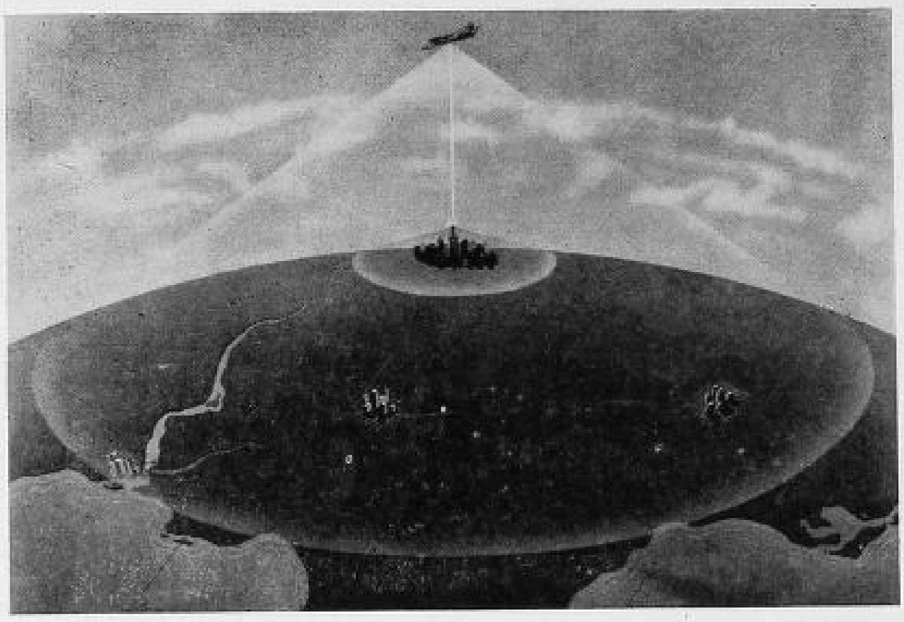


Antennas 6 miles aloft blanket nation with television, FM. Key to Westinghouse Stratovision is airplane operation. Reason is that the radio waves which carry these services do not travel beyond the horizon as do those of standard-band radio. This means that television and FM programs are available only in a direct line from their transmitters.

Pictured here is a ground station with its coverage radius of about 50 miles indicated by the small circle. Large circle shows how coverage is increased when programs from the same ground station are "beamed" to an airplane flying at 30,000 feet and broadcast from that altitude. Large circle covers about 103,000 square miles lying within a radius of 211 miles.

The Stratovision System for Television, FM

By *C. E. NOBLES*

INDUSTRIAL ELECTRONICS DIV., WESTINGHOUSE ELECTRIC CORP.

ALTHOUGH television has been developed to a technical degree that allows the broadcasting of good pictures over short distances, and although it is possible to broadcast a picture which is very good, even in full color, several sizeable stumbling blocks must be hurdled before it is possible to realize a national television coverage approximating present-day standard broadcasting coverages. By telecasting from airplanes cruising 30,000 feet above the earth, most of these problems can be overcome.

Television and frequency modulation broadcast waves arrive at receivers in a manner different from the way standard and international short waves arrive at receivers. Unfortunately for television and frequency modulation, this results in a limitation of the range possible for these services.

In standard broadcasting and short-wave broadcasting, the signal at a receiver is composed of a "ground wave" which follows the earth's curvature and a "sky wave." At the relatively low frequencies used for these types of broadcasting the ground wave bends in such a way as to follow the earth's curvature. Also, at these low frequencies, a highly ionized layer, called the Heaviside layer, which is about 100 miles above the earth's surface, reflects the "sky wave" and sends it back to the earth's surface. It can be seen that the receiving antenna may be far below the horizon with respect to the transmitter and still receive both ground and sky wave signals.

"Line-of-Sight" Problem

In ultra-high frequency broadcasting, involving very high frequencies, the "ground wave" does not curve appreciably to follow the earth's curvature nor does the Heaviside layer bend the sky wave back toward the earth.

This means that a receiving antenna located below the horizon from the transmitting antenna receives no signal either from the ground wave or the sky wave. When the receiver is within line-of-sight distance to the transmitter, however, it receives a "directly transmitted wave" and a "ground reflected wave" from the transmitter. Television and FM broadcasting are, therefore, limited to "line-of-sight" distances.

These two waves—the direct wave and the ground-reflected wave—tend to cancel each other at the receiver. If they traveled over identical path lengths they would cancel each other and no signal would be heard at the receiver. The receiver gets its signal by virtue of the fact that the paths traveled by the direct wave and the reflected wave are different.

Generally speaking, anything we can do to increase this path difference will result in a greater signal at the receiver.

Line-of-sight distances between the transmitting and receiving antennas may be increased by raising the height of either antenna. It would be economically impractical to raise thousands of receiving antennas, but the transmitting antenna can be raised to take advantage of an increased distance to the horizon. Many FM and television broadcasters are planning to locate their transmitters and transmitting antennas on tall buildings or high hills in order that their service areas may be increased.

The Stratovision system for broadcasting television and FM programs was originated by C. E. Nobles, 27-year-old Westinghouse engineer and was further developed by the Westinghouse Electric Corp. in cooperation with the Glenn L. Martin Co., pioneer aircraft designers and builders. The accompanying article by the brilliant young originator of Stratovision describes in detail the underlying reasons for the development of the system and includes detailed information as to its operation, including notes on plane design and consideration of weather as an operations factor. Highly competent engineers hold that the Stratovision system is not only wholly feasible but in the present state of the transmitting art offers the most promising method for the speedy attainment of the goal of network transmission of television.

The average service radius of high-powered television and FM stations with fortunate antenna locations is about 50 miles. At the present state of the art, because of very difficult tube problems at high frequencies and wide band widths, there is no very satsifactory way of obtaining the radio frequency power required to cover a service radius of even 50 miles. This is especially true of the higher frequency, high-definition color television. At the present time color television powers of the order of five kilowatts can be developed, whereas about 50 kilowatts will be required to properly serve a 50-mile radius from, say, the Chrysler Building in New York City.

Present Range Restricted

Because any television transmitter has a range which is relatively small and because the cost of producing a television program which will hold an audience's attention is very high, it becomes necessary to distribute a program to a good many transmitters so that the program cost may be distributed over a great number of listeners. It is anticipated that there will be two main television programming centers located in Hollywood and New York City, where shows will be originated and fed into a network of television broadcasting stations all over the country. This is an arrangement much similar to the present broadcast network set-up.

The distribution of standard broadcast programs to the various broadcasters is a very simple process compared with the nationwide distribution of television programs. Existing telephone lines are inadequate because of the bandwidth required to transmit a television program.

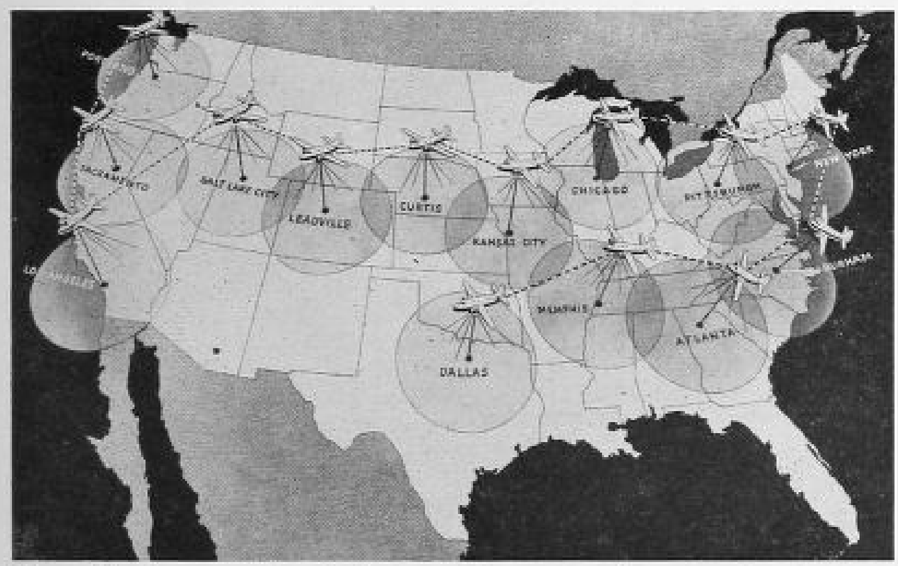
Two methods are being used to distribute television programs, namely coaxial cables and radio relay stations.

Coaxial cables have been installed and used to distribute television programs. Published information indicates that by approximately 1950 it is intended to complete a cross-country link from Boston to San Francisco and make it available for the distribution of television programs to television broadcasters. These cables at the present time will not transmit the definition required by black-and-white television standards and are very much inadequate for high-definition color television.

The construction cost alone for laying this cable is about $3 per foot, thus the proposed route will cost approximately $100,000,000.

Relay-Link Needs 100 Towers

The other approach to the program distribution problem is a series of radio relay stations which use highly directional radio for relaying the program from one point to another. A typical installation in a relay-link chain consists of a tower approximately 300 feet high with a receiver to receive the program from one tower and a transmitter to relay the program to the next successive tower in the chain. Because of the line-of-sight characteristics of the frequencies involved in this relaying, relay towers will be located approximately 35 miles apart. This means that 100 relay towers would be required to get a program tie-up from New York to Hollywood.



Geographical coverage plotted for Stratovision system. Programs for the system would be originated in ground studios and "beamed" (solid lines), as in military radar, to planes for broadcast. Similarly "beamed" plane-to-plane connections (dotted lines) would form a nationwide network. Each plane would receive and broadcast 9 simultaneously available programs throughout a 103,000-square-mile area within its 422-mile line-of-sight diameter (shaded circles).

Broadcast locations shown would provide coverage for 78% of the nation's population; 100% coverage merely would require more airplanes.

Such a system of relay stations is now in operation connecting Washington, Philadelphia, New York and Schenectady. Plans have been published to install and operate a chain of relay stations which will network the country.

Either of these systems—coaxial or radio relays—has the disadvantage that large quantities of expensive equipment are necessary to distribute the program, and that any city desiring a network tie-in must bear the added expense of cable or radio relay connections to the main route.

The operation of relay or cable networks presents very sizeable technical problems because of the number of times the program must be handled. At each relay station additional distortions are added to the picture in the form of noise, phase distortion, and amplitude distortion. Unfortunately the resulting picture degradation increases very greatly as the program is handled more and more times.

This means that a very good picture might be put into a network at New York, and gradually become worse until it arrives at Hollywood almost completely unrecognizable. The size of this technical problem is such that it is doubtful if a "good" picture will not be transmitted from New York to Hollywood by this system for many years to come.

A great many of all of the aforementioned difficulties, both in broadcasting and program distribution, could be eliminated if a greater service range could be had from a television station and if relaying stations did not have to be so close together.

It is obvious that if one station had sufficient broadcast range to cover the nation, there would be no necessity for relaying and that if broadcasting stations had smaller service areas, there would be need for more relaying. It is axiomatic, therefore, that the service area covered by a broadcast station and the amount of relaying necessary to give nationwide television are inversely related.

Airborne Transmitters

It is technically possible to realize relatively enormous service coverage for television and FM broadcast transmitters and at the same time increase radio relay spacings enormously by departing from past broadcast practices.

If a television transmitter were placed in an airplane and the television program broadcast from the airplane in flight, the transmitter's coverage area would be increased by virtue of an increased line-of-sight distance to the horizon. At an altitude of 2,000 feet, a

(Continued on page 34)

STRATOVISION

(Continued from page 17)

coverage radius of 50 miles is possible, whereas at an altitude of 30,000 feet a coverage radius of 211 miles is possible, and at 50,000 feet about 300 miles is possible.

Another very interesting feature of high-altitude operation is the fact that as the station's height is increased, the transmitted power necessary to deliver a usable signal to the line-of-sight distance is sharply reduced.

Fifty kilowatts of power will deliver a usable signal at approximately 50 miles from a ground station, whereas only one kilowatt of power will deliver the same usable signal at approximately 200 miles from 30,000 feet. Smaller powers are required from the higher altitudes because the path difference between the direct wave and the ground-reflected wave is increased.

The fact that such small powers are required from high altitudes is very inviting for several reasons:

1. The broadcast service area covered is relatively tremendous.

2. The smaller-powered transmitters can be made in sizes and weights which are practical from the standpoint of carrying them in an airplane.

3. Powers of the order of one kilowatt can be generated with tubes which are available today—even for the CBS high-definition color television frequencies.

4. The small amount of power required to operate the transmitter can be obtained from power plants installed in the airplane. If so desired, the power required to operate the equipment could be taken from generators connected to the aircraft's engines. This power will represent only about four per cent additional load on the plane's engines.

If we transmit from one plane to the next plane in the chain, the line-of-sight distance between the two planes is about 400 miles instead of the 35-mile spacing for ground stations. With such large relay spacings a program link from Hollywood to New York is obtainable with only eight airplanes as compared with 100 relay points on the ground.

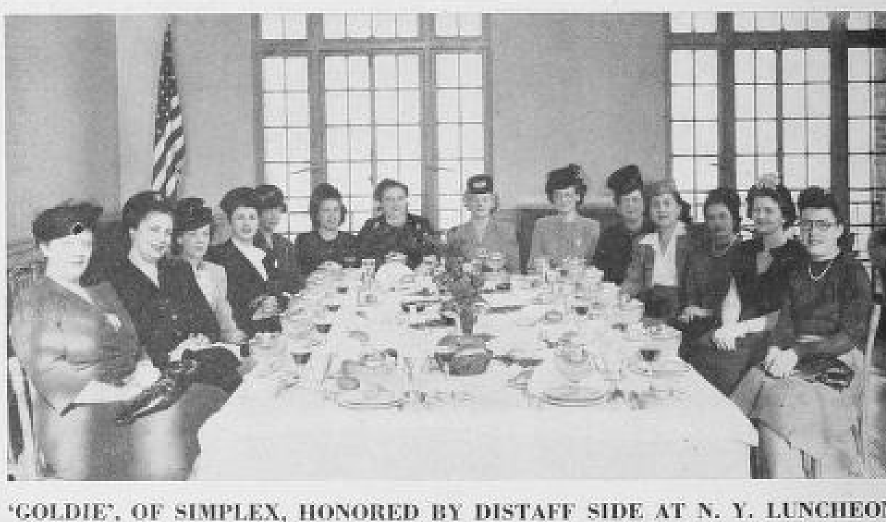
This greatly reduces the technical problems involved by virtue of requiring fewer handlings of the program. With directional antennas and utilizing relay frequencies on the order of 2,000 megacycles, this relaying can be done between airplanes with powers of less than one watt. Tubes readily are available which will generate powers of 5 watts in this frequency range.

These relay stations could be designed to carry several television programs and also an abundance of other information such as FM network programs, facsimile, motion picture theatre television, etc.

Because the broadcasting service area and relay spacings increase with altitude and the power required to service the broadcasting area comes down as altitude is increased, it is desirable from a standpoint of radio operation alone to operate the plane at as high an altitude as possible.

The altitude of operation of the system is limited by the economic and technical problems involved in operating planes at extreme altitudes. A study of the overall combination of radio and airplane operation indicates that an operating altitude between 30,000 feet and 50,000 feet provides a good compromise.

(TO BE CONTINUED)



'GOLDIE', OF SIMPLEX, HONORED BY DISTAFF SIDE AT N. Y. LUNCHEON
Technically smart and super-efficient ladies of the industry's technical branch recently threw a luncheon party for Dora Goldman, secretary extraordinary for many years to high officials of International Projector Corp. Pictured above (l-r) are: Florence O'Neill, National Theatre Supply; Ruth Entracht, International Projectionist; Betty Connolly, Warner Bros.; Toby Roth, Prudential Circuit; Elizabeth White, RKO; Frances Tannenbaum, RKO; Evelyn Gang, I.A. Local 306; Miss Goldman; Lee Schindler, Century Circuit; Clara Schmitt, N.T.S. Co.; Lillian Perlman, Paramount; Lillian Morgan, Loew's, Inc.; Veronica Stock, Loew's Inc., and Margaret Marayno, Local 306. (P.S.: They found time to eat, too.)