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Wired for Sound

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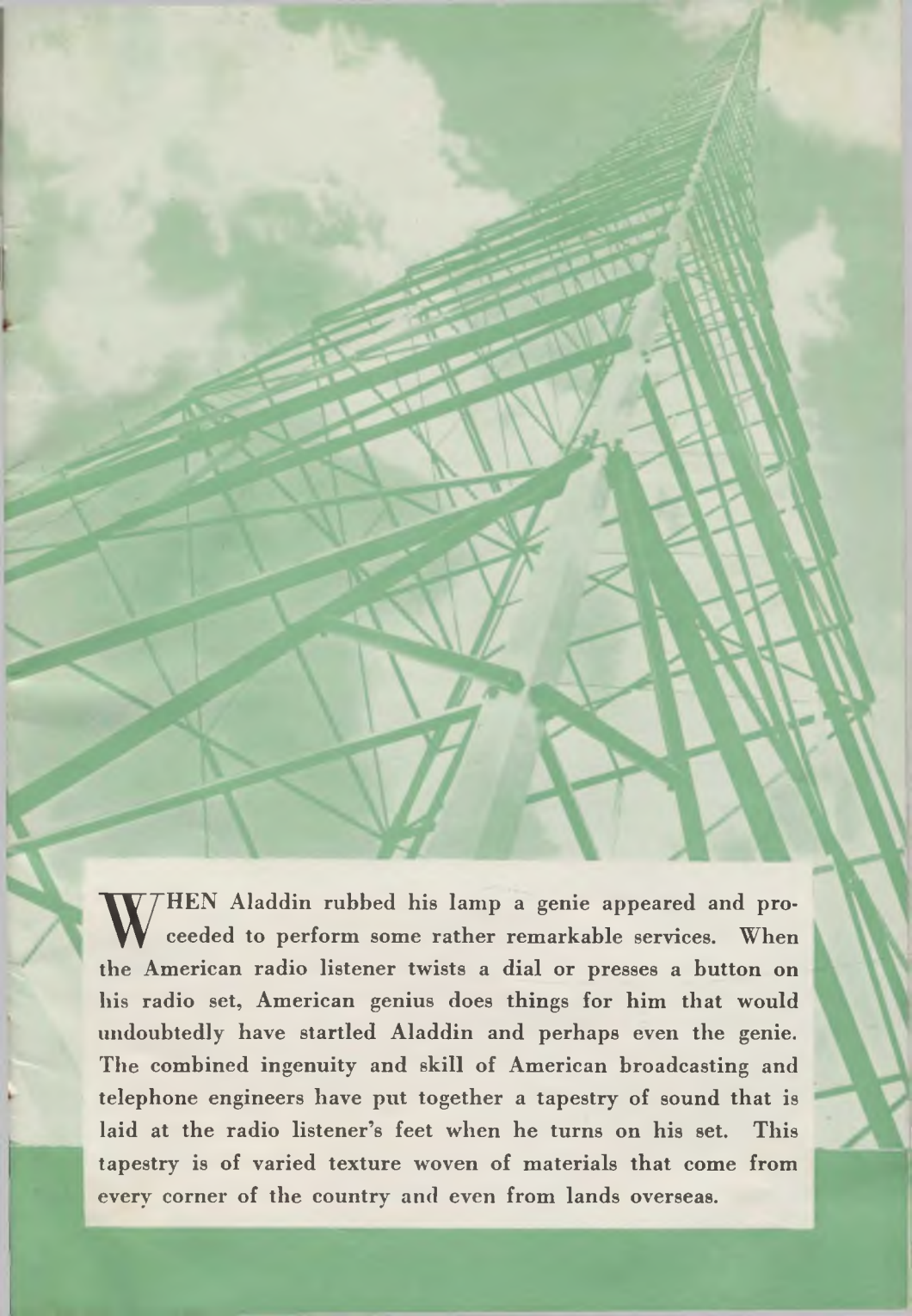
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WIRED



Long Darling
Shamrock, Me.

FOR SOUND



WHEN Aladdin rubbed his lamp a genie appeared and proceeded to perform some rather remarkable services. When the American radio listener twists a dial or presses a button on his radio set, American genius does things for him that would undoubtedly have startled Aladdin and perhaps even the genie. The combined ingenuity and skill of American broadcasting and telephone engineers have put together a tapestry of sound that is laid at the radio listener's feet when he turns on his set. This tapestry is of varied texture woven of materials that come from every corner of the country and even from lands overseas.

Piping Programs

TO A NATION

Part of the creed of this country's telephone system envisages service so contrived and operated that it will enable "anyone anywhere, at any time, to pick up a telephone and talk to anyone else, anywhere else."

It is not an accident therefore that another service operated by the telephone companies—the furnishing of wire networks to the broadcasting companies—has a similar objective: a wire system over which any broadcaster, anywhere, may transmit a program to any other broadcasting station, anywhere else in the country.

This objective is within measurable distance of achievement. The American Telephone and Telegraph Company and its Associated Companies have established a web of wire channels over the country that is capable of connecting almost any broadcasting station in the United States into a nationwide network. As a result of this, a program originating anywhere along that web or near it may be fed to practically any station throughout the entire United States.

Exploring from an Armchair

Let us suppose we are in the living room of the Average American Radio Listener. We will assume that he is near the geographical center of the United States, somewhere in Kansas.

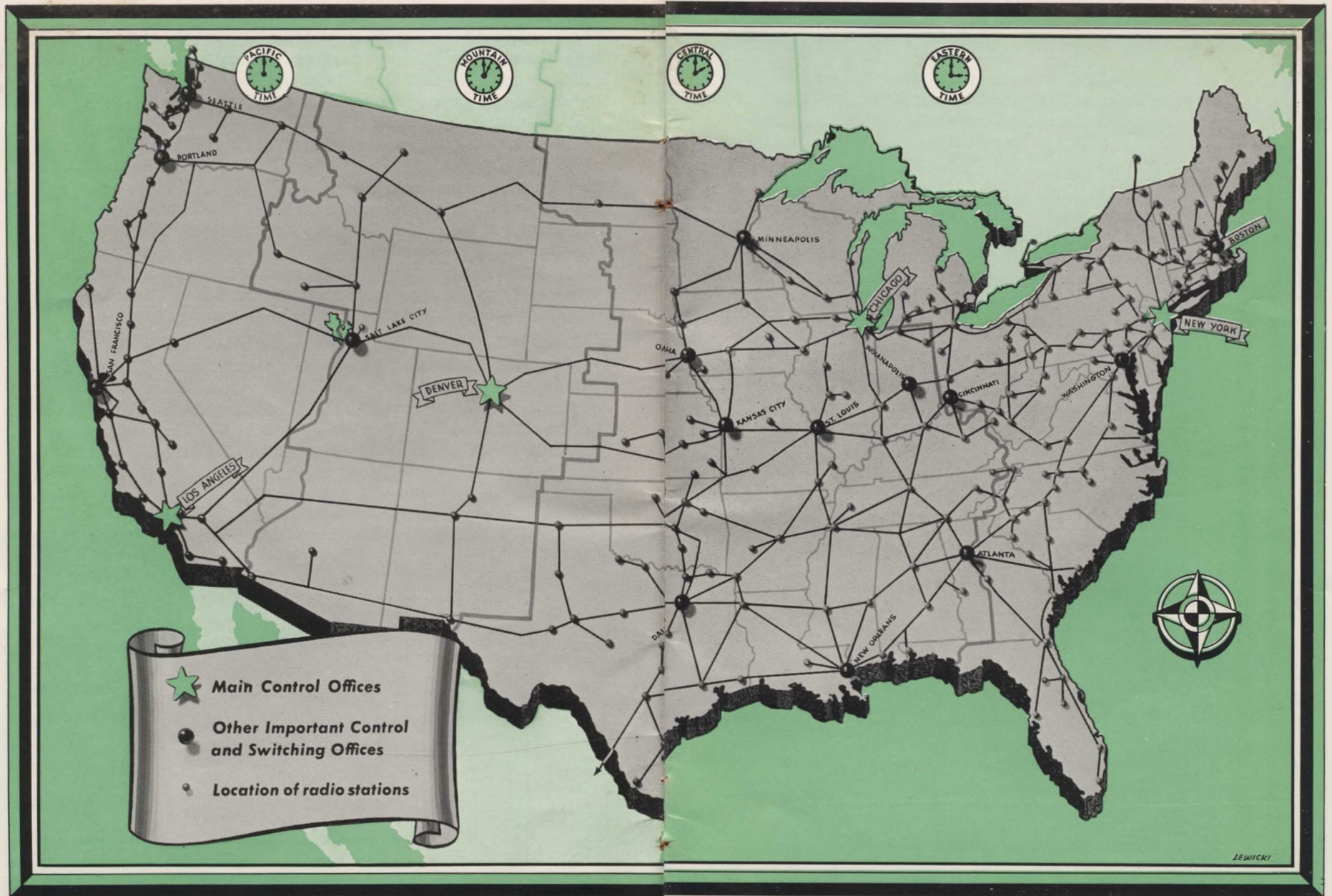
He flips on his radio set and first picks up a local station broadcasting a production by the town's high school students. A turn of the dial and he is listening to a speaker on farm problems in Chicago. More twists and he picks up a symphony orchestra in New York, a variety show in Hollywood, and finally a news commentator in some European capital.

What makes this worldwide choice possible? Let us go backstage on chain broadcasting and see what properties are used to enable our Average Listener to explore the world without quitting his own living room.... We'll start with the New York orchestra.

It's a Mutual Broadcasting System program. On the stage of the concert hall are microphones from which wires run to a control room set up in the hall. Here Mutual engineers prepare the music for its journey over wires to the hundred or more radio stations that are taking the program. It then goes—by underground telephone cable—to the master control at Mutual's headquarters whence it is fed to the nerve center of the Bell System's web of broadcasting channels in New York's Long Distance Building, known as "NR." Here a corps of technicians have lined up the wires and equipment over which the music is to travel and have subjected them to certain exacting tests. By this means they insure pleasing reproduction of every bar of that particular number, whether it be marked *fff* or *ppp*; whether it involves the high fragile tones of the flute or the deep-pitched thump of the kettle drum.

From NR telephone cables carry the music under the city's streets, under the riverbeds, under New York's far-flung hinterland of industry and suburban colonies, to the great trunk routes of communication set up by the A. T. and T. Company's Long Lines Department. These carry it to radio stations in New England and the South, in the Mississippi Valley and on the West Coast.





A network of wires over 67,000 miles long brings radio programs to some 400 broadcasting stations. Strategically located

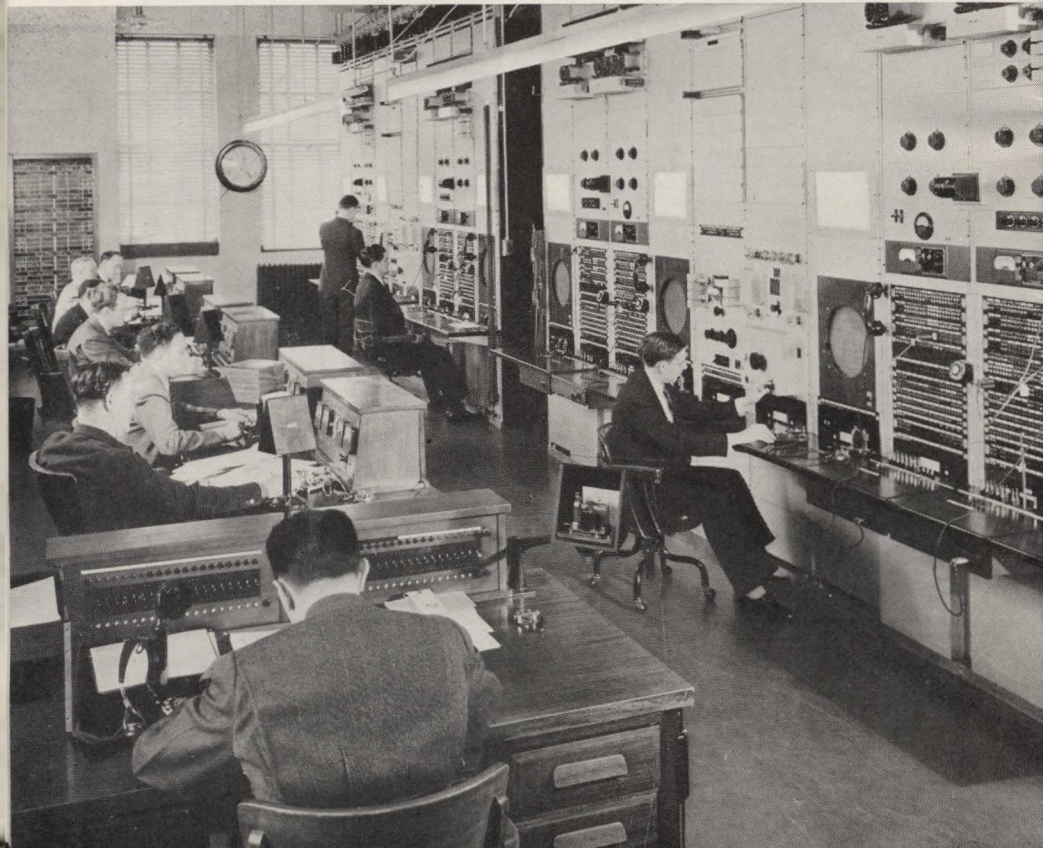
telephone company control offices give the broadcasting company complete flexibility in the hook-ups that can be made.

Hollywood and Europe

Let us now turn the dial to another station within reach of our Kansas listener. It is the Hollywood variety show, over one of the National Broadcasting Company's networks, which has traveled a similar kind of path in the opposite direction to that taken by the previous program.

The show is in one of the studios at NBC's Hollywood headquarters. On the stage are a number of "mikes" that pick up the vocalists, gag-men, orchestra and master of ceremonies. Wires from these mikes terminate in the control room on the other side of a great sound proof window. In this room technicians blend the output of the mikes into a harmonious whole that will enable the listener, by shutting his eyes, to imagine himself in the front row

New York's main control office for broadcasting network service, known by its call letters "NR."



Transatlantic receiving antenna at Manahawkin, N. J.

at the studio. This mixture of words and music goes from Hollywood to the Telephone Company's control room in Los Angeles. Here the Company's network staff start it on its way up the Coast and across the country, over wire channels that have been adjusted with all the care that the virtuoso lavishes upon his violin.

Once more we turn the dial, and pick up a Columbia Broadcasting System program bringing us a commentator on the other side of the Atlantic. How did that get into Kansas?

From that distant European city wires carry the speaker's words to one of the terminals of Transatlantic radiotelephone service, where they are amplified several millionfold and hurled across to America. Caught at the A. T. and T. Company's receiving station in New Jersey, they are brought into the Overseas Control Room, in the Long Distance Building, adjacent to NR. Under the hands of skilled technical operators, the voice of the distant speaker is given its maximum clarity and sent to NR. By means of a web similar to that handling the symphony orchestra, the foreign commentary spreads out to stations in every part of the country—including central Kansas.

A Web of Wires

We have so far mentioned only a fraction of the elements that comprise the wire grillwork set up by the Bell System for chain broadcasting. One of the features of this web is a series of control offices at strategic points throughout the country, so located that a broadcasting company's chain can, in the time it takes to flip a



Chicago's focal position in the Middle West makes it an important point in network operations.

switch, be broken up into a dozen separate little chains, and as quickly coagulated again into a single web.

The principal control points in this system are New York, Chicago, Denver and Los Angeles. Among the cities controlling regional webs or parts of the main webs are Boston and Washington; Atlanta and New Orleans; Cincinnati, Indianapolis and St. Louis; Minneapolis, Kansas City, Omaha and Dallas; Salt Lake City, Seattle, Portland and San Francisco. These and subsidiary control and switching offices permit any desired combination of stations and quick changes from one hookup to another.

Split-Second Schedules

Anyone who has given any attention to the details of broadcasting is aware of the split-second schedules on which all stations operate. On the air, time is literally money, and when a program is scheduled to start at eight p. m., Eastern Standard Time, that means exactly eight bells *on the button*. Switching on this exacting schedule is facilitated by a communication system that keeps the major control offices at New York, Chicago, Denver and Los Angeles in close and constant touch with each other and with secondary

control points; while each of these in turn is in equally close touch with every link in the chain in its own territory.

This wire web that reaches nearly half of the country's radio stations has certain features which are of particular interest. The first characteristic is the high quality of the circuit employed. In the telephone line the principal requisite is complete intelligibility. Any improvement of the quality of the circuit beyond this point would merely increase the cost of the service with no commensurate gain to the user. But it's different when it comes to handling radio programs. The wire must carry not only the fundamental tones of the various instruments, but enough of the overtones to make the music sound pleasing and natural.

Again, the telephone line would not be more useful if it were engineered to enable people to alternately shout and whisper at each other. But the radio program demands a considerable volume range. The musical selection that stayed at mezza forte all the time would be rather monotonous. Whether it is a symphony orchestra or a dance band it must have a channel which will approximate the changes in volume that an actual auditor would hear:—from the faint sound of a solitary flute off-stage to the climax of a concerto with every instrument "wide open," including the brasses and the kettle drums.

It might be added that music is not the only fragile freight which these wires must carry. Every radio play requires certain sound effects. Faithfully reproduced, they add greatly to the effect of a "scene"; badly done, they may sound a bit ridiculous. Footsteps, for example; a door slamming, a pistol shot—all of these must be recognizable as such. It so happens that part of the "sound pattern" creating one of these noises is on the fringe of audible sounds deep down in the bass clef. That means an extension of the sensitivity of our broadcasting circuit downward also.



The Minneapolis office switches the Northwest leg to another network.

Anatomy of a Circuit

Let us see what is needed to meet these requirements. We will begin by examining the interior of the long distance cable that runs alongside—or underneath—the highway through your town. Among the thickly packed wires of this cable are usually six pair of larger size, put there for permanent duty carrying radio programs from city to city. This is the first special feature of network service. Now let us jog westward over these wires, stopping to examine any unusual equipment through which they pass.

The first device is the “repeater,” or vacuum tube amplifier. This device is necessary in the transmission of any kind of electrical impulses over wire because of the energy loss. Inserted at intervals along the line, repeaters boost the current back to its original strength. The interval ranges from 25 to 250 miles. In the

average transcontinental network circuit this is done at some forty points.

The repeaters employed for network service are of special design. First, they must “pass” the wide tonal range just discussed; second, they must be responsive to those wide swings in volume; third, they must be able to keep those “sound patterns” in their original shape despite the wearing effects of a journey over thousands of miles.

For notes of different pitch do not always travel at the same speed. Suppose the pianist in the broadcasting studio strikes a chord. Its course along the wire might be likened to that of a wave breaking upon a beach. The shelving sand slows down the wave at its base and the crest rushes on until it breaks. In the case of elec-

trical waves, notes in the middle range travel faster than the low or high notes. Uncorrected, this would introduce effects tending to impair the naturalness of the sounds.

In 68 Scenes

Broadcasting networks vary in size from a handful of stations to more than a hundred. The number of programs likewise varies. In a 17-hour day it is possible to have 68 fifteen-minute programs, and many stations come close to that. Some programs are local shows, some are on regional networks and some coast-to-coast. Obviously the job of keeping each station in the right company for seventeen hours is not as easy as rolling off a log.


This is accomplished through a communication system extending right down to the smallest spur of the nation’s smallest network, a nervous system capable of producing the correct reaction in the remotest fibers, in a matter of seconds.

The teletype and telegraph circuits used in this system carry two kinds of messages—information regarding forthcoming programs, and orders relating to facilities to be used for these programs—as in cases of rerouting, adding stations in a special hookup, and so forth. The bulk of a network’s schedule of programs is naturally made up considerably in advance. But the switching orders based upon such a schedule have scarcely been formulated, when some last-minute change must be made. For the radio is a lot like the daily newspaper, and some sudden or outstanding development may push every other program right off the air—a speech from the national capital, a headline from some important gathering, a flash on some dramatic or significant episode in the war across the sea. At such times the inter-station channels must be cleared with dispatch. Within a few minutes the most distant stations must be lined up for the new program.

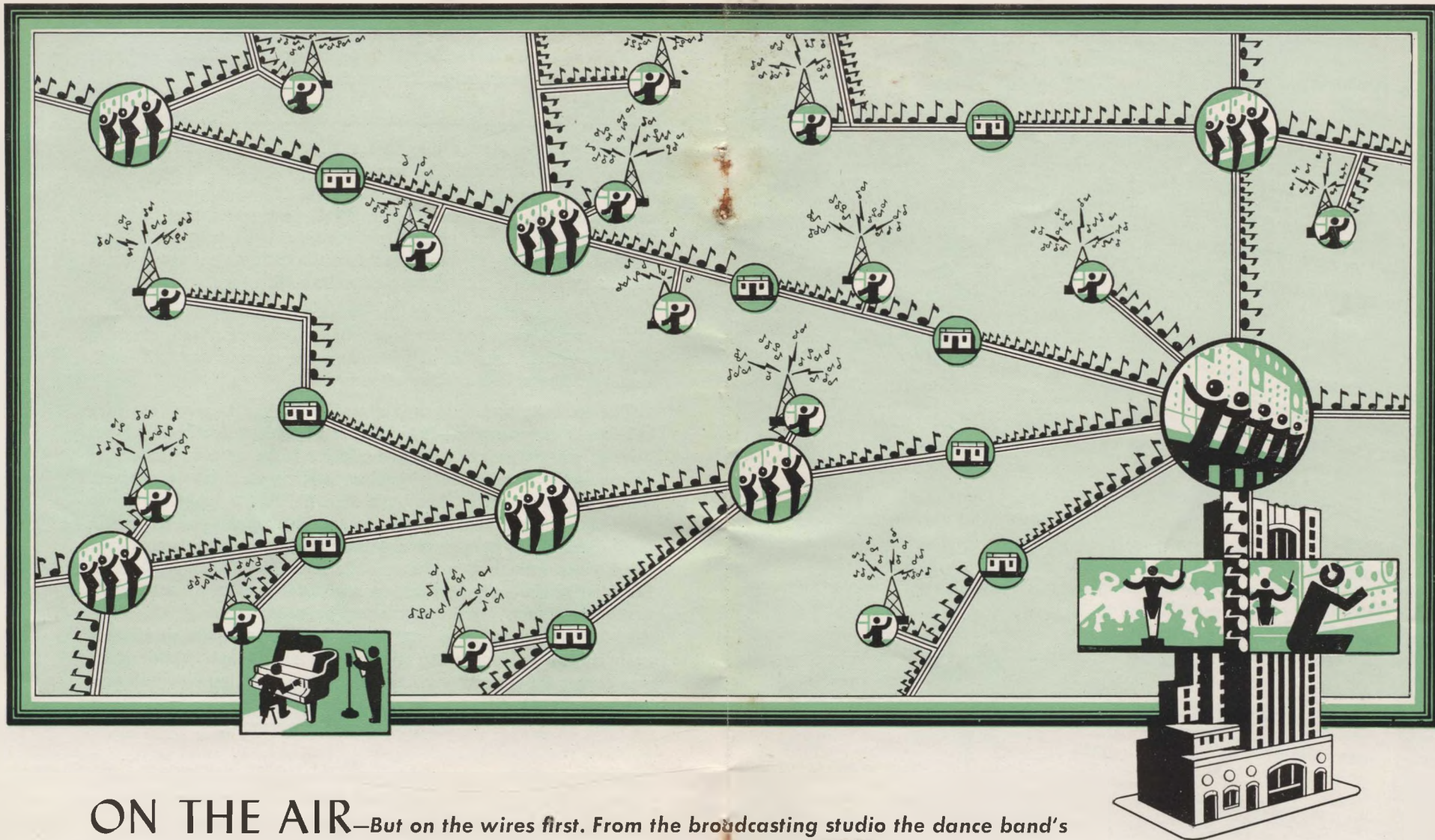
Putting a Network Together





Perhaps you have wondered just what is happening when you hear a program shifted from one city to another.

Take a network that has been operating “in pieces” and that is about to be reassembled to hear a speech of national significance from a political gathering in Washington. Back in our Kansas living room we are listening to a regional program from St. Louis.



Typical long distance cable, showing its 600-odd paper-wrapped wires, with those for network service projecting.



ON THE AIR—But on the wires first. From the broadcasting studio the dance band's music passes through the station's control room to the main control office  of the telephone company and thence to wires that may carry it to perhaps a hundred or more stations. Telephone company "repeater" stations  along the route re-energize the music-current, and switching offices  control various "legs" of the network. In a distant studio, a pianist  awaits the cue that will throw the entire network to his microphone for the next program.

NBC OO NO 49

TIME 730-745 PM EKD

RED (1) RICHARDSON & ROBBINS (COM)
(FABLE NR-SB)

F /PIT/ KYW (WRC RED) MAN WBZA

RED (2) WM PENN ORCH (SUS WCAE) (NBC) (NYM)
(BASIC EX KYW & MAN) SOC SWT WOOD WIRE HBR

BLUE EASY DOES IT (SUS)
Z /WBRE/ (BASIC EX WBZA) STE TEE NOW NH WORK WEEU WSAN LOU TEX

KANS KSOO COL

SWITCHES AT 730 PM EKD

CLEVE NORM

TOL NORM

CIN TEE TO KY ON KY CHIMES

SRD NONE

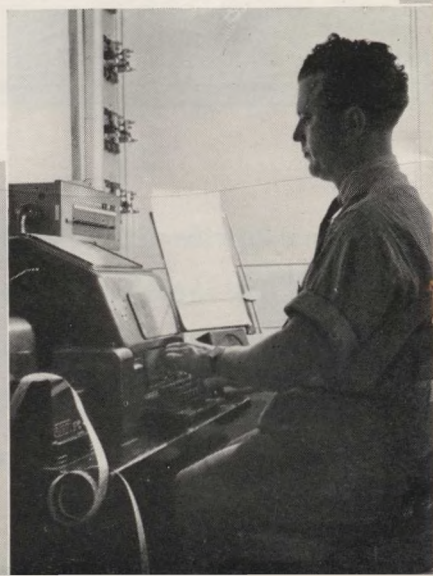
LAG NORM

OMA KSOO TO COUN ON COUN CHIMES

MPLS NOW TO COUN ON IOA CHIMES

KC KANS TO COUN ON COUN CHIMES

Complete information on every program, what stations it involves and what switches are to be made, is sent to all telephone company offices. Code words reduce the verbiage.



New England is listening to a talk from Boston; the Michigan stations are huddled around Detroit; elsewhere stations are broken up into small clusters, with perhaps a number of them operating entirely on their own.

As we approach the end of our program a man in the St. Louis control room hovers over a switch, his eye on the clock. He wears a headphone in which he hears the St. Louis program. Beside him another man with a headphone hears the other program, over the main line from New York. With 20 seconds to go, the programs fade into silence. In that silence he and the men at the other control rooms in Boston, Detroit and perhaps a dozen other cities from Atlanta to Seattle flip their switches, and a hundred stations are welded together. There are other offices where as many as four men may be listening to four separate lines that are to be put together.

Extra-curricular Program

"Good-night." The announcer is signing off. It is one or two in the morning. Voices and music fade from the air. The listener switches off his now-silent set. The programs are over for the night.

That is, all but one program. This is a program put on by the telephone company technicians. The various radio stations and the networks with which they are affiliated are usually in service seventeen continuous hours, from 8 or 9 a. m. until 1 or 2 a. m. But for the telephone company employees scattered over a nation-wide front, the network day is twenty-four hours long, and the network "good-night" marks the beginning of a coast-to-coast program of tests and adjustments in preparation for the start of service the following morning.

The air is silent. What then are the duties of these radio technicians? Let us look over one of their programs. This morning, for example, amplifier tube tests are to be made at all offices between New York and Chicago from 2:00 to 3:00 a.m. Is the volume and quality satisfactory? Each control office measures its own section, including the spare circuits kept ready for special services or emergencies.

The section tests completed, the network is put together and New York pumps out a succession of different tones over the entire chain. Measurements and necessary adjustments are made at a

score of places. This work completed, the telephone staffs send in by teletype reports on the service furnished, and yesterday's comments from the radio stations.

A news and weather program starts at 8 o'clock over the Sapphire Network. So at 7:30, in preparation for this, each office checks its set-up in accordance with the schedule sent out by the broadcasting company, to be sure the stations slated to receive the show are cut in.

At 7:45 the New York studios of the network start transmitting test programs to their chain. By means of a control telegraph wire, New York receives telegraphic reports from along the line that satisfactory volume and quality are being received. Check and double check makes it certain that your local Sapphire station will get that program, and in as good condition as it left the studio.

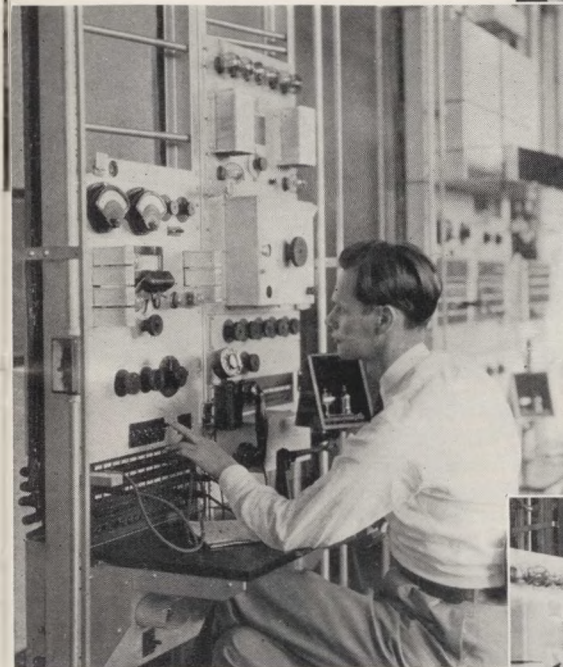
Professional Radio Fans

There is one group of listeners to network programs that is not counted in any radio poll. It comprises the telephone company technicians who "monitor" the programs that flow over the nation's networks.

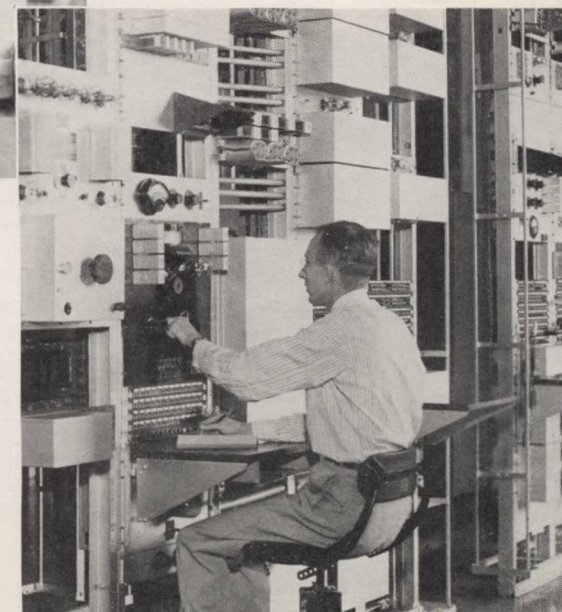
They listen with a regularity that would delight the radio sponsor—to symphonies, kiddie programs, talks for the housewife—anything that comes over the network. They could probably not tell you whether the girl on the last program sang or hummed. But they could tell you just what kind of a "hum" or "sing" there was yesterday on the Vermillion Network, and how long it took to get rid of it. They wouldn't remember much about the "Cooking for Two" program, but they could tell you all about that "frying noise" that was traced to a repeater on the Bismarck-Helena section of the Indigo chain. Because it's their job to see that the wire channels are functioning satisfactorily for sixty seconds out of every minute, and to rub out, as quickly as possible, every *click* and *buzz*, every *howl* or *hiss* that might make a network circuit *UFB* (unfit for broadcasting).

Bell System network service permanently links into various networks nearly half of the 800-odd broadcasting stations in the United States. The circuits used for this purpose have a total length of approximately 75,000 miles. These circuits are permanently and

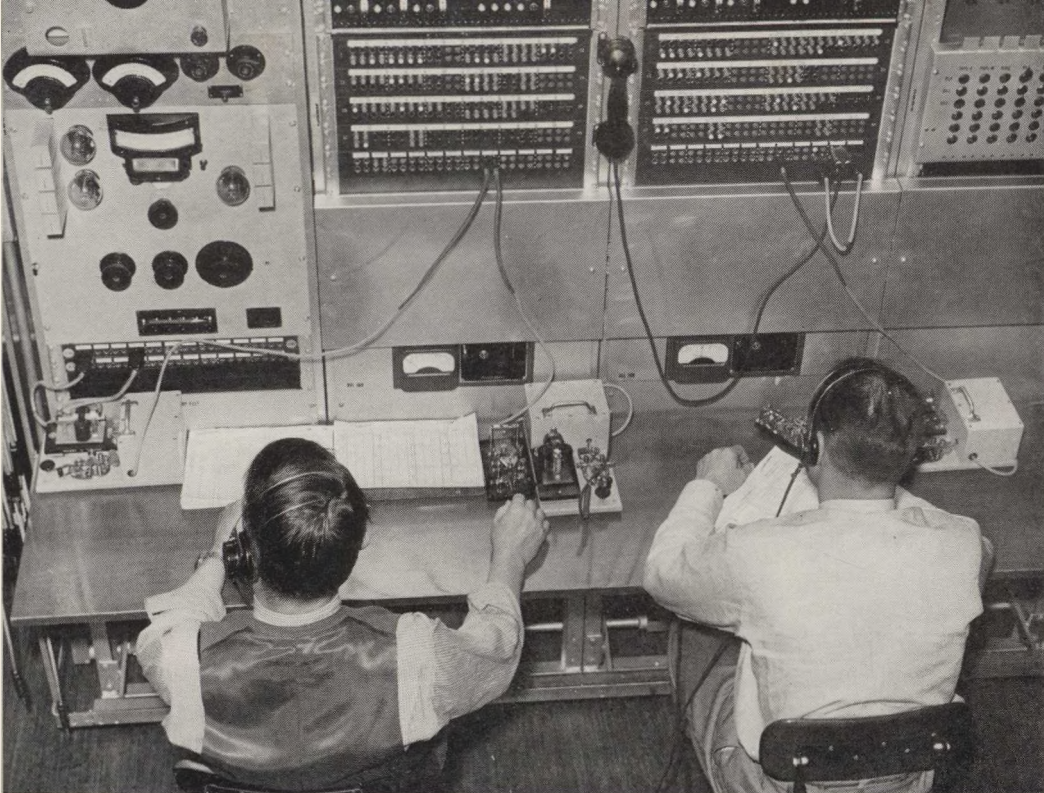
Right—The Louisville technician checks the "peaks," making sure that the volume-indicators in his office and in Cincinnati read the same.



Left—Kansas City "lines up" a circuit, measuring the fidelity with which it transmits sounds of various pitch.



Right—Charlotte adjusts the volume of a 1000-cycle note from an oscillator, a device for producing tone of variable pitch.



With the vigilance of an exacting music-master the telephone company "monitors" listen for the faintest flaws in transmission. Through this board in Denver run the important Transcontinental channels of the four major networks.

exclusively allocated to this service. To this total are added some 40,000 miles of wire lines permanently set aside as spare network channels for use in special events features, "repeat" programs, unusual hookups and in such emergencies as storms, floods, and so forth.

The greater part of Bell System network service is used to form four coast-to-coast broadcasting chains. The central feature of each of these is a great loop of wire linking cities in the north-eastern section of the country between New York and Chicago. Known as a "round-robin," this loop enables the broadcasting company to pipe a program from any city on the round-robin to all the

other points, of which there are over twenty for one of the networks. At points along this loop are connections to various "legs" that spread out over the other parts of the country.

Because of the special type of equipment required for broadcasting, nearly all network circuits are one-way. In order to give the two-way service that permits picking up New York and Hollywood in quick succession, the transcontinental circuits over the western half of the country are fitted with devices for reversing such a circuit in a single operation. A button is pressed in Los Angeles and the apparatus in a dozen telephone offices along the Transcontinental is reversed. The wires that a moment ago were carrying our orchestra to the West Coast are bringing eastward a program from Hollywood.

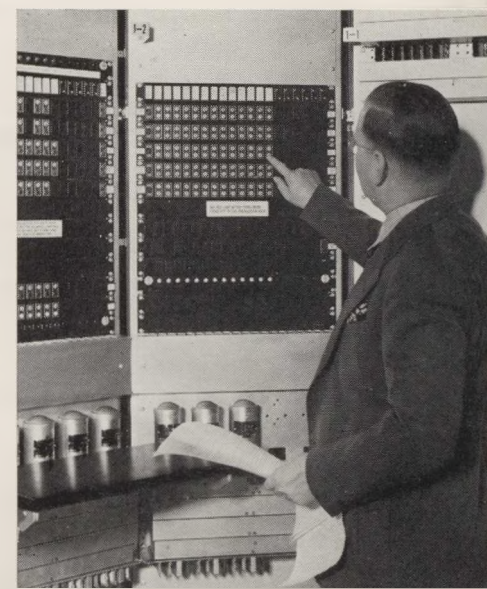
For the statistically minded we will list a few figures on the subject of network facilities. These wire channels run through about 300 telephone company offices; they use over 2,500 of the special type of vacuum-tube amplifiers designed for network service. In addition to the four major coast-to-coast chains, there are approximately thirty regional webs. About 1,000 Bell System transmission specialists are engaged in operating them.

Words, Music and Pictures

Network channels are but a part of the multi-purpose communication system that links the telephone in our Kansas living room with 21 million other phones in the United States and thousands more abroad; that pours thousands of words of news into our local newspaper from every part of the country by teletype or telegraph, and the pictures that go with them; and that carries the ceaseless tide of messages of the nation's business world.

For this varied freight the Bell System has built up a system of large-capacity lines that interlace

Omaha's "cue pre-selection panel." By pressing a series of these buttons the technician sets things up for instant change of network connections at this office—effected upon receipt of cue or cues, by tapping one more button.





Stretching from palm to pine, and wet with the spray of two oceans, the telephone line carries the radio program to stations all over the country.

the country's great cities, with branches that tie in practically every town and village from Maine to California. Throughout the Northeast and the Middle West is a closely-knit network of virtually storm-proof cables. Aerial wire lines crisscross the rest of the country, and four major routes across the Continental Divide insure contact between coast and coast. Parallel routes and cross-connections at a dozen switchboards along a route make it possible to reroute traffic around almost any obstacle. It is this profusion and flexibility of wire channels, every one adaptable to two or more uses, which enables the telephone companies to maintain network service as well as other communications in the face of hurricanes, floods, earthquakes and other effects of "Nature in an angry mood."

Sometimes the telephone staff have warnings of a rupture of this kind—a telegraphic flash from some isolated repeater station: Ice

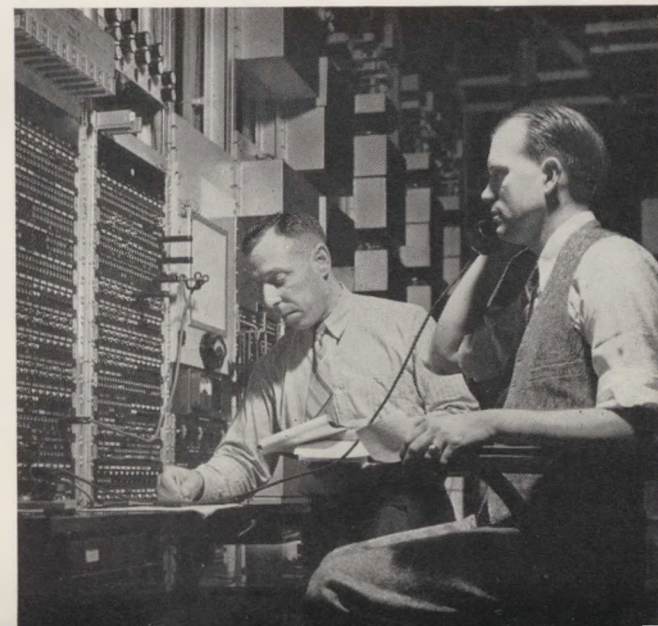
is forming on the wires or the water is within four feet of the line and still rising. In these cases, offices near the affected area usually have at least one alternate route and generally more than one, set up in anticipation of a break; and in a few seconds the program can be sent traveling over an entirely different path.

There are other times when there is virtually no warning—a twister or a cloudburst, or an explosion that rips a line in two. Things like this can happen in the Rockies or the Sierras or the Appalachians; and they can happen too along some highway through the busy cities of the plains. These are the accidents that test the flexibility of network service. Constant vigilance is not only the price of liberty but the price of uninterrupted radio programs.

Even in these sudden accidents there is usually some spare circuit that can be patched into place in a matter of minutes. Usually it's just a *click!* heard in your set. It may mean a hundred-mile detour, or it may mean that the program from San Francisco that was reaching you through Denver is now coming eastward over the Northern Transcontinental route through Seattle and Minneapolis.

These are the men and mechanisms that have been set up by the Bell System to bring the network program to the American listener, whether it originates in the local station, or on the other side of the continent, or from some itinerant microphone roving a far corner of the earth.

A complete "meeting of minds" between broadcasting and telephone company technicians assures faultless teamwork. Los Angeles checks its operating schedule with the broadcasting company.





RADIO TELEPHONE SYSTEM - New York - Broadcasting from Walker-Lispengard Station.

AMERICAN TELEPHONE AND TELEGRAPH COMPANY
LONG LINES DEPARTMENT

TELEPHONE AND TELEGRAPH BUILDING
195 BROADWAY

NEW YORK APRIL 18, 1922
565-10

14781

Mr. L. R. Jenney, Div. Plant Dept.,
New York, N.Y.

Dear Sir:

With regard to the furniture for the studio at the Walker-Lispengard Radio Station, the Engineer recommends that the following musical instruments be provided:

- 1 Stearns Parlor Grand Piano
- 1 Welte Mignon Piano Player
- 1 Victor Type VV110 Phonograph, equipped with Western Electric Reproducer

The Engineer recommends the piano with a player attachment rather than a player piano because he understands that some of the artists prefer to use the straight piano rather than an instrument having the player built into it.

Predecessors of today's coast-to-coast hook-ups, A. T. and T.'s volunteer entertainers thrilled the crystal-set earphone listener of the early twenties with "Oh, that we two were Maying" and other old favorites.

MILESTONES

The transmission of radio programs by wire began with the broadcasting by Station WEAF, New York, of the Princeton-Chicago football game at Stagg

Field, Chicago, on October 28, 1922. WEAF had been established by the A. T. and T. Company in July of that year. The first program to be broadcast over radio stations linked by wires was a concert in the WEAF studios in New York, which was broadcast from WEAF and station WNAC, owned by Shepard's Stores in Boston.

In the next three years stations sprang up all over the country, and Bell System wires carried an increasing freight of political speeches, play-by-play descriptions of intersectional football games and more and more variety in programs for the radio listeners. On February 8, 1924, the wire hookup spanned the continent for the first time with a demonstration given at the Bond Men's Club in Chicago. This included a three-way conversation linking Havana, Chicago and San Francisco, and was broadcast by stations WEAF in New York; WCAP, Washington; WJAR, Providence; WMAQ, Chicago; KPO, San Francisco; KLX, Oakland; and PWX, Havana.

On November 1, 1926, the A. T. and T. Company sold WEAF to the newly formed National Broadcasting Company, as the key of its first network. On January 1, of the following year, WJZ and its associated stations went into network operation. Red and blue pencils used by telephone engineers to mark two wire chains furnished to NBC gave them the names they are now known by—WEAF's Red network and WJZ's Blue network. Both of these are now coast-to-coast networks.

At the time of Charles A. Lindbergh's New York-Paris flight in May, 1927, hookups had reached impressive proportions. Fifty stations carried a description of the welcome to him at Washington, while Bell System wires fed the show to loudspeakers at public gatherings in the capital.

On September 18 of that year the United Independent Broadcasting, Inc., the predecessor of the



Columbia Broadcasting System was formed. The following year—in August, 1928—the number of stations wired together for a single program twice passed 100 in connection with notification ceremonies of the two political parties.



It was not long after Bell System telephone service reached Europe that one of the Transatlantic circuits was drafted for a broadcasting program. On September 28, 1929, the Columbia Broadcasting System put on its network a program featuring a talk by Maurice Chevalier, French actor-singer, who was in Paris. This importation began a phase of network service which has since become a daily part of the business.

The fourth coast-to-coast network went into operation on December 29, 1936—that of the Mutual Broadcasting System, whose key stations are WOR New York and WGN Chicago. This company had been operating a regular network since February 1, 1935.

In all of these chains, the coverage of events—sports, politics, music, wars—has increased steadily, and the smallest stations of a chain have had a constantly widening horizon of news and talent from distant points. Among these are many cities on the other side of the world, from which programs have been brought to an American network by a Bell System radiotelephone channel.



