Receiving Television Signals at Ultra Short Waves

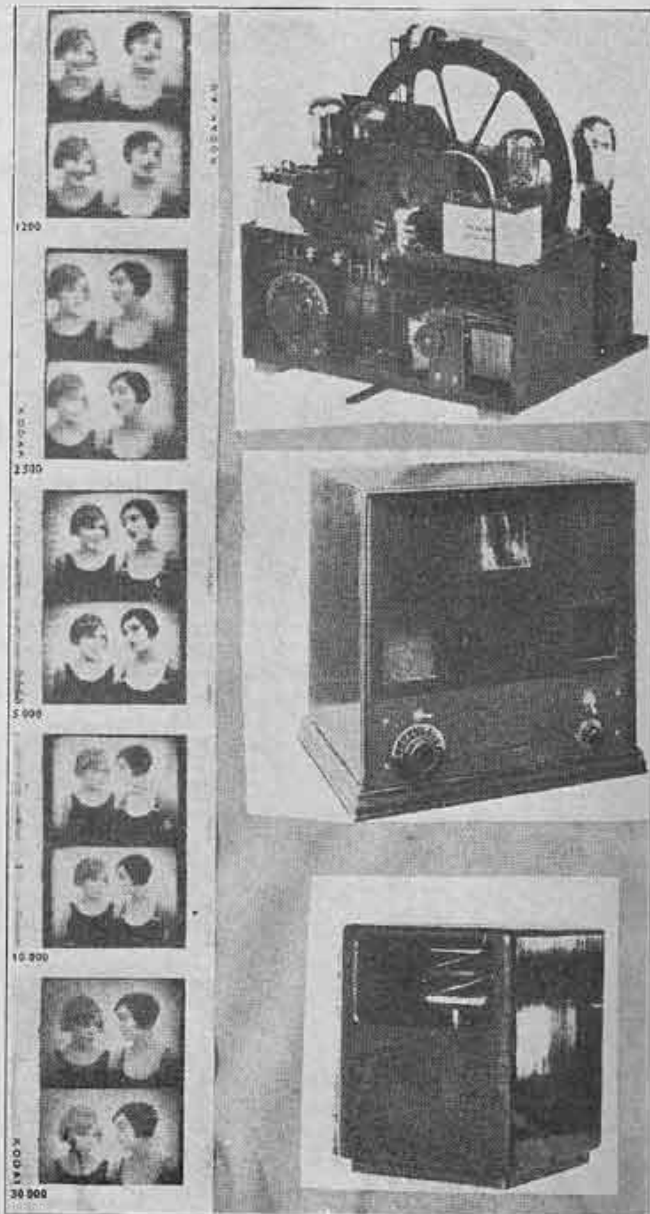
Empire State Building

TELEVISION has moved to ultra short waves from pure necessity. The channel occupied by one reasonably good picture is so wide that operation anywhere else is out of the question; kilocycles are too scarce in the standard wave region. The photographs show this point clearly.

Having moved to ultra short waves television automatically becomes, for the moment, a local affair serving only a single city area over which signals can be sprayed from an elevated antenna. We now turn to an outstanding example of a single-city television transmitter, namely that in New York City. With modifications the discussion applies to others. The text following is quoted from *Modern Radio*. The German apparatus photographs are due to *Radio World*.

"There is fun to be had from "looking in on" the so-called 5-meter radio talkies from Al's place, officially called the Empire State Building. These radio transmissions lay down a whale of a signal over a wide area, days, nights and Chinese holidays, without any of the usual horrible television fading, and with no very serious shadows behind hills — all of which agrees with amateur 5-meter experience of other years but fits poorly into the "quasi-optical" argument. One can also prophesy that very soon these signals will be heard trans-continentally and trans-oceanically, just as amateur 5-meter signals have been. Even now a California observer has been troubled by hearing a 5-meter station which transmitted some NBC material and then degenerated into "a lot of fool noises" — exactly a description of W2XK when it switches from WEAF to the sound-track of a Micky Mouse film just been fed into the W2XF sight-transmitter. Incidentally, on sunny days, the signal isn't too bad at Hartford, although 90 miles is well into the skipped distance for anything but a very good signal.

All this, plus the good quality of the pictures seen by various "lookers," makes one take Empire State seriously.



German Post Office Foto

At the left, detail of television picture as compared to number of picture points, indicated at lower left of each. At upper right, a German television receiver chassis with neon tube and scanning wheel. Next below the same in its cabinet. At lower right, a cathode ray receiver showing zig-zag path of ray much opened out

Dr. D. McFarlan Moore, who years ago devised glow-discharge tubes containing neon and other gases. The ability of these lamps to follow extremely fast changes in the current supplied to them has made possible some of the best sound-on-film recording, and around them have grown up most of the present television receivers. Will the cathode-ray tube replace them?

Admittedly this is a New York City affair at the moment. Note, however, that the transmissions are from sound-film which is quickly made and transported after an event. Thus the newsreel transmissions may be a prelude to direct-pickup, or else an attack against

Empire State Schedules at Time of Printing

(As observed by Mr. Boyd Phelps)

Sight-channel, W2XF, 6.28 meters or 41 megacycles.

	E. S. T.
Carrier	2:00– 3:00 p.m.
Facsimile (twitterings)	3:00– 4:00 p.m.
Television	5:00– 6:00 p.m.
Silent	6:00– 7:30 p.m.
Television	7:30–10:00 p.m.
Facsimile	10:00–10:30 p.m.

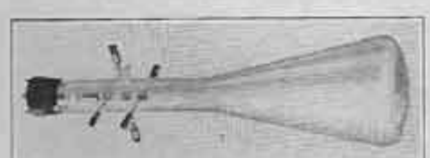
Sound-channel, W2XK, 4.9 meters or 61 megacycles either transmits the sound-film noises to go with W2XF pictures, or else uses NBC material.

Generally both stations are silent on Sundays and holidays, also there are variations in the schedule.

movies. The latter is quite possible, for RCA now has the film sources and through its RKO affiliation has become a rival of the Warner brothers. While wearing Mr. Gernsback's cloak of prophecy one may as well continue and guess that the grandiloquently-named "Radio City" may serve as a point of origin for sight-sound programs to be sent about in film form to cities where experience shows local program sources to be insufficient. Whether the actual film is sent, or some method of instant relaying is devised, is not to be guessed now. The weak spot is that America does not go to the talkies for their own sake — but rather to be going somewhere.

The Transmitter

The transmitter at Empire State is some ways (280 feet?) from the antenna. The transmission line between, after many headaches, appears to be subdued and no longer mangles the pictures. The grapevine telegraph bureau reports that electrical and mechanical scanning have



A cathode-ray tube by Von Ardenne. The picture appears in a spooky blue or green on the round screen at the large end

been used, but normal receivers seem to fit the scanning-order. As to power — one may guess. The license says 5 kilowatts, rumor says 1½ and the signal sounds like 50. The receiver is the main interest anyway.

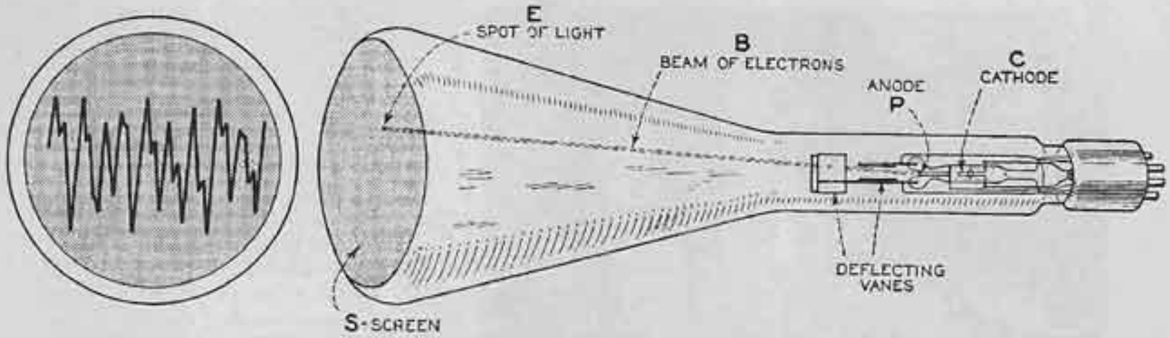
The Receiver

Over most of New York reception with a neon lamp and scanning disc seems possible with no more than a detector followed by two audio stages with the high-quality couplings described in the free circulars of International Resistance Co. The 120 hole disc is not easily made but until commercial ones appear folks are making their own or using the commercial 60-hole two-turn-spiral discs which ruin the picture by cutting it up and shuffling it but allow the parts to remain nearly undamaged and thus permit other problems to be studied. The sound-receiver and sight-receiver are no easy job, but the sight one is vastly the tougher because of the big frequency range. The first rush toward super-regeneration has given way to a variety of double and triple detection receivers with flat intermediate-frequency amplifiers using coupling which combine resistance-capacity with inductance. It is also found that signal-frequency gains are possible with normal screen-grid tubes.

The RCA receivers are reputed to center about a cathode ray tube built in the large Corning Glass envelope, which admits a 9 inch screen, on which appears the picture of ordinary sound-film proportion — height .748, width .878, or about 5 x 6 inches. The auxiliary equipment is discouraging. Merely to produce the electron-jet and center it to produce a bright light-point about 1/16 inch across at the center of the screen requires: low filament voltage, focusing cylinder voltage around 300 (there are other ways) and accelerating disc voltage around 2000. Then the jet must be wiggled one way 24 times per second, and transversely 120 times as fast. The wiggling waves, which are applied to the deflection plates, must be of correct frequency, phase and WAVE FORM — and the form is one tending to raise the deuce in a radio receiver. Accordingly one has assorted plate supplies, two special oscillators with odd wave forms, and a variety of shields and filters. The special oscillators provide only low voltages and must be amplified, or else one must use a two-stage cathode ray tube, first deflecting a low-speed jet and then speeding it up to secure enough impact to make the screen glow brightly. The distortion possibilities are many.

Even now one has but a woven rectangle of light, painted by the wiggling electron jet. Next the jet speed must be modulated in accord with the scene on the distant movie film. This requires superimposing the a.c. output of the receiver on some electrode of the tube, perhaps through a high-mu 100 volt tube with indirectly heated cathode to prevent filament-ripple overlays. (An 841 serves experimentally.)

Again — all speed changes involve a focus change — the dot changes size as well as brilliancy. Additional devices



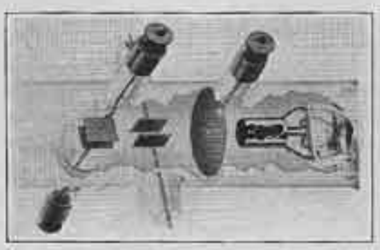
The mechanism of a cathode-ray tube minus the focussing electrode and modulating electrode. At left, wave form shown on screen of tube

— too numerous to describe — are used to combat this. The simplest is a separate metallic coating run at about 3000 volts.

All this machinery, and two radio receivers, easily account for the 24 tubes reported to be used in RCA's experimental sets, and render it likely that they will cost at least the $750 introductory price at which guesses are aimed.

Beginner's Receivers

The beginner will first wish to HEAR the signal. A detector-audio receiver has been suggested, and if built it should base on an a.c. screen-grid tube whose input circuit uses a 1½ inch turn of wire tuned by a .000025 midget vernier-dial driven. The regeneration control is best made as in National's SW-5, in



The vital machinery at the small end. Electrons from the filament focussed by the surrounding tube, are attracted to the accelerating disc and some dive through the central aperture, then between the two pairs of deflection plates to which the deflection-frequency a.c. voltages are connected. The wiggling ray cross-hatches the screen with fluorescent lines, the intensity changing as the jet speed is modulated in accordance with the light seen by the distant electric eye as it stares through the scanning equipment at the movie film

fact one of those receivers is readily modified for the purpose. For sound alone nice work has been done with an HY-7 superheterodyne with the detector tuned circuit cut down and the oscillator run at 3 or 4 times the signal frequency. Naturally the i.f. selectivity spoils the picture. In any case the household antenna can be coupled inductively or conductively, avoiding over-close coupling. Ranges are checked by oscillating the detector and using a General Radio wavemeter in the familiar Judson click-method. Recall, though, that the circuit is detuned greatly with the oscillation control and work near the no-oscillation point.

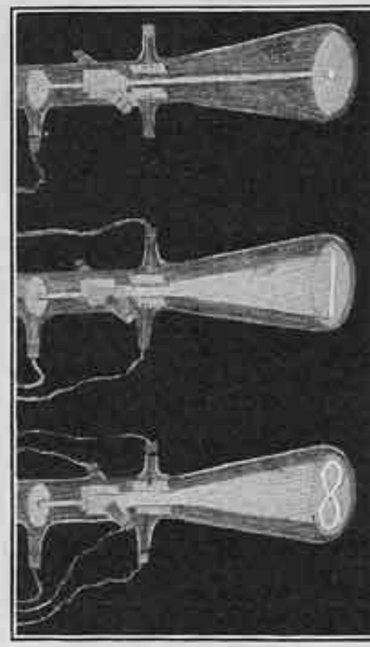
Following Schedule Changes

While RCA will certainly welcome reports from observers, they will probably be unable to advise of all transmission changes, hence the "looker in" should use his ingenuity in following changes of wavelength, picture frequency and number of scan-lines. The following is a method used by Mr. Boyd Phelps with invariable success in quick analysis of television signals. Receivers based on the information gained have invariably worked.

High precision is not needed. The "whine frequency" of the signal is first determined by comparison with any available audio standard — crystal-controlled beat-oscillator as first choice — but ranging on down to the family mandolin or piano. A piano is really a very decent frequency standard. In the case of the Empire State signals the whine is at 2880 cycles, which is the product of scan-lines times pictures-per-second. One might — at great cost in time and $$$$$ — make many discs and

An engineer's nightmare — waveform such as used by cathode ray deflection plates, and noisily resented by nearby radio devices

try all of them at various speeds — but there is a simpler way. One determines the picture-rate directly as follows. A steel strip is clamped in a hand-vise and the free length changed until it seems to stand still when illuminated by a neon lamp driven by the signal to be analyzed. The reed is now in tune with the picture-rate. (The reed used by Mr. Phelps was



CATHODE-RAY TUBES IN ACTION

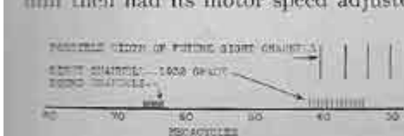
At the top, filament lighted and anode voltage applied, with ray properly focussed and centered.

In the second tube a.c. has been connected to one pair of deflection plates and the ray is swinging up and down, the spot on the screen becoming a line.

In the third tube the timing wave has been connected to the other pair of deflection plates, swinging the ray sidewise. The "figure 8" on the screen shows that the ray is making two sidewise swings for each up-and-down swing, therefore the timing-wave has twice the frequency of the other wave. If the frequency had been the same the picture would be one of those in the first column of the curve sheet following

no more than a Starret 8 inch hacksaw blade.) Now it is necessary to calibrate the reed, which is done by starting with a short length and comparing against the family piano (middle C is 256 per second), using the easily audible beats between piano and reed to adjust the latter by. Below 300 cycles it is better to use piano notes 1, 2 or 3 octaves above the reed which beats easily with such notes as it has strong harmonics. A fairly decent curve is obtained. In Mr. Phelps' work check-points were wanted. The local power system wanders as to frequency, hence a 60 cycle point was obtained by feeding a neon lamp from a radio receiver tuned to an amateur station with a strong plate-supply ripple due to a network known to serve many electric clocks — and therefore probably fairly correct. The reed was adjusted to "stand still" by this lamp, its length measured, and the point marked on the curve.

An amateur movie projector without film then had its motor speed adjusted



Nice fresh puzzle for the Radio Commission — the allocation of sight-sound channels in pairs

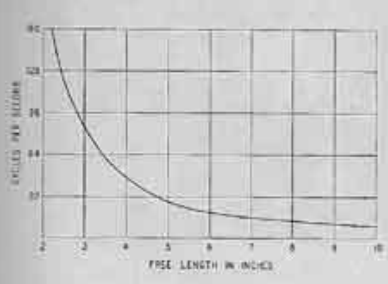
so that when aimed at the motor disc its flickering light caused 2, 3 and 4 spokes to appear — corresponding to 30, 20 and 15 shutter-openings per second. In each case the reed was held in the flickering beam and the length adjusted for "standstill" — the motor speed being meanwhile checked against the distant station's neon light. The points all fell neatly on the original curve.

In the case of the Empire State transmissions 24 came out as the picture rate and 2880/24 is the scan-line number of 120.

If such a measurement as this gives outrageous results such as 120.3 lines, there should be no difficulty in the mind of anyone able to unravel amateur radiograms, or listen to shortwave broadcasting with enjoyment."

The Cathode Ray Tube in Action

If the experimenter wishes to use a cathode-ray tube he must learn the technic of that device to some extent. It obviously cannot be set down here and the following is offered merely as a preliminary explanation of the fashion in which the ray follows the voltages fed to the tube. This should simplify the understanding of its use in television.

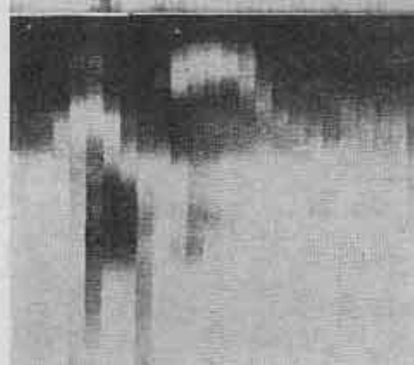


Calibration of the hacksaw frequency meter

Something for the future to aim at. To transmit such pictures at the minimum required rate of 16 per second will take about 8,000,000 pulses or 4,000,000 cycles per second. This is about 400 broadcasting channels or everything from 545 meters down to 66 meters! The pictures have 250,000 "elements" each. The amplifiers must handle all frequencies from 16 cycles to 4,000,000!

An "88-hole" picture with about 6,250 elements. If sent at the rate of 16 per second this requires 10 broadcasting channels; if sent at the rate of 20 per second it requires 12½ channels. The amplifiers must handle frequencies from 16 to 100,000 cycles in the first case and from 20 to 125,000 cycles in the second

If only two ordinary broadcasting channels are to be used one can send 16 such pictures per second, each having 1,250 "elements." This corresponds approximately to the "48-hole pictures," lately considered standard



To get television into a single broadcast channel one would need to tolerate such things as this, even when sending but 16 pictures per second

1. Sensitivity: An average tube requires a potential of about 45 volts to swing the spot across the screen. For many tests it is desirable to do this with less voltage, to eliminate the need for amplifiers.

2. Brilliance: Brilliance is mainly due to the type of fluorescent salt used as screen coating and to the anode voltage.

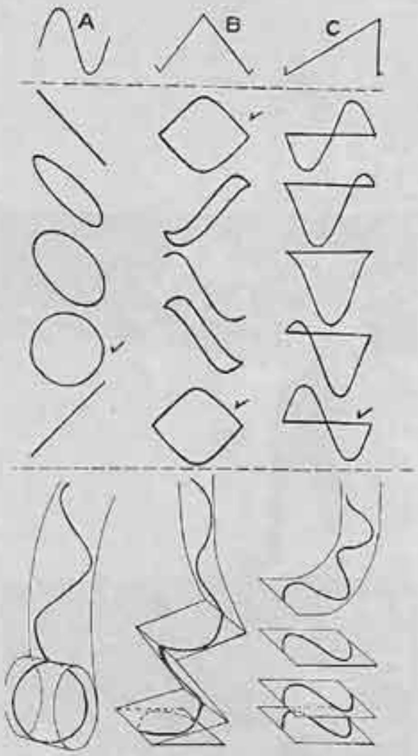
3. Accuracy: The movement of the spot should be directly proportional to the applied voltages to the deflection slates, at any portion of the screen, and for any frequency.

4. Life: The life of a tube depends (with most designs) on the active life of the cathode.

5. Focussing: In many tubes this can be done with an accurate adjustment of the filament current and anode potential. In other tubes an auxiliary electrode is provided for this purpose.

Timing

In the ordinary vibrating-mirror oscilloscope or oscillograph, a time scale is produced by a synchronous motor



Effect of different timing-waves. If sine-wave a.c. is connected to one pair of the tube's deflection plates the curves shown in each column can be produced by connecting to the other pair a timing wave of the same frequency, and of the shape shown above the dashed line.

A is a sine-wave and produced the "rolled up" effect (see text).

B is a saw-tooth wave and gives the zig-zag folding (see text).

C is a snap-back wave and produces the cut-and-pile effect, with the straight snap-back line added.

A and C are the most useful.

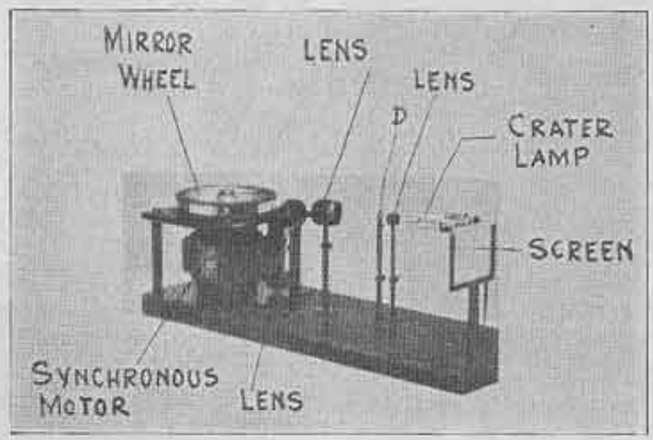
The mechanical equivalent of each folding method is shown at the bottom of the column.

driving a rotating mirror. In the cathode-ray tube many tests are made with the wave-to-be-investigated applied to one pair of deflection plates (see illustrations) while a "timing wave" of known wave-form is applied to the other pair of deflection plates. In any oscilloscope the effect of a timing device is to show on the same screen successive sections of the curve produced by the voltage (or voltages) being investigated.

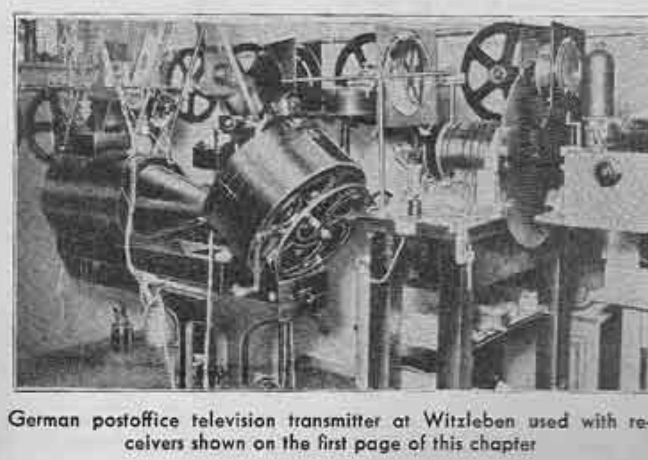
Imagine that this curve is somehow marked or printed on a long transparent film — the length of course being due to TIME. If this long picture is to be gotten into the limited area of the oscilloscope screen, several possible schemes occur to condense it. One method would be (A) to wrap the film around and around a glass cylinder, and then to look through the whole thing in that form. Another way (B) is to hold it up into a zig-zag by creasing at regular intervals — whereby every second section is reversed as to direction in the finished pile. A third scheme would be to (C) cut the film into short sections and pile them all up.

In the cathode-ray tube we do not have a long film, but we do have a curve which is ELECTRICALLY folded so as to get all parts on the screen. The folding is done automatically by the timing oscillator as already suggested and it is such an action which permits the ray to paint many pictures per second on the television screen.

A portable cathode-ray oscilloscope with power supply. The potentiometer at the left controls the potential on the anode, to make the tube more brilliant (right) or more sensitive (left). The right-hand knob controls the focussing field



A simple form of "projection" televisor. The neon crater lamp is a strong point-source (almost) of light modulated in accord with the received signal. Its flickering light passes thru the lenses and diaphragm to the mirror-wheel which cause the light-pencil to wipe across the screen once for the passage of each of the mirror-faces. Each mirror has a slightly different tilt so that successive trips of the light-pencil fall at different heights on the screen, corresponding to the successive scan-lines, just as do the holes of the ordinary spirally-pierced Nipkow disc. The advantage is in the greater optical efficiency and in the smaller size of the rotating member



German postoffice television transmitter at Witzleben used with receivers shown on the first page of this chapter