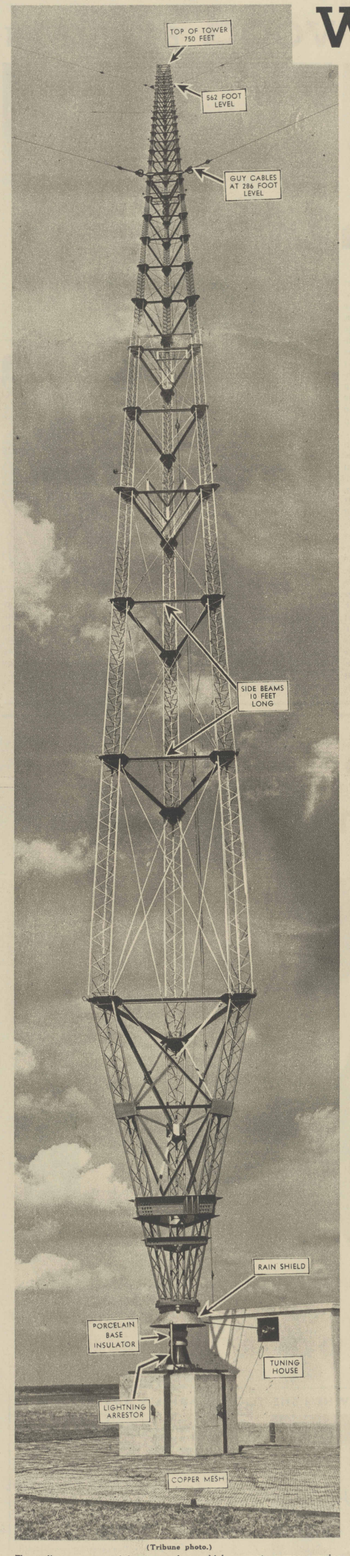
W-G-N—Modern Radio Marvel

A Tour Through the Plant That Makes Possible Your Favorite Program

By LARRY WOLTERS



(Tribune photo.)

The radiator, or transmitting tower, from which emanate waves carrying W-G-N programs. White building is tuning house.

WE TAKE radio for granted. We sit in our living rooms and turn on a switch. We dial a station. If we like the program of the moment we listen. If we are displeased we turn it off. But we don't ask many questions about its magic.

If some one asks, "How does radio really work?" one can, of course, dismiss him lightly by explaining: "As I understand it, sound goes into the microphone, it's sent through the air, and then it comes out of the loud-speaker."

But it isn't as simple as that. No. But some day your curiosity may be piqued. It will be if you chance to drive by W-G-N's lofty new radiator some twenty miles northwestward from Chicago.

Let us say you are bowling along Rohlwing road (route 53) on a Sunday afternoon. Suddenly you behold a tower sweeping skyward. Up. Up. Up. Higher than Tribune Tower. As you draw nearer you realize that it is probably the highest thing you have ever seen. Soaring up 750 feet, this new transmitting tower is the tallest man-made structure in all Chicagoland.

Silhouetted against blue sky and fleecy clouds, it hangs there like a giant needle, suspended, perhaps, from the heavens by an invisible thread. On closer view you find that it actually appears to rest on the earth and that it is kept in position by two sets of guy cables that anchor it to the ground. A beautiful, graceful tower of steel.

As you drive on you may ask, "Why build such a tower?" The answer is progress. And progress in this instance means greater public service. W-G-N is committed, as are all broadcasting stations, to operate "in the public interest, convenience, and necessity." W-G-N meets this responsibility fully.

Since 1935 W-G-N has spent a million dollars to offer listeners the best station in America. Three-quarters of a million dollars went into its new studio quarters. During the last year W-G-N spent an additional quarter million dollars to increase the efficiency of its transmissions and to make its reception the best.

Already much evidence has been accumulated proving that W-G-N's objectives are being realized even more fully than had been expected and that they are meeting a wider public acceptance than ever before. Today no station has a finer signal or greater coverage.

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If you happen to be a Chicagoan you may say that W-G-N's reception has been irreproachable. All you needed to do was to turn to 720 kilocycles and you got what you wanted. True enough.

But there were localities away from Chicago where reception conditions were not all that was desired. Listeners at a distance who sought programs bearing the characteristic stamp of W-G-N were sometimes disappointed.

Radio interference just when the bases are filled is an aggravation. These problems of unfavorable reception long challenged the ingenuity of the technical men of radio. Now they have found a partial solution in the vertical radiator.

The vertical radiator, or transmitting tower, has been found to be much superior to the old twin towers with antenna strung between them. Under the old system the wires drawn between the towers were responsible for the radiation, or dissemination, of the radio waves. The towers themselves in most cases served primarily to support the antenna and only secondarily had any effect on the transmission of program matter. Often special provisions were made to minimize the effect of the towers on the transmission.

The old antenna system used by W-G-N at its Elgin plant was of the "T" type, that is, it consisted of a vertical wire supported by a horizontal conducting member at the top. Its ends were insulated from and supported by two towers spaced 500 feet apart. Each tower was 250 feet high.

A few years ago it was discovered that an ideal antenna would take the form of a giant pole hanging from the sky. Such a position, it was found, would provide for the more effective dissemination of radio waves. But a giant "curtain rod" can't be hung from a cloud. And even if it could, how could one attach the wire carrying the potential speech and music from the studios to it for sending into the sky? So engineers did the next best thing.

They fashioned a tall tower and balanced it on end. This whole tower is electrified from this pin point to its tip. Radio waves fly out at every point and angle along its whole height. The tower itself has taken the place of the old style antenna.

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The new W-G-N radiator, which rises 750 feet above ground, is of the vertical type. Its uniform cross section simulates the effect of a single wire or a cage of wires.

A radio tower is a little like an iceberg. What you see above the surface is only a small portion of the whole. It tells only a fraction of a fascinating story.

In building W-G-N's new transmitter plant many interests had to be considered, many obstacles surmounted, numerous problems solved. Several factors were involved in selecting the site. It is important, for instance, that the subsoil be suited for radio transmission. An ideal location would be a tidal flat where salt water could lap the base of the tower. It is imperative to avoid gravelly or sandy soil. Deposits of ore must be avoided. In this region tests show a good clay (truck garden) subsoil, which cleaves tightly, is the best. The site chosen answers to this specification.

Public safety, convenience, and pleasure had to be remembered. Old receivers and faulty installations in homes sometimes result in interference from nearby transmitters. Thus W-G-N sought a sparsely populated area. It found the most thinly populated area in the county northeast of Roselle. Fewer than 4,000 persons live within a radius of five miles.

Measures to protect the public safety: The radiator is built on a tract of land of 101 acres and at a point a quarter mile from the highway. Even if it were to fall—and that is not anticipated, since it is designed to withstand gales upward of 110 miles an hour—it could topple in any direction without striking the transmitter house or any other structure. The entire tract is adequately fenced to restrict trespassers who might be imperiled by high voltages.

The tower is almost five miles off regular air routes. It cannot be a hazard to air travelers. No radiators may be built exceeding 490 feet in height on or near regular flying lanes.

Radio towers on air routes must be topped by rotating beacons. When located off the regular flying courses flasher beacons are employed to serve as warnings to aircraft.

W-G-N's tower is surmounted by two 500-watt flashers producing alternate luminous periods of one second and darkness of one-half second. Lights of aviation red (a sort of orange red) are inclosed in prismatic globes. From the 650-level downward there are lights at 100-foot intervals. Since the lights have a life of about 2,000 hours, frequent climbs all the way to the top are required by a service man to make replacements.

An electric eye (photo-electric cell) pointing into the north sky atop the transmitter house a thousand feet away automatically assumes the chore of turning on the tower lights when the level of daylight falls below a certain minimum.

The tower is painted with alternate bands of red and white to serve as warning in the daytime. Nothing in the public interest and safety has been forgotten.

Weighing 65 tons (130,000 pounds), the tower is supported by a single pivotal base of porcelain less than a foot in diameter. From this "pin point" base the shaft spreads out into an equilateral triangle ten feet on a side, and in this shape rises straight upward 750 feet.

The guy cables, also insulated from the tower, are so tightened that they exert a tremendous down pull on the insulator, which can support 900 tons.

A factor exerting a profound influence on the strength of the radiated signal is the ground system installed beneath the tower. From a copper mesh 48 feet square lying directly under the tower 120 lengths of copper strips stretch outward radially 800 feet from the tower like the spokes of a wheel. These strips, one-half inch wide and 1/32 inch thick, are buried eight inches in the ground. More than 18 miles of these strips are used in this underground system.

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These ground wires and tower together form what is called the radiation system. Its counterpart in the home on a smaller scale is the antenna, or aerial, and the ground to which the receiver is connected.

A W-G-N engineer gave this explanation of why a ground system is needed in conjunction with the antenna for good signals:

"To establish an electrical current in the tower a ground is needed.

"The current established in the tower is responsible for the signal. But the ground system is required for establishing the current. The ground system does no radiating; the tower does that."

The new type of radiating system is used because its form and dimensions have been found to produce greatly superior transmissions to those previously employed.

With the new type of antenna as a radiating element it is possible to produce a discrimination in favor of waves transmitted horizontally along the ground as compared to those sent angling skyward. This is important. This discrimination enables the station to increase and expand its "primary service area." (There is also a "secondary service area," which will be touched upon later.)

With the new antenna a concentration of radio energy in the space just above the earth's surface occurs, and a corresponding reduction of energy sent skyward results. This concentration is desired because it is this part of the radio wave which is used to serve territory within 300 to 400 miles of the station by daytime.

Beyond this distance the radio wave just above the ground (called ground wave by the radio engineering fraternity) becomes too weak and is no longer useful.

Anything that can be done to increase the strength of this signal will increase correspondingly the primary service area.

That the new radiating system has reached out farther is evident from reports of improved reception from every direction, particularly from Michigan, Iowa, Wisconsin, and, of course, Illinois.

Strengthening of the ground wave has improved reception to points 400 miles or more away. The signal strength has been raised about 40 per cent and the primary service area substantially increased.

The night time transmissions also are improved by the new radiating system. To understand how, it is necessary to become acquainted with a phenomenon known to scientists as the Kennelly-Heaviside layer. This "layer" consists actually of many strata of gases one above the other up in the "ionosphere" which surrounds the earth like the stratosphere does. The Kennelly-Heaviside layer, named for its co-discoverers, varies in height from 60 to 200 miles.

Radio signals sent upward from the antenna at night are reflected back to earth at varying angles from these layers. A portion of the wave reflected back to earth is directly responsible for long-distance reception. This distant area lying beyond the primary service area is called the secondary service area.

In this area radio service is received almost entirely from the wave reflected from the upper atmosphere—from the sky wave—because the ground wave at this distance has been absorbed.

The distant reception is provided by that portion of the wave reflected back at low angles (see diagram for clarity). So this portion of the wave is desirable. But signals are radiated also from the antenna skyward at high, or steep, angles. These cause trouble. They come bouncing back to earth where the ground wave still has a useful value. (Radio waves bounce back from the atmosphere much like a handball thrown against a wall. If thrown directly at the wall the ball returns almost to the spot from whence it was thrown. If thrown at angles it will return at varying distances. The greater the angle the greater the distance.)

When a high-angle signal is reflected back to earth at a point where the ground wave still has strength we have in effect at this point two signals. The reflected sky wave at this point will interfere with the ground wave. This causes the undesirable phenomenon known to every listener as fading.

The fading effect may be compared to the reverberations or echoes noted in a large, bare auditorium. Reflections of a speaker's voice may make his words unintelligible in certain parts of the hall.

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This radio interference will be most destructive at points where the two signals (ground and sky) are of nearly equal value. The affected area exists at the outer boundary of the primary service area.

Clearly, then, at night an undesirable condition exists. This must be minimized or rectified if possible. That is exactly what the new W-G-N radiating system attempts to do—to push the fadeout area outward from the transmitting station.

By reducing the signal sent skyward at high angles and increasing the signal sent out directly above the earth at low angles the fading area is reduced and the area served by the ground wave augmented.

The new radiating system has demonstrated that it has accomplished these results—expanding the primary service area, while maintaining coast-to-coast reception (secondary service area) with a minimum of fading area.

In the above discussion terms such as "along the ground," "into the sky," "ground wave," and "sky wave" have been used. However, these are descriptive only. It should be remembered that radio waves, in common with other electromagnetic waves, including light, require no material medium for transmitting or carrying them.

They appear to travel through empty space. The inability to understand the propagation of these waves without requiring a material medium led scientists to postulate an "ether" or "all-pervading medium." But the existence of such an "ether" has never been affirmed.

Much more than a new radiating tower is required to provide superior W-G-N service. Behind the tower is the new transmitter house, where the radio programs, or their electrical equivalents, are made ready for sending out. Beyond the transmitter house are power lines for bringing the tremendous voltages required in a modern radio plant, the special telephone wires that carry the programs from the studio at Tribune Square. And behind the microphone are the performers themselves.

To appreciate the rôle of the

(Continued on page five.)

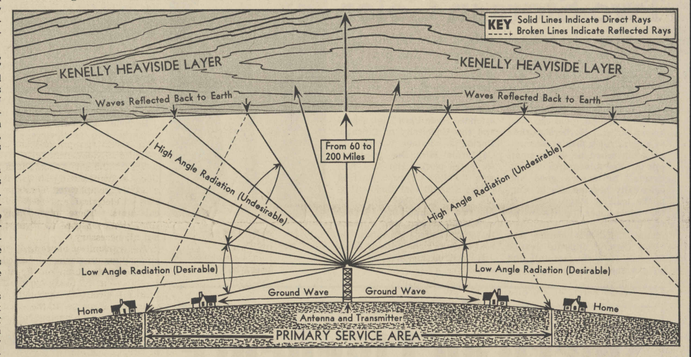
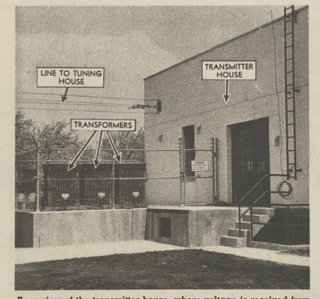
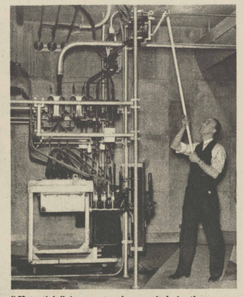


Diagram showing how radio waves are reflected by the Heaviside layer.

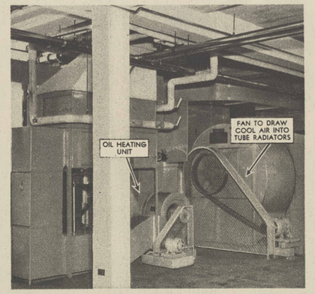
Putting "Voice of the People" on the Air



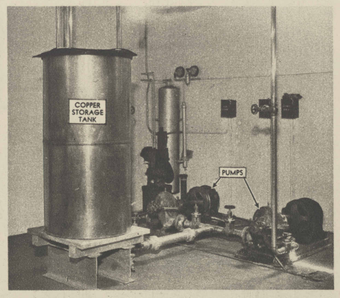
Rear view of the transmitter house, where voltage is received from commercial power substations.



"Hot stick" in use to close switch in the power distribution room. It safeguards the operator.



Heating unit for transmitter house and part of cooling system for tubes used in transmission.



Basement tank storing distilled water, and pumps that circulate it through tube cooling system.

The Story of a Mighty Transmitting Station

(Continued from page four.)

magical new transmitter plant let us start at the beginning:

A pianist, let us say, strikes a note—middle C—in W-G-N's big audience studio. Before the person in the last row has heard it radio will have carried the tone around the world. For radio travels with the speed of light—more than 186,000 miles a second. Sound waves travel just a little over 1,000 feet a second.

For radio, then, it is necessary to combine sound waves with radio waves. A sound wave sets air in motion. The pitch determines the number of vibrations. For middle C it is 256 vibrations a second. For higher notes the number of vibrations would be correspondingly greater.

These vibrations in the air are converted into electrical impulses by the microphone. When middle C is struck the microphone will vibrate 256 times a second. Behind its surface flows electric current. As the microphone responds to the middle C vibrations, so does the electric current.

The microphone converts sound waves into electrical frequencies in exact accordance with those set up by the sound waves.

These vibrations of electrical energy in this form will not carry through space. So they are conducted by telephone wires to the radio transmitter.

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Here these electrical equivalents for sound are built up to tremendous intensities; they are "modulated," or superimposed on radio waves. Finally they are radiated from the transmitter system into space. In the receiving sets of the nation they are reconverted into sound.

All this takes place practically instantaneously. But it is a vastly complicated matter. There is the matter of obtaining a supply of electrical power and preparing it for broadcasting.

Two power lines carry to the W-G-N plant the electricity necessary to operate the many units that are needed. One line carries 33,000 volts from Waukegan to W-G-N's "north" substation. The other carries 12,600 from Maywood to a "south" substation. The first is the regular source of power, the second an alternate or emergency source. These substations are just off the road on the W-G-N site.

The substations contain transformers for reducing the voltages to 2,300 volts. In this state the power is carried by underground cable to the basement of the transmitter house. Here it is metered and distributed.

That portion of the power which is to be used in the transmitter proper must undergo considerable refinement before it is usable. Up to this point it is "raw" alternating current. Before it can be used it must be changed into "pure" or "unipotential" current. This refinement is made in a unit called a rectifier.

Then the rectified current is passed through a filter. Here final traces of "ripple" are removed. If this were not done the radio or carrier wave would produce an annoying hum in home receivers.

The current is now ready for use in modulation. Modulation, you remember, is the coupling of the signals, or sounds from the studio, with the radio wave or carrier. A carrier wave is just about what it says. Like a horse, it carries a "rider," the rider in this case being the middle C note that has been sent out to the transmitter from the studio. This "load" is brought from the studio through special telephone wires.

The signals from the studio encounter the modulator, which unites them with the radio waves, created by a crystal oscillator. The loaded carrier must operate in a given pathway. That is the station's frequency. W-G-N is assigned to 720 kilocycles. Each station must stay exactly on its pathway of frequency. In the transmitter house are instruments to check on its adherence to the channel on which it is licensed to operate.

A cannon cannot be fired without ammunition. That is true of radio waves, too. Before they are ready for projection they must be tremendously strengthened, or amplified. This takes place in the tubes of the transmitter. There are six stages of amplification. Four types of tubes are used. These vary in size. The largest cost $1,650 each.

A whole set of tubes costs around $7,000. A complete set of spares must be kept on hand at all times.

High power in radio transmitters is possible only because of water cooling in the tubes. The tubes are not very efficient. They waste power in the form of heat. Air-cooled tubes of more than 5,000 watts are impractical. But water-cooled tubes of 100,000-watt capacity are practical and in regular use. W-G-N uses two such tubes.

An elaborate water-cooling system is employed to keep the tubes cooled to a safe operating temperature. One hundred gallons of distilled water is pumped through the jackets of the tube system each minute. Some of the heated water is diverted through a ventilating system and provides regular heat for the building in the winter time.

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In describing a process that is exceptionally elaborate it is easy to err on the side of simplification. A transmitting station is a vastly complicated combination of electrical and mechanical units. These play many rôles, some obscure to laymen, but all necessary.

The transmitter house is filled with automatic devices designed to keep a broadcast on the air in the event of many types of failure—electrical, mechanical, or human elements. In the event of the failure of a normal source of power supply a selector switch will employ an auxiliary or emergency line.

Complicated organisms require a nerve center to operate and control them. As may be expected, a modern transmitter has such a coördinating center. It is called the master control desk. In it are located a score or more controls. Many indicators are watched by an operator who sits in a comfortable chair.

Some of the things indicated or controled on its panel are:

Power line voltage and current.

Plate voltages on various transmitter units.

Current in the antenna.

Audio program level going into the transmitter.

Percentage of modulation.

Deviation from the assigned frequency.

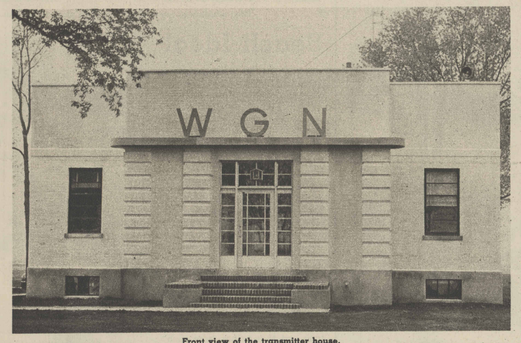
Lights indicate the proper operation of numerous units in the complete transmitter. There are many other controls and indicators—baffling and mystifying to any one but a technical expert. To him they are filled with meaning. They give him control over mighty forces with his finger tips. This type of control makes for greater efficiency in operation, as well as for safety.

A radio station is never unattended. Even when it goes off the air it requires the presence of technicians to care for it.

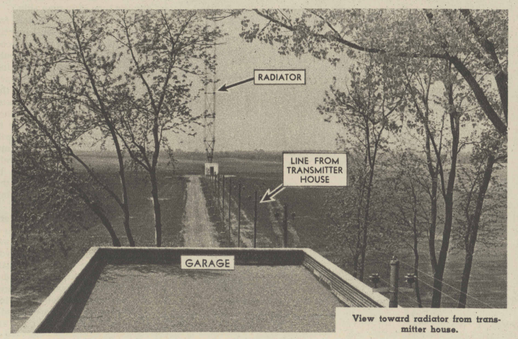
After the radio cargo has been given its last boost in amplification it leaves the transmitter house, whence it is sent by a transmission line to a little cubicle at the base of the insulator called the tuning house. Here it is given one final touch before it is ready to go out on the air.

And then comes the final dramatic step of transmitting, or the flashing of the signals through space.

To capture this electric cargo you must know the roadway it is traveling. In this intance set your dial at 720 and the receiver will do the rest. In a flash middle C will be sounding in your ears. While it took many minutes to read this article, it required only the tiniest part of a second for this note to reach you. Such is the magic of radio.

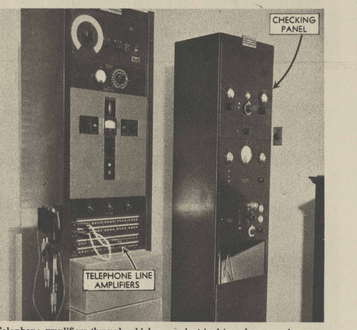


Front view of the transmitter house, in which are located instruments pictured on this page.

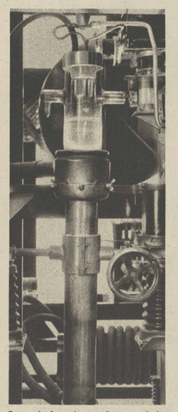


View toward radiator from transmitter house.

W. R. Crane of W-G-N staff at the master control board, where are located automatic devices to maintain continuity of broadcast. This is the nerve center of the transmitter unit.



Telephone amplifiers through which pass electrical impulses carrying program from W-G-N studios. Checking panel is used to keep tab on equipment.



One of the giant tubes used in transmitter and mentioned in connection with picture at right.

Transmitter front panel. Behind doors are giant tubes used to amplify power. (Tribune photos.)