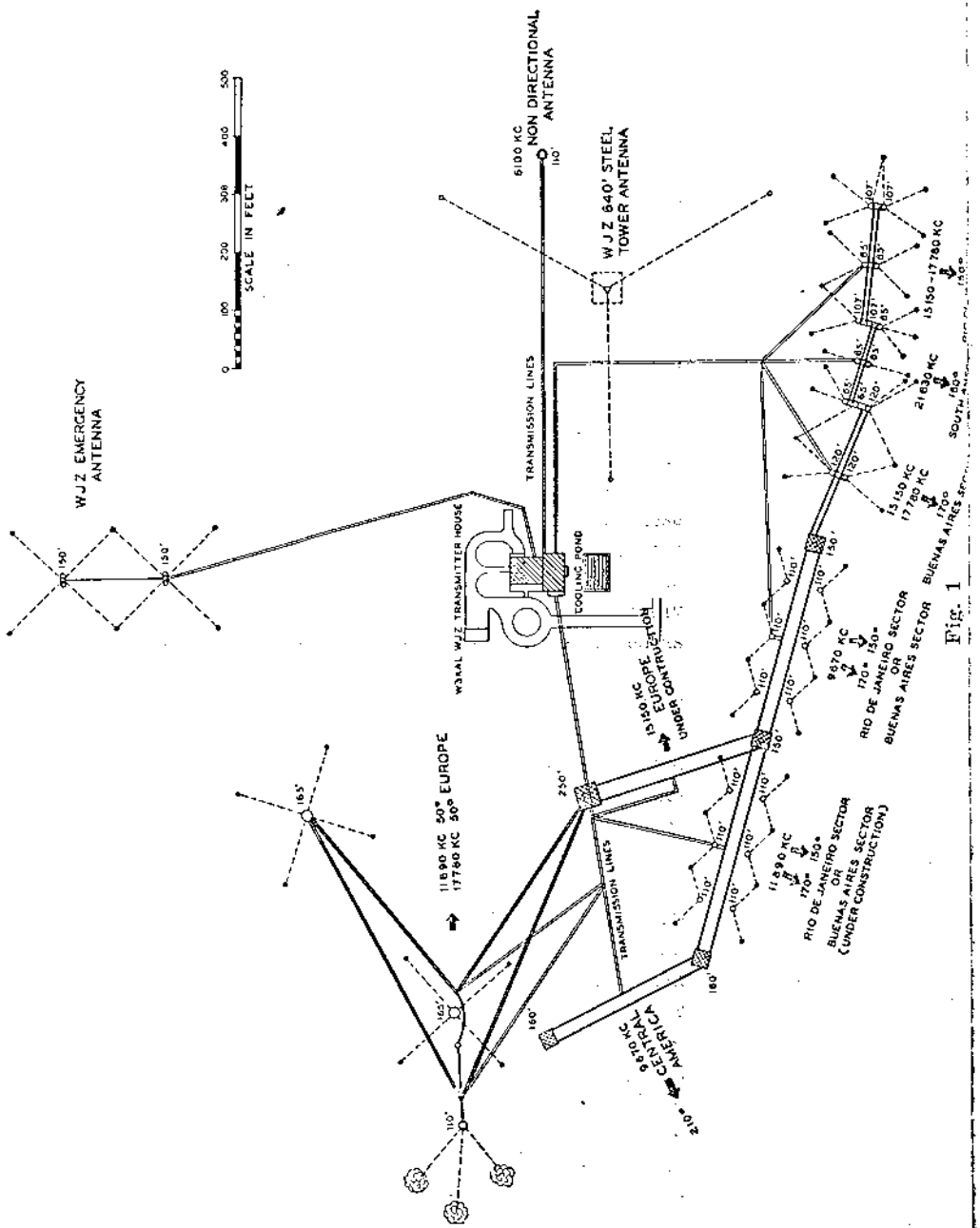

Fig. 1

designed to be steerable by phasing horizontally displaced groups of radiating elements, as described in the text which follows.

The Bound Brook site shown in Figure 1 is rectangular in shape with the long dimension facing in the general direction of the Latin American countries. This is important because a considerable number of antennas is necessary properly to serve the various sectors within the span of 100 degrees between Pernambuco and Mexico City. The short dimension of this site faces Europe. A smaller number of antennas will suffice to serve the European sector inasmuch as the span between Moscow and Madrid is only 30 degrees. To serve Latin America no fewer than three separate groups of antennas, divided approximately equally across the 100-degree Latin American sector, are required to give service to all areas. The problem presented in covering this great expanse is dealt with in more detail in other sections herein.

Antennas—Language Areas

Brazil is unique among Latin American countries in that it is the only one having Portuguese as its native language. Throughout the balance of Central and South America the native language is Spanish. Obviously listeners in Brazil, speaking Portuguese, are little interested in programs transmitted in Spanish, English or other languages. Similarly, listeners in the other portions of South and Central America, speaking Spanish, are little interested in programs in other languages. Therefore, to broadcast effectively to the two different language areas, individual antennas and separate language services are essential. As an example, nightly service is provided to Brazil on a 9670-kc beam during one part of the evening and to the Spanish speaking countries at another time on two other 9670-kc beams. To provide European service on this frequency a fourth 9670-kc beam would be required. It may be seen that to provide service to four basic areas with the most useful of six different assigned frequencies and six different languages, and do it with the optimum beam pattern, requires an impressive list of antennas.

In the design of a directive antenna the engineer must decide the proper compromise between power gain and beam width because one is, of course, obtained at the expense of the other. A beam broad enough to cover all of South America would have such low gain that it would not provide the signal intensity required to give satisfactory service. The design of antennas of very high power gain presents no special problem in itself. It would be a comparatively simple matter to increase the power gain to the point where a somewhat higher concentration of field were obtained in one area at the excessive sacrifice of adjoining areas of importance. To insure satisfactory field intensity

to South America, at least two separate antennas must be used for each frequency, one directed toward the Portuguese areas and the other toward the Spanish areas. To cover Central America, still a third antenna is required. Service to Europe must of course be provided on a different array of antennas. It happens that the distribution of service areas in South America and Europe are such that the optimum

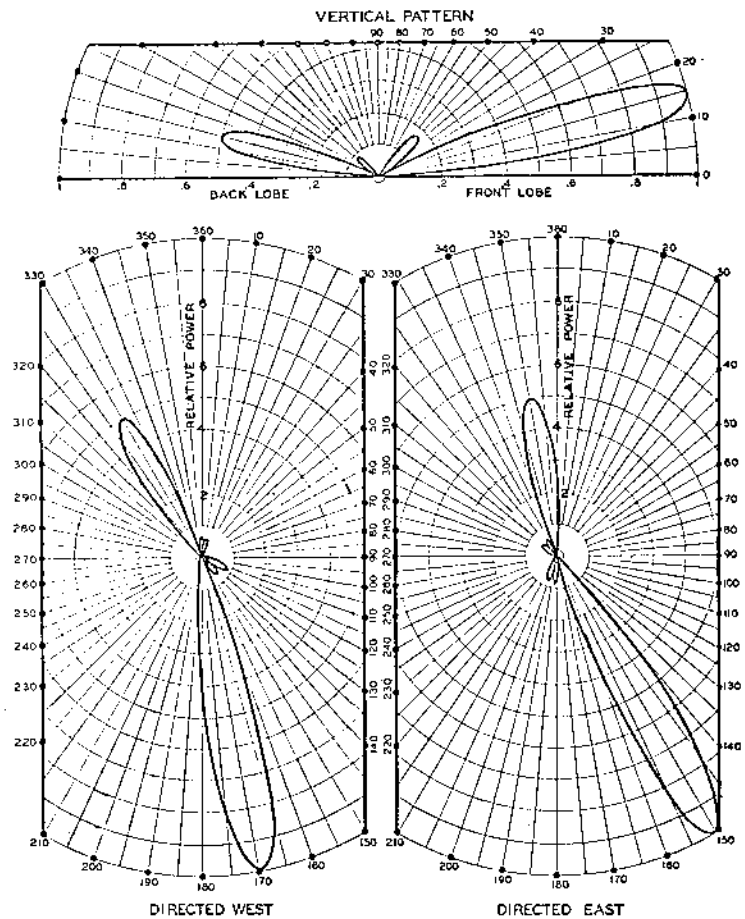

Fig. 2

beam width is in each case about the same. As a result NBC has practically standardized an antenna design which was evolved to give optimum performance to Europe and South America. It is the result of many years of applied experience and constant observation.

The angle 150° E of N centers on Rio de Janeiro, the middle of the concentration of population of Portuguese-speaking Brazil. It is also almost exactly in the center of the country as viewed over the great circle path from New York. It is natural that 150° should be the direction of a Portuguese language beam and it has been selected as optimum for that utility.

Buenos Aires is not quite so ideally centered geographically, but is the center of the greatest concentration of Spanish-speaking peoples on the South American continent. Considering population distribution, 170° was selected as the optimum angle for the Spanish language South American beam. On the theory that one picture is worth ten thousand words, the reader is referred to Figures 4, 5, 6, and 10 which show distributions of field intensity. In transmitting to Central America there is room for more latitude. The present 9670-kc antenna is directed 215° E, but in a pending move it is intended to shift the beam a few degrees to the south.

The European antennas are directed 50° E centering on the major European capitals which are quite closely grouped as viewed over the great circle path from New York.

The following tables show the number of radio receivers and in some cases the number of telephones per hundred persons in the United States of America and in the countries of Latin America.

Country	*Receivers*	*Telephones per hundred persons*
U. S. A.	.....	15.37
Bahamas	1,880	
British Honduras	1,200	
Costa Rica	20,000	
Cuba	150,000	1.29
Dominican Republic	7,000	
Guatemala	21,700	
Haiti	3,000	
Honduras	16,000	
Mexico	300,000–350,000	.81
Nicaragua	4,000	
El Salvador	8,500–10,500	
Panama	24,000	
Argentina	1,050,000	3.13
Brazil	500,000	.59
Chile	160,000	1.69
Colombia	100,000	.44
Ecuador	6,500	.29
Paraguay	11,200	.35
Peru	68,000	.43
Uruguay	150,000	2.2
Venezuela	138,000	.67
Bolivia	.....	.08
Central America	.....	.40
Puerto Rico	.....	.86

Over a period of many years there has never been an interval when construction of new NBC international radio facilities was not being carried forward at Bound Brook under special capital appropriations

provided for the purpose. The increasingly diversified type of operations, the nature of cyclic changes in wave propagation, the expanding scope of the service, the growing importance to National Defense, new developments in circuits and circuit elements and increases in the number of assigned frequencies all contribute to the occasional need for new or improved radio facilities. The inventory of directive antennas in use or under construction is shown below. Of this inventory only two units, the third and sixth, are not yet ready for operation. The list of nondirective and comparison antennas is not included.

Frequency	*Language Area*	*Degrees*	
9670 kc	Brazil—Portuguese	150° E of N	Steerable
9670 "	Spanish	170° "	
6100–9670 "	Spanish—Central America	215° "	
11890 "	Brazil—Portuguese	150° "	Steerable
11890 "	Spanish	170° "	
11890 "	South America	160° "	To be dismantled
15150 "	Brazil—Portuguese	150° "	Dual Frequency Unit
17780 "	Brazil—Portuguese	150° "	
15150 "	Europe	50° "	
11890 "	Europe	50° "	
17780 "	Spanish	170° "	Dual Frequency Unit
15150 "	Spanish	170° "	
17780 "	Europe	50° "	
21630 "	South America	160° "	To be dismantled
17780 "	South America	160° "	

There are at least five methods of specifying antenna gain, all different. They all involve comparison of the "unknown" antenna field with the field of some simple "comparison" antenna. If the "unknown" antenna is compared with different types of "comparison" antennas, or similar "comparison" antennas in different positions, the apparent power gain of the "unknown" antenna is different in each case. Some of the methods of specifying antenna gain are described as follows:

1. Absolute directivity. This compares the maximum signal power of the "unknown" with the signal power of a vertically and horizontally non-directive comparison antenna, all assumed to be located in the center of a sphere.
2. Comparison with a Hertz doublet.
3. Comparison with a half-wave horizontal dipole at the same height above ground. This compares the maximum signal power of the "unknown" with the signal power of a half-wave dipole, the two ordinarily being located side by side.

4. Comparison with a vertical dipole with its center ¼ wavelength above the earth.
5. Comparison with a horizontal half-wave dipole one-half wavelength above the earth.

The indicated power gains are different for these methods over a range of more than 60 per cent. NBC has used, for comparison, a half-wave dipole horizontally polarized and at the same height above ground as the unknown. This method and one other, comparison with a half-wave dipole one-half wavelength above ground, are believed to be most used.

The "same height" method gives the smallest indicated power gain of any, but is the only method which expresses the actual gain of an array over an effective half-wave dipole such as would be used for broadcasting.

It may be seen on Figure 1 that the 70 acres are almost ideally laid out to provide service to the nations interested in the viewpoint of the United States. The transmitter building is located in the center of the property with transmission lines radiating in various directions to the transmitting antennas. The antennas are adequately isolated from each other and the frequencies are so staggered among these antennas that coupling between adjoining units is kept to a negligible amount.

Figure 2 shows the polar power pattern of the type of antenna which has been adopted by NBC as best for the service areas in South America and Europe. The figure shows the two beam patterns for the steerable type antenna to be described. This pattern was adopted years ago by NBC after consideration of population distribution, the size of the distant service area, the power gain and other factors.

This pattern is obtained with a broadside antenna having a horizontal width of six half-wave elements two tiers of such elements being stacked vertically, with a complete duplicate set of such elements to the rear, making a total of 24 radiating elements. The 12 rear elements forming the reflecting tiers are parasitically excited.

NBC Steerable and Dual-Frequency Antennas

The most important language areas of South America are centered around Rio de Janeiro and Buenos Aires. These areas are 20 degrees apart as viewed from New York. One of the earliest investigations conducted in connection with these antennas was to determine whether or not a single antenna could be built which could be steered to either of these two language areas. A cost study showed that for the lower-frequency antennas which involve massive supporting structures and

long spans, an electrically steerable antenna entirely satisfactory in performance would be cheaper than the construction of separate antennas for the two areas. The 12 elements which are driven are segregated into three groups, each fed separately, because it was determined that the desired radiation pattern could be obtained by separately feeding three bays. The center bay is always kept at zero degrees for reference to the outside bays. It is desired to steer this beam ten degrees to one side or the other of the center line to serve either Rio de Janeiro or Buenos Aires. This can be accomplished when one outside bay is retarded 75 degrees and the other one is advanced 75 de-

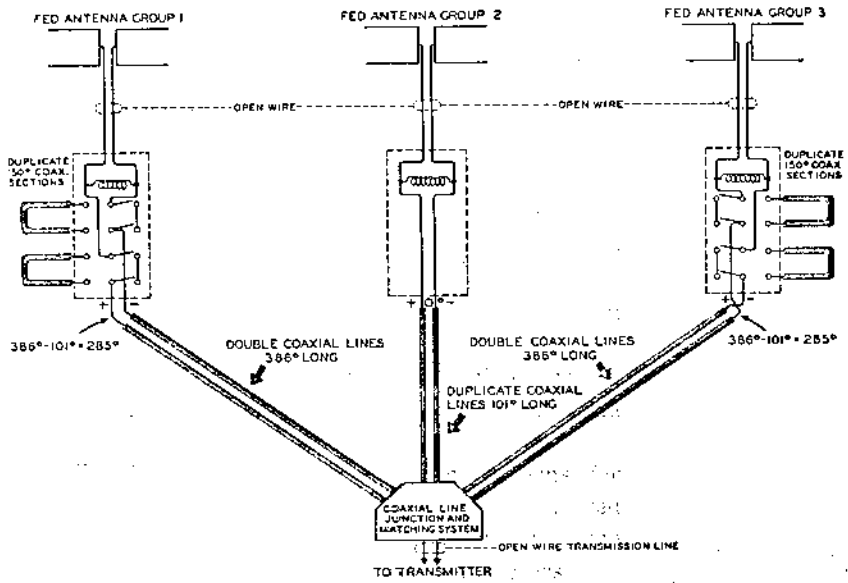

Fig. 3

grees with respect to the center bay. The manner in which this is accomplished is shown diagramically in Figure 3. The transmission line from the station building divides into three coaxial branches, terminating in phasing boxes directly beneath the three sets of down leads. The branch to the center down lead is 101 electrical degrees long. The branches to the outer phasing boxes are 386 degrees long. The net result is that the outside phasing boxes lag 285 degrees with respect to the center box. The advance condition which makes reversible steering possible requires that both the outside boxes be 75 degrees ahead of the center box. This was easily accomplished by proper choice of the branch line lengths as described above. In other words, a lagging phase of 285 degrees is equivalent to a leading phase of 75 degrees. Therefore, if all three of the down leads were connected directly

through the phasing boxes to the transmission lines, the outside elements would each be advanced in phase 75 degrees with respect to the center box.

It was stated above that to steer the beam to the east or west, one outside box must be advanced 75 degrees and the other one retarded 75 degrees. Since, when connected directly through, both outside sections are advanced 75 degrees, it is possible to obtain the desired steer-

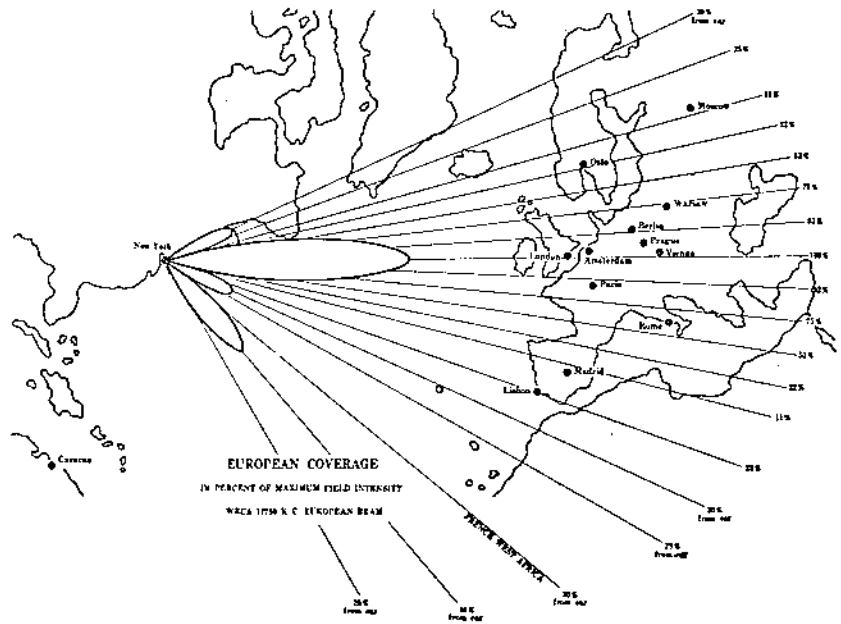

Fig. 4

ing condition by retarding the phase of one or the other outside elements 150 degrees. This is accomplished by inserting by means of specially built high-frequency contactors, 150-degree "building out" circuits which introduce a lag of 150 degrees into one side or the other. The contactors are operated from the transmitter control point in the transmitter building by remote control and are interlocked with the main rectifier in such a way that the rectifier may be shut down, the antenna directivity changed and the rectifier re-energized in one operation. Coaxial transmission lines are used for the 150-degree phasing-out sections and also to connect the phasing boxes to the common junction of the three branches, as shown in Figure 3.

The impedance of the down leads must be matched to the output of the phasing boxes and this is accomplished by circuit elements adjacent to the relays in the boxes.

The 9670-kc steerable antenna has been in daily service for some years and has been highly satisfactory. On the higher frequencies in which the supporting structures and spans are smaller, separate an-

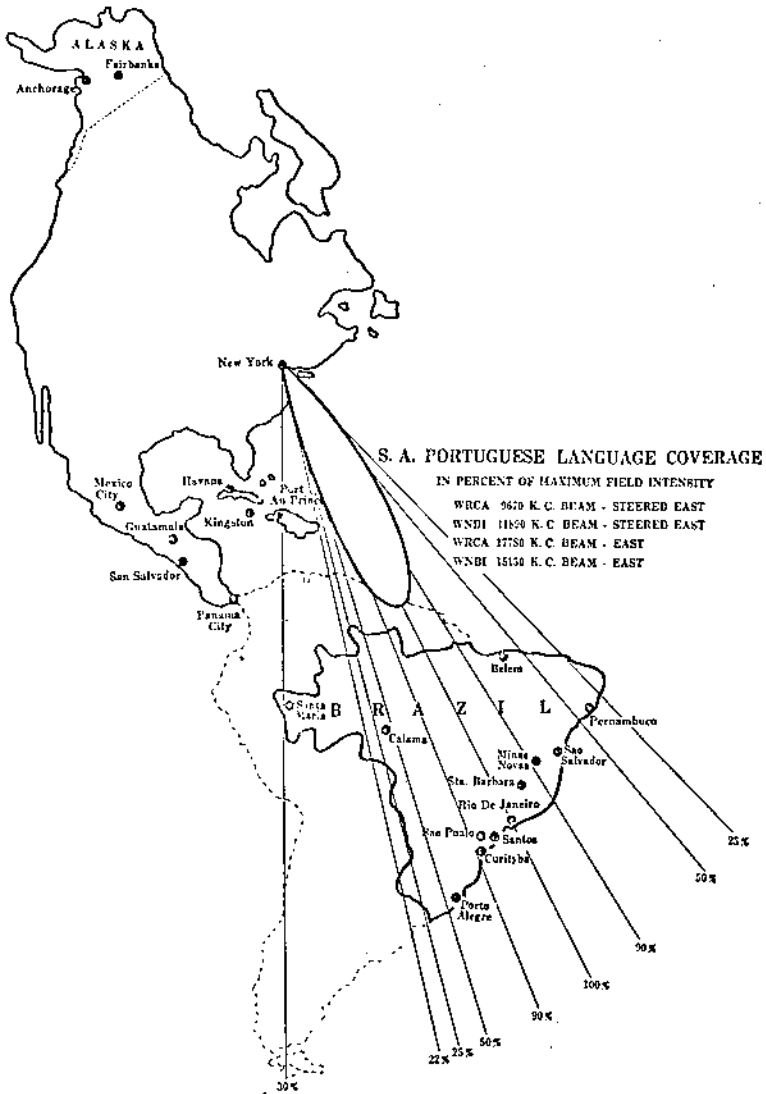

Fig. 5

tennas are more economical to build. In this connection an investigation was made to see what advantage could be taken of operation of one antenna on two or more separate frequencies. It is possible to properly terminate and operate an antenna on several frequencies, but if they

are too widely separated the antenna pattern departs too far from the optimum.

Two frequencies, not widely separated, may be used on one antenna without a significant change in the directive pattern. As a result of

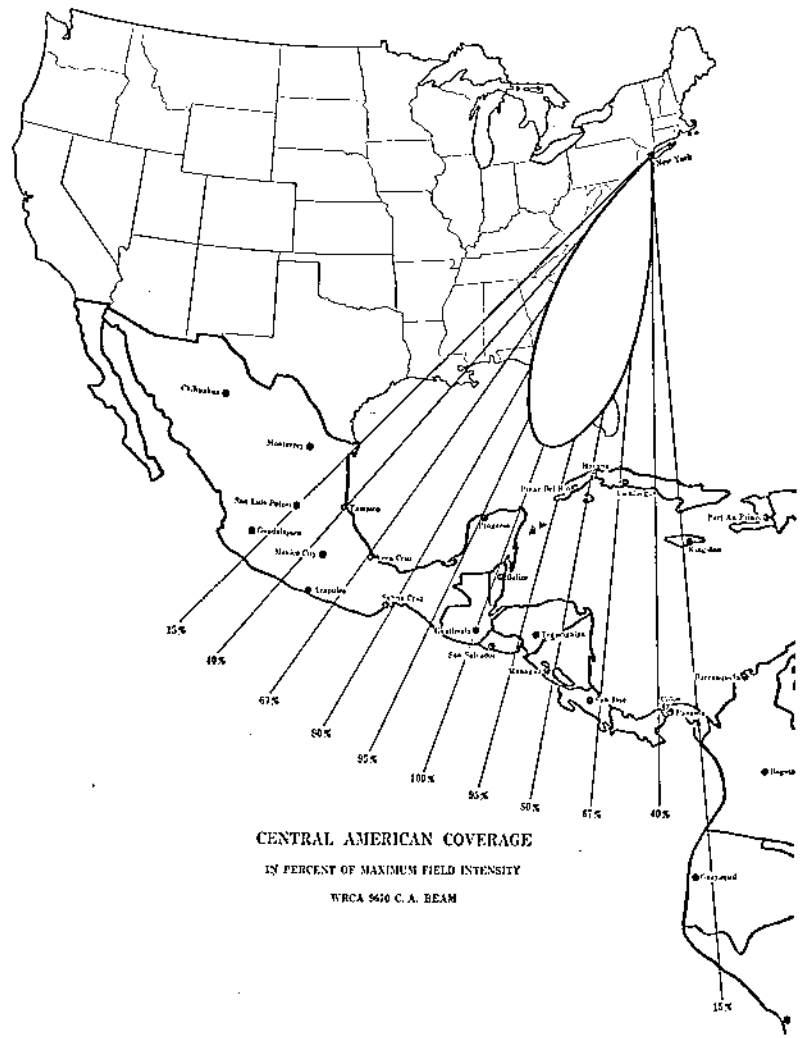

Fig. 6

this investigation two antennas, one directed to Buenos Aires and the other to Rio de Janeiro were designed and built so that each could operate on either 15150 kc or 17780 kc. The patterns are almost alike, the antennas can be terminated correctly for each frequency and the overall result is that two fixed antennas accomplish in this way substan-

tially the same result that would be obtained with two steerable antennas.

Figure 4 shows the field intensity distribution, in per cent of maximum, throughout Europe, when the 17780-kc European antenna is transmitting. Figure 5 shows in the same manner the field intensity

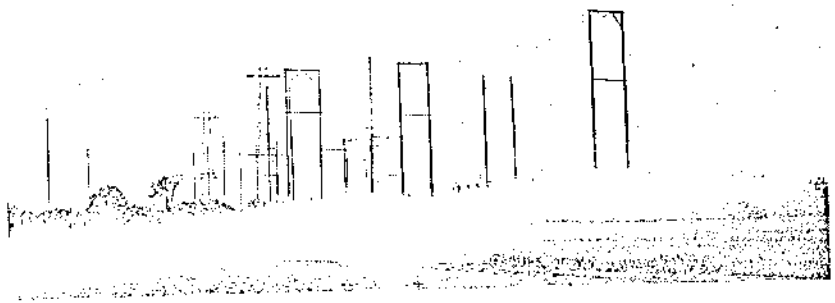

Fig. 7

distribution throughout Brazil for the east leg of the 9670-kc steerable antenna. Figure 6 shows the field intensity throughout Central America for the 9670-kc Central American antenna. Space does not permit showing patterns for all antennas nor is it important to do so when nearly all alike.

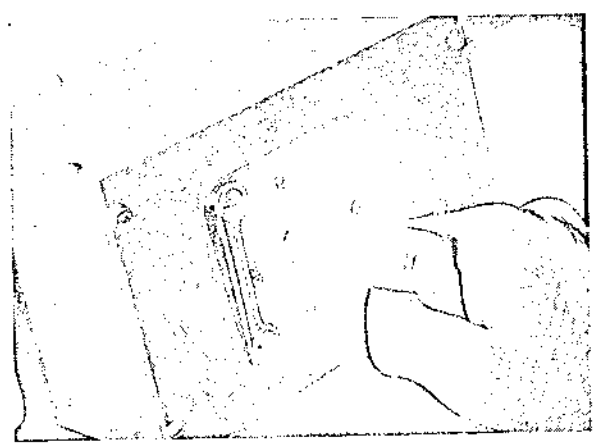

Fig. 8

The group of antennas used in transmitting to South America is illustrated in the photograph of Figure 7. Figure 8 shows the type of switch employed, and the only operation necessary, to direct the beam of the steerable type antenna developed by NBC.

In the design of beam antennas such as are used at WRCA and WNBI, maximum forward transmission is not accomplished with the same adjustment which would produce maximum suppression to the rear. Therefore, an appreciable amount of power is transmitted to the rear of such a system. When the steerable antenna is directed to the west leg an effective beam power of about 120 kw is transmitted in the direction of Alaska. A Fairbanks station has requested and received permission to rebroadcast the WRCA programs thus received. Simi-

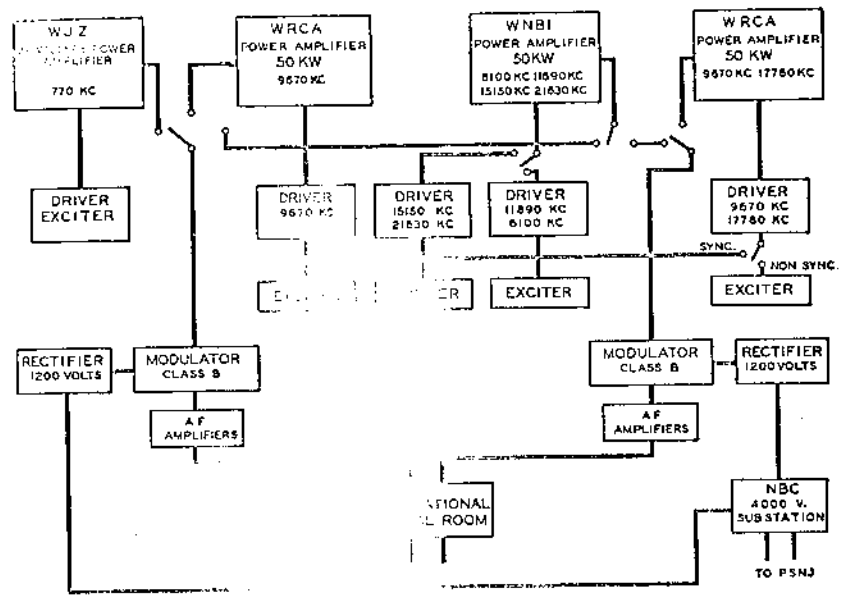

Fig. 9

larly, a station in Puerto [illegible] requested and received permission to rebroadcast the programs of WRCA and WNBI.

WRCA and WNBI Transmitters

The transmitter facilities of WRCA and WNBI are shown in Figure 9. Facilities are provided for the operation of two transmitters simultaneously. The frequencies are divided between these two transmitters in such a way that the maximum number of useful adjacent frequency combinations can be used together. Six frequencies are assigned to WRCA and WNBI, 6100 kc, 9670 kc, 11890 kc, 15150 kc, 17780 kc, and 21630 kc. Dual 50-kw transmitters are available, the WNBI transmitter having one power amplifier and duplicate exciters identical except for the operating frequencies. WRCA is provided with similar duplicate exciters and also two duplicate power amplifiers dif-

for reconstruction. Then upon completion of the first 50-kw transmitter, temporary wave-changing facilities had to be built into it to facilitate its operation on the frequencies of the second transmitter so that no program interruption resulted. After this was accomplished, the

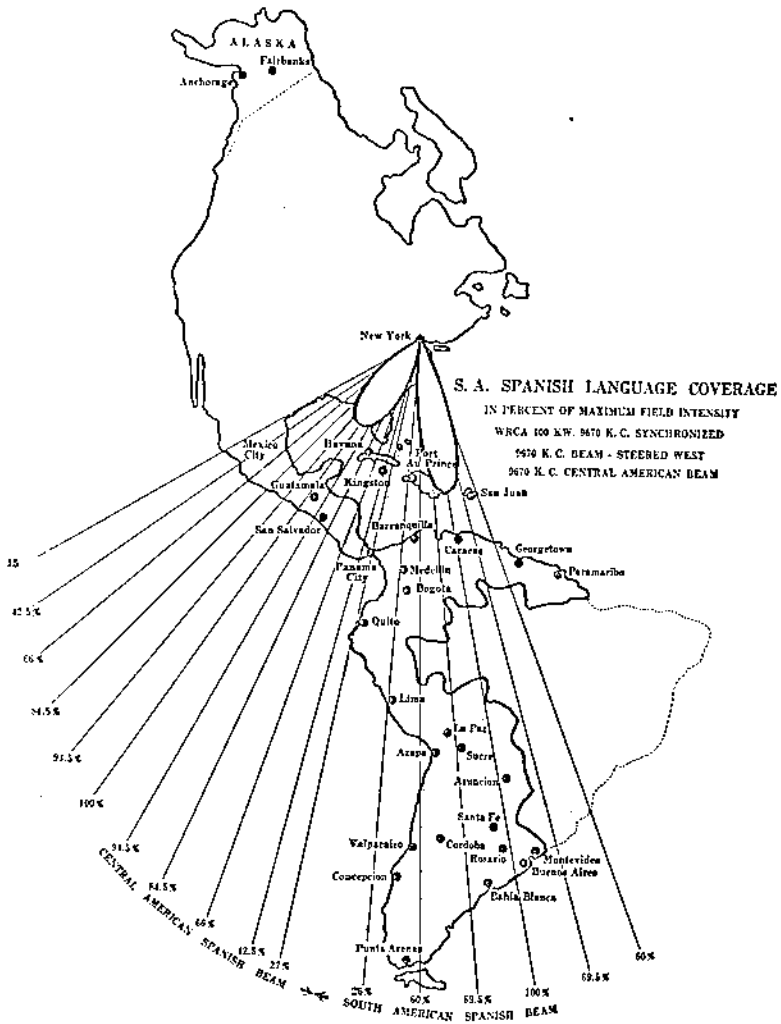

Fig. 10

second transmitter was made available for reconstruction for 50-kw operation and so on with the third transmitter.

An inordinate amount of extra work and planning were required under these conditions to rebuild completely all three transmitters. Most of it had to be done after the 1 A.M. sign-off period at night

because only then could power be removed from the WRCA-WNBI equipment.

As a part of the project it was necessary to increase the power-handling capacity of the main 4000-volt substation and also expand the water-cooling facilities to withstand the added plate dissipation attendant upon the transmitter power increases.

Coinciding with the power increases of the transmitters, the power-handling capacity of r-f transmission lines and antenna systems had, also to be increased by installing larger transmission line and antenna cables and increasing the insulation. Most of this work also had to be performed at night after the end of the daily schedules.

Simplification of mechanical design has been accomplished by the use of removable shelf-type construction utilizing duralumin frames, panels, chasses, and shelves. For maintenance and repair of the low-power stages the shelves are removable on sliders from the front panels, like desk drawers. Other stages are made accessible through interlocked doors, or perforated screens.

As a result of many years of high-frequency broadcasting transmitter experience, the high level modulating system was retained as the most satisfactory. The RCA tube lineup in each transmitter starts with crystal controlled oscillator and frequency-multiplier units containing an 802 crystal oscillator and two 802 doubler stages. The outputs of the second doubler stages are amplified by 813 amplifier stages and push-pull 803 stages. These in turn are used to drive the intermediate power-amplifier stages utilizing four 833A tubes in push-pull parallel arrangement.

The outputs of the 833A stages of the exciter units are normally 3.5 to 4 kw and drive the grids of the push-pull 880 modulated power amplifier stages to saturation. All r-f stages are equipped for a-c filament heating from the 60-cycle power mains through suitable transformers.

The modulator units of these transmitters consist of cascade 211 and 845 audio amplifier stages and push-pull 891 driver stages. These driver stages have the desired excellent regulation for driving the 893 Class B modulators. The drivers and modulator stages operate at 10,500 volts of d-c power supplied by 3-phase full-wave main rectifier units utilizing six 857B hot-cathode mercury vapor rectifier tubes in each.

The power amplifier units of these transmitters are of improved design with a view toward greatest efficiency and operating stability. In each case two 880 power tubes, shown in Figures 12 and 13, amplify the transmitter carrier power to 50 kw. Modulation is accomplished with audio power provided by the RCA 893 Class B modulator unit.

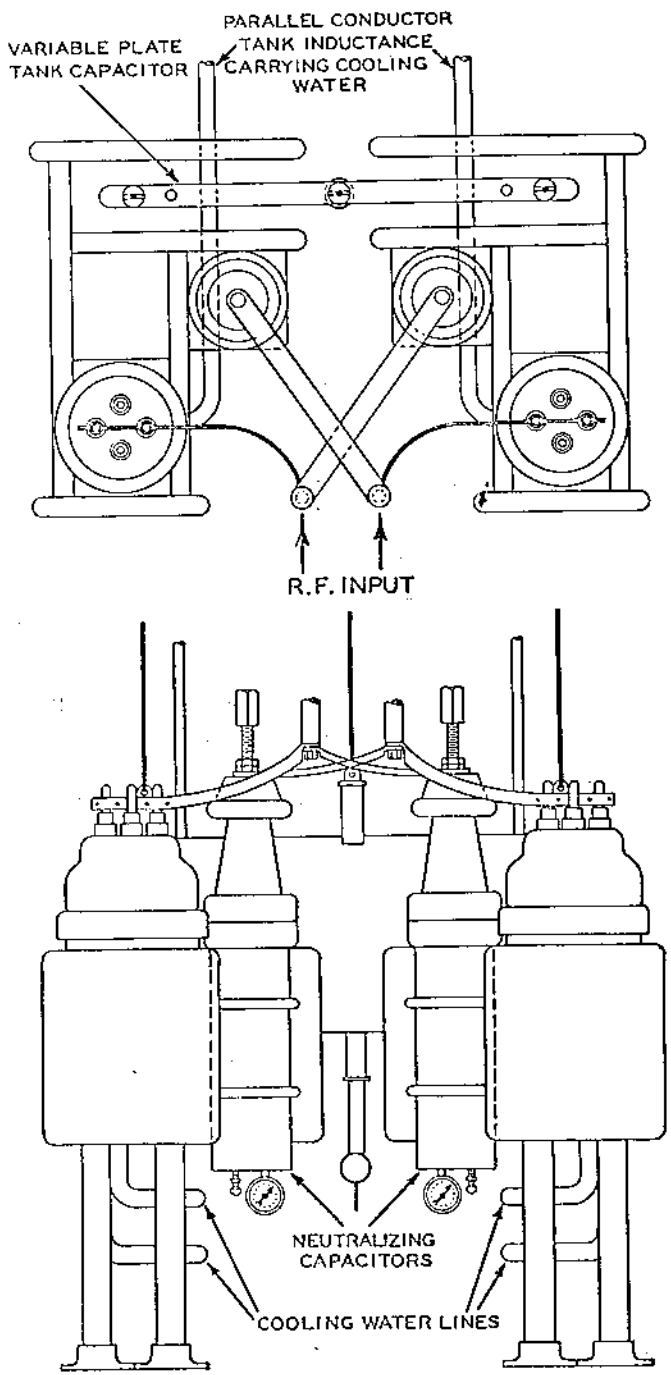

Fig. 11

In Figure 11 there is shown an assembly drawing of the water-cooled RCA 880 tube mountings, the output tank circuit tuning capacitor and the neutralizing capacitor arrangement. The variable compressed-air neutralizing capacitors are used in a standard cross-neutralized circuit with excellent stability over the wide frequency range in which the transmitters are used. An air pressure of 150 pounds

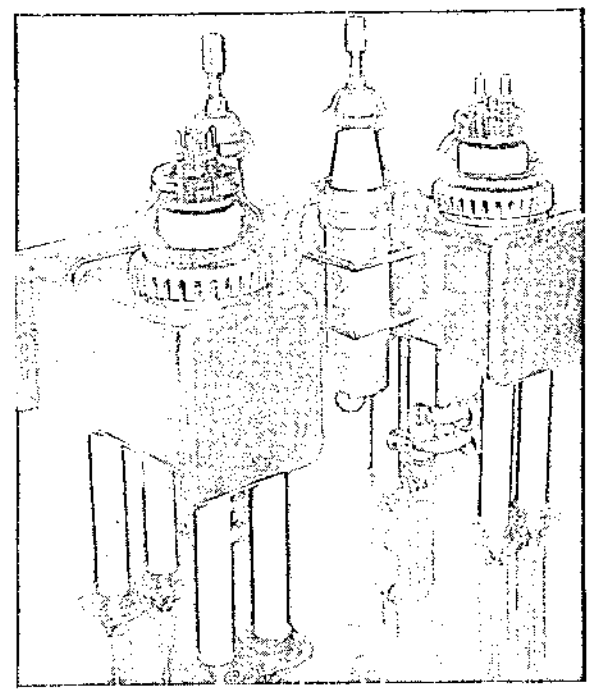

Fig. 12

per square inch has been found ample to provide air-dielectric strength suitable for this purpose. Two blower units are provided to supply sufficient air cooling for the grid and filament seals of each RCA 880 tube by means of three-inch bakelite ducts leading to the tops of the power amplifier tubes.

In the compact assembly shown in Figure 11, one-inch solid duralumin plates are used throughout. All corners and edges are carefully rounded and all surfaces highly polished. The variable, output, tank, tuning capacitor consists of a single movable grounded plate sliding vertically into the U-shaped chambers on each side of the assembly. This is illustrated in Figure 11. Figure 12 is a photograph of the assembly.

By this arrangement the capacitance from each side of the tank circuit to ground is perfectly balanced. Stray and minimum capacitance

is reduced to a very low value. This is especially true with the movable plate raised to its extreme upward position where the capacity effects to it are negligible. A wide range of tuning of the parallel-conductor tank inductance output circuit is thus obtained by the sliding plate which is operated by means of gears from a knob on the front panel of the power amplifier unit. Counterweights are provided to reduce the effort required to vary the position of the movable plate.

The operation of high-powered, high-frequency amplifiers depends upon short direct r-f connections, lumped circuit elements, and simple construction if it is to be stable in operation. This is particularly true if the amplifier is to operate on two or more different frequencies. One of the difficulties in designing equipment of this kind is properly to locate the circuit elements with respect to each other, to minimize the length of the connections, and at the same time provide proper insulation for high-powered operation. One of the troublesome circuit elements is the neutralizing capacitor. In a push-pull balanced amplifier the neutralizing circuit must be insulated for d.c. plus r.f. but at the same time the capacitor itself should be as small and compact as possible. The use of compressed-air neutralizing capacitors offered an excellent solution. The capacitor is of a type developed and used by R.C.A. Communications, Inc. in high-powered telegraph transmitters and has been adapted to these broadcast units.

Figure 13 shows a photograph of one of these units. Figure 12 shows the manner in which it is mounted in the plate tank assembly. It may be seen that the RCA type 880 tube jacket is mounted adjacent to the compressed-air neutralizing capacitor, both being mechanically and electrically enclosed within the machined aluminum frame assembly.

These capacitors normally are kept at an air pressure of 150 pounds by means of a small motor-operated compressor. They have been tested under normal operating conditions on pressures as low as 60 pounds without any tendency to flash-over and have been tested, with normal pressure, at 90,000 volts without flashover. The capacitance is variable over a sufficiently wide range to insure optimum neutralization. The units are, of course, built to have the proper range of capacitance for the particular circuit in which they are to be used. The variation of capacitance is accomplished by turning the threaded end rod which varies the length of a copper bellows in the pressure chamber.

Distilled water for cooling the anodes of the RCA 880 tubes flows to and from each power amplifier tube through the parallel-conductor tank inductance, which consists of a one-inch square (outside dimension) bronze pipe and is illustrated in Figure 13. The tank inductance

thus forms a part of the distilled-water system so that water is fed into the circuit through the porcelain water coils at the low r-f voltage point of the output tank with the result that r-f leakage to ground through the insulating water column is a minimum and at the same time the temperature of the tank inductance is maintained at a lower value.

Some of the problems encountered in building and operating dual high-power international broadcasting transmitters include those of eliminating harmonics and spurious frequency radiation. The har-

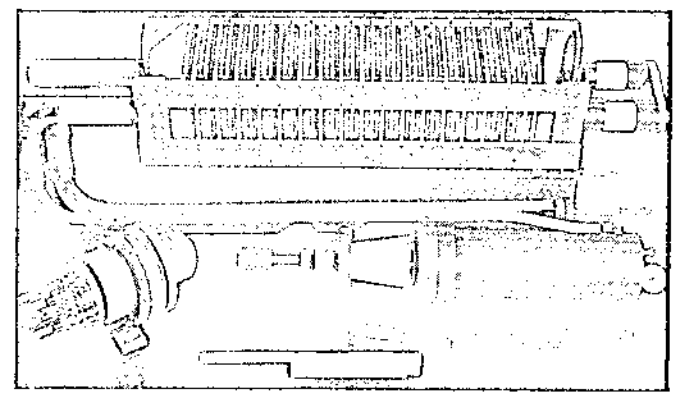

Fig. 13

monics usually can be eliminated by suitable filters located at the sending end of the transmission lines leading to the antenna. However, in addition to harmonic frequencies, there must be eliminated a wide variety of other spurious radiations which may be produced by a combination of two or more transmitters operating simultaneously on different frequencies, especially where open wire lines operate in the fields from the other antennas.

Effectiveness of the Service

For many years NBC has conducted an effective International Broadcasting Service. With the outbreak and spread of the present world conflict and the continuous improvement in NBC radio facilities, the value of this service has multiplied in importance and scope. New thousands of letters and telegrams incessantly convey that fact with stirring impact. One cannot but be deeply impressed by those many communications from Europe which express despair and misery, nor

can one read their pleas to continue and expand our efforts without more fully appreciating the high patriotic and humanitarian function which has come to be served by American short-wave licensees. International broadcasting as conducted by our country has become a powerful instrument which has earned the respect and confidence of foreign listeners through the truthfulness of its reporting and the character of its programs.

It has been the writer's privilege to be associated with radio for 26 years and with broadcasting for 20 years. Rarely has there been an opportunity in those eventful times for any form of communication to demonstrate such unique feats as are now becoming accepted commonplaces in international broadcasting. Barely 16 years ago the first rebroadcast from across the seas took place[1]. Scheduled rebroadcasts from the far corners of the earth have since become matters of but casual interest. But only in recent months has the bewildered victim of catastrophe, propaganda, and censorship so fully appreciated the modern miracle of radio which enables him to listen, perhaps secretly, to free stations thousands of miles overseas for frequent and authoritative reports of world events, at times taking place in his own country, frequently at points but a few blocks distant.

The following are excerpts from typical long letters from Europe:

"I am sending you this letter through a friend of mine to thank you for your excellent broadcasts of the French Hours. Whatever happens, keep on with them . . . At least may your radio stations remain with us, we beg of you. In our great sorrow, crushed as we are . . ."

"I follow your transmissions regularly. For months they have been helping me to bear up under the present situation and I cannot thank you enough for the moral support you give us".

"Living in a channel port you can't imagine the comfort my friends and I receive from hearing your transmissions . . . We shall be listening especially on April 13 unless a bomb shatters us."

"Literature you sent me before was destroyed during an air attack last June, from which, through a miracle, my family and I escaped although five bombs exploded surrounding our house."

The following is an example of the effectiveness of the WRCA-WNBI service in Central America. It is a telegram from Tegucigalpa, Honduras. "The broadcast was received in this capital perfectly. The speech has caused a sensation in our country as it did in the rest of Latin America. Rarely have I seen so many people gathered on the plazas where we have had our loudspeakers installed as I saw last night. We can guarantee that in our country there were many thousands of people who listened to the Spanish version of the presidential speech (Fireside Chat to the Americas) which we might add was very well read by your announcer."

NBC broadcast the President's speech direct to every one of the American republics and to Europe. Stations in the 20 Latin American republics and in Puerto Rico rebroadcast the Spanish and Portuguese versions which were given from Radio City simultaneously with the English broadcast from the White House. The speech was rebroadcast by the British Broadcasting Co. and Italian, German, and French translations were beamed to Europe on the regular times assigned to those languages.

The following is an example of the technical character of the 9670-kc signal received in Rio de Janeiro from the steerable antenna. It covers from 6.00 to 7.45 P.M. E.D.S.T. on May 15, 1941. Reception was on a common receiver with six feet of wire for an antenna.

	WRCA—9670 kc
Carrier strength	Very strong
Fading—Depth	Very slight to slight
Rate of fading	Very slow to slow
Interference from other stations	None
Static	Very weak
Background noise	Very low
Transmitted noise	None
Degree of modulation	High
Quality	Excellent
Overall rating	Excellent

ACKNOWLEDGMENTS

The combined cooperative efforts of many men are required in the planning and fulfillment of a long project. The writer wishes to gratefully acknowledge the unusual engineering ability and unselfish application of Mr. Carl G. Dietsch and Mr. William S. Duttera in planning and building the NBC radio facilities described herein. Mr. Dietsch has been assigned to the WRCA-WNBI project for many years and has directly superintended the construction of all of the transmitter and antenna facilities described. He has also invented and developed many improvements in methods and devices including the high-power tank-circuit assembly described. Mr. Duttera has from time to time collaborated in antenna development, design and adjustment, including particularly the steerable antenna system described.

In making major construction changes in equipment in daily operation countless vexing problems arise. Their solution has been simplified over a period of 17 years through the unfailing and sympathetic cooperation of Mr. D. N. Stair, Station Engineer at WJZ, WRCA and WNBI.