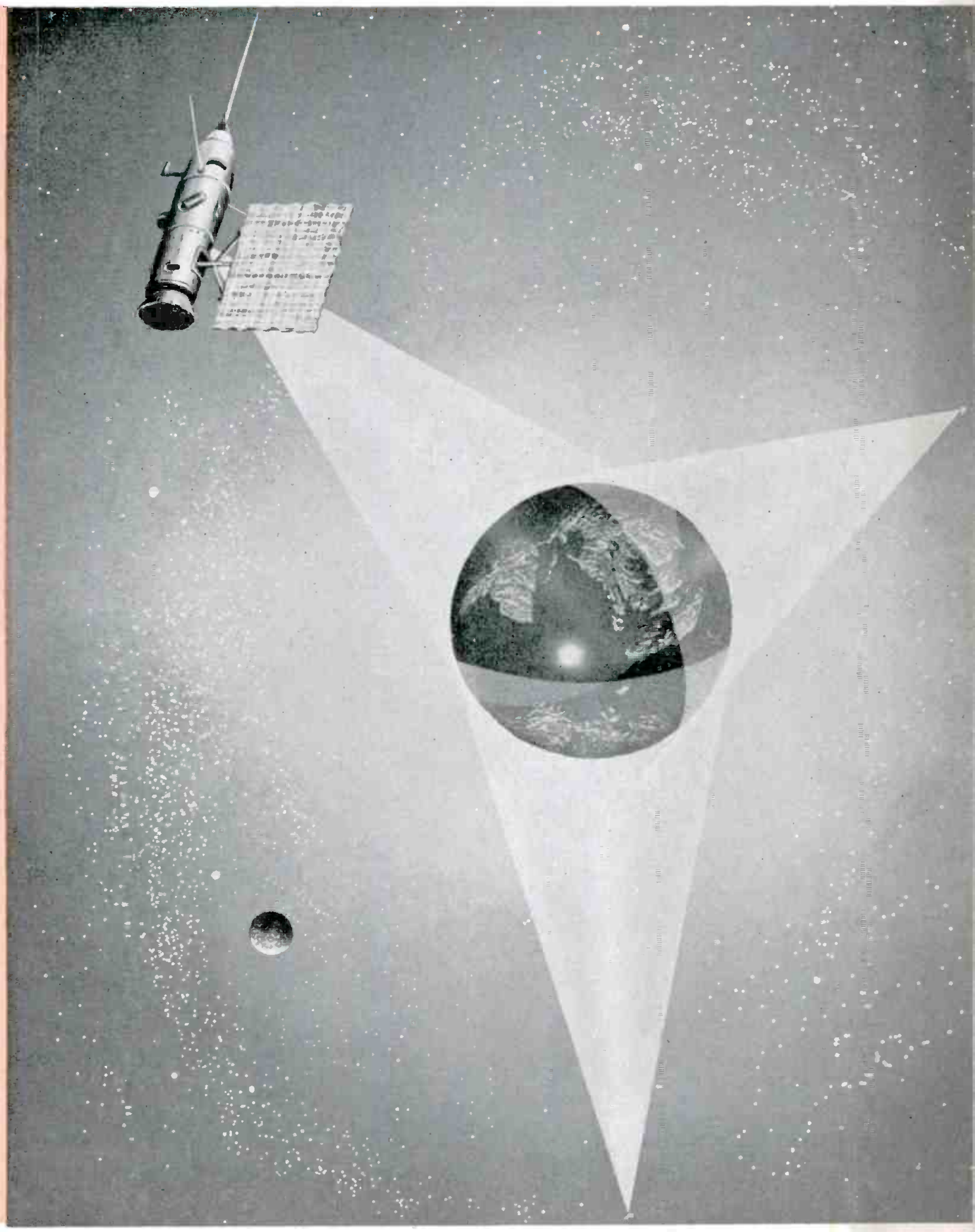
AUGUST 1959

Covering all phases of . . . AM FM TV

BROADCAST ENGINEERING

THE TECHNICAL JOURNAL OF THE BROADCAST INDUSTRY



In this issue . . .

A K G

FOR TV, FILM AND BROADCASTING

STUDIO

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BROADCAST ENGINEERING

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DEPARTMENTS

Editor and Publisher — D. E. Mehl

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COVER

The entire earth can be covered by three satellites to provide world-wide television facilities. This and other developments are described in the article "World-Wide Television" in this month's issue.

Sounding Board

Editor:

Please let me congratulate you on your fine magazine. I have thoroughly enjoyed the issues which have been received and am looking forward to future issues.

Here is a list of articles that I would like to read which would be a good review and contribute to better standardization and understanding:

Setup of a Vidicon Camera for Film and Slide Use.

Stabilizing Amplifiers—Their Purpose and How They Work.

Common Troubles in Sync Generators.

What to Watch for in Microwave Studio Transmitter Links

Proper Method of Pulse Width Measurements.

Maintenance of Video Switching Relays.

Standard Audio and Video Levels with Respect to Telephone and Studio Facilities. (What is the proper level to feed an audio STL using telephone facilities? What are the recommended video levels throughout the studio and what levels should be fed the STL? What audio level can be expected from telephone lines that are equalized?)

Pre-Sign-On Equipment Checks Utilizing Tone and Test Pattern.

Frequency Response Tests of Turntable Pickups, Amplifiers and Over-all Frequency Response Measurements.

A. P. Young

Editor:

Would like to see articles on CONELRAD reception methods, and transmitter conversion for CONELRAD operation.

Joseph M. McClain
WASK
Lafayette, Indiana

Editor:

Would like to see more technical articles on video tape and vidicon live and film chain cameras.

Lawrence D. Curtis
WNHC-TV
Hartford, Connecticut

Editor:

I have received the first two issues of Broadcast Engineering and I find them most interesting and educational. This is the magazine the broadcast field has been looking for for many years.

First, let me say the articles are of utmost importance and up to date, especially your idea of keeping them short and to the point for people today don't have the time to read lengthy articles. Please keep them varied as you have in these first two issues.

I noticed and read the comments concerning publishing of the FCC Regulations and I disagree that it is a waste of space. When does the average technician in this business today have the time to read the regulations in their entirety, other than in the short form such as you are presenting? This is a real opportunity for everyone to read, review and familiarize himself with the rules and regulations. Keep them coming, I think the average reader will appreciate your idea and efforts.

The very best of luck and may your circulation continue to grow and keep on growing.

Raymond Murphy
Studio Operations Supervisor
WFLA Radio and TV
Tampa, Florida

Editor:

Long life to Broadcast Engineering!

This letter is written in appreciation: (1) Generally, for the whole magazine, and (2), particularly, for der Snikrah's article "Are You a Dibber?" in the July issue. The latter we found humorous in the highest degree. We're constrained to say, however, that somebawdy musta been peekin' . . .

If you ultimately are forced to print up re-runs of the article, please bear us in mind.

More power to you folks.

Mike Lamson
WRKD
Rockland, Maine

Editor's Note: *Articles on the subjects mentioned by our readers and other subjects pertaining to broadcast engineering will be welcomed.*

COMPATIBLE SINGLE SIDEBAND FOR AM BROADCASTERS

By

RAYMOND D. SCHNEIDER*

A FORM of single sideband modulation has been developed for use in the standard broadcast band. The system, called Compatible Single Sideband (CSSB), is a result of the work of Leonard R. Kahn through the Kahn Research Laboratories.[1] The system is said to be "compatible" in the sense that existing broadcast receivers are suitable for reproducing the signals. While single sideband (SSB) has been widely accepted for communications use, such use has of necessity involved special single sideband receivers. The Kahn Compatible System is now being field tested to determine its capabilities.

Our purpose here is to show the general operation of the CSSB system. The description of CSSB will be preceded by a review of the familiar methods of amplitude modulation.

Figures 1† and 2 are examples of a double sideband (DSB) signal. Note that the carrier is not changed by the process of modulation. Only the sidebands are changed. The frequencies of the sidebands are fixed by the frequency of the modulating signal, while their magnitudes are fixed by the modulating signal's magnitude.

To this point we have considered only single tone modulation. A non-sinusoidal modulation would produce an upper and lower sideband component for each of its Fourier parts.

For the process of detection we can again look at the system from two viewpoints. First, we can think of the total transmitted signal as a unit—that is, as a varying R.F. envelope as in Figure 1. When this envelope is applied to a detector (half-wave rectifier) the modulation information will be recovered. We can also look at the detection process from the sideband component point of view. Here the sidebands are

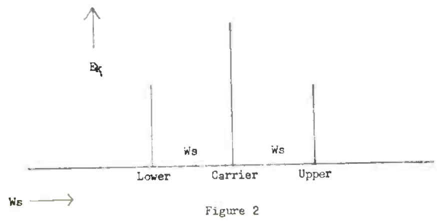

Figure 2

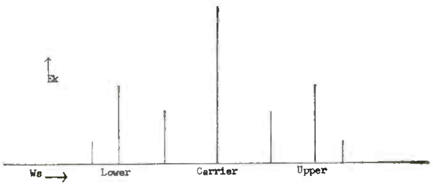

Figure 3

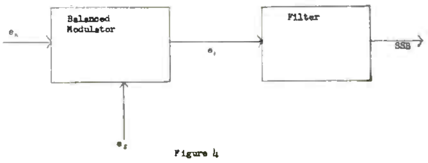

Figure 4

*Chief engineer, WIRL, 121 N. E. Jefferson, Peoria, Illinois.
†Figure 1 omitted.

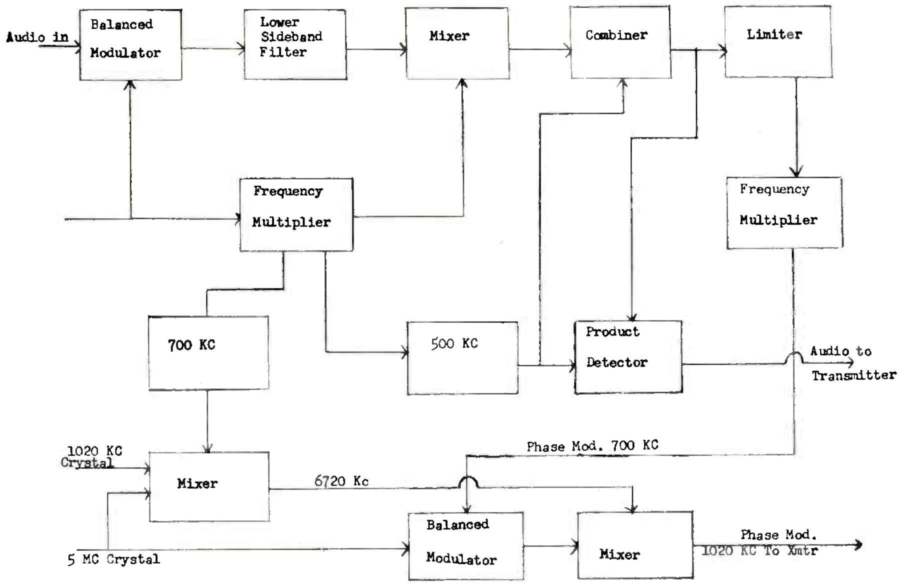

Figure 6

Block diagram of Kahn CSSB Adaptor.

combined in a non-linear unit (the same detector as above) and the intermodulation frequencies produced are the original modulating frequencies. The second viewpoint makes it somewhat easier to study the single sideband systems to come.

Assume that a typical DSB spectrum containing several modulating components of variable amplitude is shown in Figure 3.

In order for undistorted information to be recovered from this transmitted signal, the phase and amplitudes of each of the sidebands and the carrier must be retained. Long distance transmission (especially when such transmission depends on ionosphere reflection) often destroys the sideband-carrier relationships. The carrier or other components may be individually attenuated or changed in phase. This effect is called selective fading. It results in severe distortion of the detected signal. Single sideband will materially reduce the effects of selective fading.

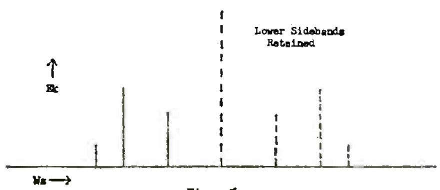

Figure 5

To obtain a single sideband signal the modulation process must be revised. Let e_k and e_s be fed into a unit that will multiply them. This unit is called a balanced modulator.

This signal is the same as the DSB signal except that the carrier component has not been produced. We can further process the signal by merely applying it to a filter which rejects one of the sidebands. Under this process, the same modulating frequencies that produced the DSB spectrum of Figure 3 would produce the single sideband (SSB) spectrum shown in Figure 5. It is important to understand that an *envelope* that corresponds to the spectrum of Figure 5 would not look like an envelope corresponding to Figure 3's spectrum.[3]

Note that in producing the SSB, we have saved the power normally necessary to create the large carrier component. And secondly, the SSB requires only one-half of the previous spectrum space.

The receiving process in the SSB case is more complicated than in DSB. The SSB receiver must be capable of reestablishing the missing carrier. This it does by means of an internal carrier oscillator. It is necessary that this locally produced carrier be extremely stable. As distinguished from the conventional DSB detection process, the SSB receiver generally recovers the original modulation by a downward frequency conversion. The carrier oscillator converts the received sidebands to their original audio position.

The effects of selective fading will be greatly reduced by SSB since: (1) only one set of sidebands components is subject to transmission variance, (2) the locally produced carrier is not subject to any fading at all, and (3) the carrier amplitude in the receiver can be made large with respect to the received sidebands. This will result in a smaller percentage of change for a given deterioration of sideband information. The receiver sees this large carrier and small sideband as simply a lower level of modulation.

In summary, SSB results in reduced bandwidth, reduced selective fading, and a reduced power input requirement for a given peak power output. All of these factors combine to reduce the power required for a given communication function. The main disadvantage in the SSB system is the necessity of a very precise carrier insertion circuit in the receiver. It is this necessity for a special receiver that renders SSB impractical for use in the standard broadcast band.

The promise of attaining some of the preceding SSB advantages, while at the same time utilizing existing broadcast receivers, has stimulated interest in Kahn's Compatible Single Sideband. We might note here that one approach to SSB compatibility would be the transmission of a high power carrier along with the single sideband. In this system, however, standard DSB detection will take place in the unmodified receivers and a rather high percentage of harmonic distortion will result.

This last fact leads directly to the fact that the Kahn system of modulation (since it is to be detected by standard DSB detectors without distortion) must have an *envelope* identical to that of DSB. This is not possible with regular SSB as mentioned before. At the same time, for the system to resemble single sideband components must be arranged to one side of the carrier.[4]

The CSSB system is embodied in an adaptor that can be used with an existing broadcast transmitter and by such connection provide CSSB signals. This adaptor provides two outputs for connection to the transmitter. One output is a *phase* modulated R.F. signal at the transmitter's normal operating frequency. The phase modulation is in accordance with the audio information to be transmitted. This same audio is provided at the second output. The only unique characteristic of this audio output is that it has been subjected to the same delay as the audio used for the phase modulation. The CSSB adaptor's R.F. output is applied to the transmitter's regular first R.F. amplifier stage. The audio output is applied to the transmitter as a modulation signal in the normal manner.

In a general way, what is to happen is that when modulation takes place, (1) the audio, through phase modulation, causes the transmitted carrier to change frequency, and (2) at the same time this moving carrier will be amplitude modulated by the same audio signal. The net effect is a redistribution of radiated energy.

Figure 6 is a block diagram of the Kahn CSSB adaptor. This particular unit is arranged to produce a phase modulated carrier of 1020 kilocycles. This frequency was chosen since the unit was set up to be used with a transmitter whose normal operating frequency is 1020 Kcs.[5]

At the top of the block diagram, 100 kc. R.F. and the audio modulating signal are applied to a "balanced modulator." The output of the modulator produces an upper and lower sideband but *no* carrier. The output is fed to filter that passes only the lower sideband. A 400 kc. R.F. (produced by a frequency multiplier) is fed to a frequency conversion device, the "mixer", along with this lower sideband. The sum (rather than the difference) component that is produced in the mixer is a sideband that exists just below 500 kc. The "combiner" *adds* to this sideband a 500 kc. carrier. Here again, this 500 kc. is available by virtue of a frequency multiplier. The result at this point is a *500 kc. Full Carrier Single Sideband* signal. It is important to remember that the sidebands[6] in this signal are due to the original modulating audio. The signal is now fed to a "limiter" which removes all amplitude variation. As a result, only sideband-carrier phase information is retained.

Before following this same line, note that the audio has been redetected by the "product detector" and is made available as an output. The only reason for doing this rather than using the original audio, is to preserve a specific delay relationship.

Returning to the R.F. line, we see that the 500 kc. phase modulated signal is fed to a "frequency multiplier" where the R.F. undergoes a multiplication by 5/4. The result is an identical signal of 700 kc. The last significant block is another "balanced modulator." The 700 kc. is fed in as a modulating signal, while 5 megacycles acts as a carrier. The balanced modulator produces two sidebands (but no carrier). The upper sideband of 5.7 mc. is used and passed to the "mixer." By mixing with 6720 kc. that is available, the difference frequency of 1020 kc. is produced. The end result is that this output of 1020 kc. is now being phase modulated by the original audio input. The steady frequency of 1020 kc. will exist only when the audio applied is zero. If an operating frequency other than 1020 kc. were desired, the multiplier chain would have to be rearranged.

When the adaptor and transmitter are in operation the audio fed to the transmitter is amplitude modulating the simultaneously phase shifting R.F. carrier. Assuming that the input and output R.F. circuits are sufficiently broadbanded, the amplitude modulation of this carrier while it is at the same time being phase modulated, will cause the same envelope to exist as would be produced with a fixed carrier.[7] That is, the instantaneous component carrier and sidebands will add up to a regular envelope. However, the relative position and magnitude of the components will have been changed. The phase shift therefore has only changed the relative distribution of the radiated energy.

It is known that the foregoing process of phase modulation is in itself causing an infinite number of sidebands to be created.[8] However, since the resultant output envelope has been shown in field tests to have little distortion, the majority of phase shift sidebands have been cancelled or reduced by the simultaneous amplitude modulation. Spectrum analyses made in the field for single tone modulation seem to bear out the fact that radiated R.F. is contained largely in the carrier and one dominant sideband. While third and higher order sidebands do sometimes appear, they are highly attenuated in most cases, and therefore good sideband suppression is achieved. As shown before, the traditional SSB spectrum contains only *one* sideband for the same single tone modulation.

Several field tests have been made of the Kahn Compatible Single Sideband System. The first station to try it extensively was WABC New York, starting in August, 1957. In their application to the Federal Communications Commission asking for experimental authority, WABC indicated that the anticipated advantages of the system were: (1) an increase in effective signal equivalent to twice the power, (2) an improvement in fidelity with an attendant increase in loudness due to increased brilliance as heard on most home receivers, (3) a reduction in selective fading distortion in the fringes of the service area.[10]

Reports available at this time draw few conclusions. At the risk of oversimplification, however, it seems that (1) and (2) in the foregoing paragraph have been noted to be true, except when occasionally masked by poor tuning habits of listeners. Little data was gathered on the possibility of decreased selective fading. It is significant that reduction of bandwidth was not mentioned as an expected advantage, although it is precisely in this area that the system's greatest usefulness may be found. With reference to the previously mentioned higher order sidebands, the bandwidth required for CSSB could be as great or possibly greater than that required for the present broadcast service. However, these highly attenuated energies have not been proven to be detrimental. Assuming that they are negligible from an interference point of view, Compatible Single Sideband could prove to be invaluable to spectrum-starved broadcasters.

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"Factual Operation and Results on Compatible Single Sideband," Panel Discussion 12th Annual NAB Convention, Robert M. Morris, ABC; Ralph N. Harmon, WBC; Lucien E. Rawls, WSM-TV, Nashville, Tenn.

1. Freeport, New York.
2. Proceedings of The IRE. July, 1958. Letter to Editor, from Leonard R. Kahn, p. 1430.
3. Even if the carrier were transmitted with the single sideband, it would not resemble an envelope of Figure 3.
4. In distinction to SSB. CSSB does transmit what is normally known as a carrier. In this respect it is a full carrier single sideband signal.
5. Unit used by KDKA, Pittsburg, Pa.
6. When the modulating audio is a single sine wave, only one sideband component will exist.
7. "Experience with CSSB at KDKA." A paper by Ralph N. Harmon, WESCON Conf., August, 1958. Page 4. NAB reprint.
8. "Engineering Electronics," Happell and Hesselberth, McGraw-Hill Book Co., 1953. Page 373.
10. "Factual Operation and Results on Compatible Single Sideband." Panel Discussion. 12th NAB Broadcast Engineering Conference, 1958. Page 1, NAB Reprint.

THREE MEGAWATT FM INSTALLATION

Details of a secret FM installation which may revolutionize the industry.

By
PROF. OSCAR VON DER SNIKRAH*

IN THE constant battle to provide greater coverage, the best approach for FM stations has been to seek the highest possible location for the transmitting antenna and use the highest ERP. Several years ago our firm was authorized to prepare engineering for an FM station that would serve the giant Indian territory of Southern Arizona.

Early research disclosed that Stony Cloud Mountain was the ideal site for the transmitting antenna, as from its 12,232.5-foot peak, direct line of sight was available into several thickly populated valleys in the radius of 400 miles.

The whole project didn't get started, however, as no electricity was available on the mountain and access was by helicopter only. However, recently several fortunate discoveries coupled to unique circumstances have made possible the world's greatest coverage from any single FM station.

The actual beginning of the breakthrough came during a special field trip south of the border into Old Mexico. While installing one of our illegal 500 Kw. clear channel AM transmitters it was noticed by both myself and my laboratory assistant that certain unusual effects were contained in the well known Mexican tranquilizer fluid commonly referred to as Tequila.

On an experimental basis enough facts were gathered that a long chain of research projects were immediately started at the home base. It was soon proven that the Tequila liquid had unusual R.F. propagation constants that made it highly applicable to the construction of low loss transmission lines.

Fortunately the Mucho Boracho Tequila Distillery was located near our laboratory and excellent cooperation was obtained throughout the research period. After the propagation velocities and transmission characteristics of the Tequila were proven, the distilling company was approached with a "trade deal" to use their long cross-country pipeline for an R.F. transmission line without interference with its normal function of piping the raw cactus juice to the distillery.

It was found that their pipeline lent itself to this purpose in an ideal manner since the inner pipe was used to pump the finished product back from the distillery and the space between the inner pipe and the outer pipe was used to pump the cactus juice to the distillery. By pure luck it so happened that whoever designed the two way pipeline had discovered a large supply of war surplus stand off insulators that they purchased at a low price that they used to support the inner pipe so that it actually was electrically insulated from the outer pipe.

The outer pipe is 6 inches in diameter and the inner pipe is 1 inch in diameter. When filled with liquids as normally used, the surge of impedance was measured to be 596.7 ohms, which was a convenient value for matching into and out of other units of the system. The dialectric constant of the liquids being transported was excellent for our use and some unusual side effects that have not been completely analyzed yet are present that have proven to be a windfall for the whole system.

Original experiments with short lengths of the pipe showed that when used for transmission of R.F., a gain of 1.3 db was obtained for each 20-foot length. Since the pipeline went from the cactus forest in the valley over the top of Stony Cloud Mountain to the distillery, all that was necessary to do was design a form of diplexer that would permit the R.F. to be introduced at one end and taken off 29½ miles later where it passed the transmitter site. With a gain of approximately 1.7 db for each section of the pipe the predicted ERP obtainable at the take-off point at the top of the mountain was soon computed on the slide rule to be in excess of 3 megawatts (3,000,000 watts).

In the contract entered into with the distilling company they agreed to keep the line filled with both the cactus juice and the Tequila at all times so that the transmission system would not fail. (Some difference was noted between the steady state condition when the pumps weren't running and when the fluids were in motion, although the difference was only a few db so that no noticeable signal strength was apparent.)

Since the transmission line itself has so much gain an ordinary dipole is all that is necessary for the transmitting antenna.

Since there is a possibility that this installation may have to be licensed by the F.C.C. some measurements are going to be taken at a future date to submit to the Commission for a proof of performance

*Haywire Radio Co., Petrified Lake, Arizona.

of this new approach.

It is anticipated that any widespread use of the "loaded" transmission lines throughout the country will necessitate rule-making procedure with the F.C.C. Among the proposed rules will be the most important requirement that no spigot taps will be permitted throughout the system, thus insuring the sobriety of station engineers. The contract with the distillery also contains certain penalties should the metering system used on their pipeline show any loss of content due to any activities of the R.F. application. The "trade deal" calls for additional spots to be given to cover any losses in either the raw material fluids or the finished product returning back through the inner pipe. Since the inner pipe is harder to get at, few losses are anticipated as the raw cactus juice does not contain the tranquilizing elements of the finished product.

Since this whole FM system was primarily designed for multiplexing, the absolute linearity was the most important thing that was observed. A government subsidy has already been requested to provide the millions of Indian families each with a multiplex receiver in order that they will be served with background music on a continuous basis.

The Indian Service Bureau has calculated huge savings to the taxpayers in preventing another Indian uprising by the psychological use of planned music throughout the territory.

A bill is before Congress to lift the revenue tax on distilled products when the Tequila is used for this special application. Until this legislation has been completed the shorter lengths of transmission line will be too expensive for widespread use except in the most deluxe installations. Even though the long lengths are not used to obtain the gain factor, the absolute linearity made available still makes the "loaded" lines desirable for stations that are trying to multiplex. Broadcast engineers everywhere are urged to write their congressmen about this unfinished legislation.

EDITOR'S NOTE: Our research department has verified the history of the tranquilizing properties of cactus juice after it has been distilled. As far back as the year 1783 the tranquilizing effects were first noted and have been gaining widespread usage ever since. No material is available verifying the R.F. characteristics of the Tequila.—Ed.

SELECTION OF SUBCARRIER FREQUENCIES

Factors involved in choosing frequencies for two channel FM multiplex system are outlined.

By DWIGHT "RED" HARKINS*

When the Federal Communications Commission authorized multiplex activities for FM broadcasting stations, the technical standards which were adopted were rather simple and did not dictate the frequencies that could be used for the subcarriers themselves.

The rules stated that the subcarriers would have their components lying between 20 Kc and 75 Kc and that the arithmetical sum of the subcarriers injected into the FM transmission would not be responsible for more than 30 per cent of the station's modulation. At the time these standards were written by the Commission, the new art was in its infancy and it had not been demonstrated whether two or more subcarriers could be transmitted on a practical basis.

Early in the development of the multiplexing system for FM broadcast application it was believed that more than one channel could be transmitted in the allocated space between 20 Kc and 75 Kc. Based upon techniques in use by the telephone company there were some who believed that many channels could be transmitted. As many as 10 or 12 channels were theorized to be possible. In actual practice, however, it has been found that the many channels proposed in accordance with telephone system practices could not be transmitted because the multiplex subcarriers were frequency modulated. The subcarriers used by the telephone company on the coaxial cable long distance multi-channel circuits are amplitude modulated—the basic difference being that in the AM system used for telephone company multiplexing, the transmission circuit is linear. On the other hand, in the broadcast multiplex application, the subcarrier is frequency modulated and goes through circuits which impose limiting to improve the signal-to-noise ratio and are therefore very non-linear circuits. They are especially non-linear in respect to amplitude changes.

Here, then, is the first problem that arises, namely, the subcarriers are frequency modulated instead of amplitude modulated. In the multiplex application for FM stations the advantages of a frequency modulated subcarrier are apparent. Through the use of limiting and its noise improvement characteristics, a usable signal can be produced. The disadvantage of the FM subcarrier is the greater bandwidth requirement.

Our first approach, then, was to determine the practical requirements for one channel, disregarding the possible use of a second channel.

Since the subcarrier is going to be used for the transmission of music for subscribers, the minimum requirements were set up for a 50 db. signal-to-noise ratio. The noise consisted of the system impulse noise, the crosstalk from the main channel modulation products, and the noise produced at the receiving point by electrical interference. In order to achieve this goal of a 50 db. channel several things were found necessary. First, it was found that the deviation must be at least plus or minus 10 Kc. Second, it was found that an audio pre-emphasis curve was required that was more similar to the LP recording curve than it was to the standard pre-emphasis used in the main channel transmissions. These methods were necessary to overcome certain system problems that have been discussed elsewhere.

The goal at this time was to achieve one commercially usable subchannel, then to proceed to develop the second channel. In the course of these early experiments it was discovered that the limiting action being used in the multiplex portion of the receiver was a highly non-linear device that created many side effects of the frequency modulated carrier. For example, the subcarrier that was deviating plus or minus 10 Kc. would create at the limiter many additional sidebands that extended the bandwidth beyond plus or minus 10 Kc. All of the developed side carriers needed to be detected in order to preserve the fidelity of the modulation. It was also discovered that a normal tuned circuit at the subcarrier frequency would not have sufficient bandwidth characteristics to allow the passage of the generated sidebands. Just as in any system of FM, the generated sidebands must be allowed to pass through to the point of detection without any deterioration in either amplitude or phase relationship. The problem then resolved itself to the design of suitable filters or networks that would allow the amplification of the desired bandwidth of energy together with

*Harkins Radio Co., 4444 E. Washington St., Pheonix, Arizona.

the rejection of the unwanted frequencies both above and below the desired bandwidth.

Since the deviation of the subcarrier was a large percentage of the center frequency the design of circuits that would pass the energy without phase distortion proved to be a knotty problem. Disregarding the possibility of a second subchannel, it was obviously necessary to get at least one subchannel operating in a commercially salable manner.

Since the Commission's regulations dictated that the subcarriers lie between 20 and 75 Kc., a center frequency of 65 Kc. was established as the first point we could hang our hat on. A center frequency of 65 Kc. would permit operation within the Commission's regulations and still give us the desired signal-to-noise ratio, providing the filter and amplification networks used at the receiving end met the requirements of low phase distortion.

It was discovered that the use of high impedance tuned circuits and swamped resonant circuits would not permit the amplification of the subcarrier without distortion. A bandpass filter was built that had a linear amplitude response over a plus or minus 10 Kc. bandpass. Although the response of the filter under actual measurement was linear in respect to amplitude over the plus or minus 10 Kc. swing, the modulated subcarrier would not pass through without serious distortion. Considerable analysis showed that the difficulty lay in the problem of allowing the complex sidebands of the frequency modulated subcarrier to pass through the filter without changing their phase relationships with each other.

As is the case with all frequency modulated carriers, the sidebands or sidecarriers produced by the modulation process consist of many new pairs of carriers that are 90 degrees out of phase with each other. If this "bundle" of carriers passes through any circuit that disturbs the phase relationship, then the carriers either add to or subtract from each other to convert the frequency modulated signal components into a form of amplitude modulation. Under certain conditions of non-linear phase shift, the carrier is actually eliminated. This is somewhat the same problem that is encountered in the multiplier stages of FM transmitters and the I.F. strips of FM receivers. The problem in this case is highly exaggerated, however, because the bandwidth requirement is an unusually high percentage of the center frequency. In this case of a 65 Kc. center carrier frequency a bandwidth of plus or minus 10 Kc. actually becomes almost a 35 per cent figure of the carrier itself. From actual field experiences we had determined that the full 10 Kc. deviation was necessary for a foolproof system that would override system deficiencies such as crosstalk and impulse noise. With a filter characteristic that appeared too wide in reference to its amplitude response, a linear phase shift was obtained over the critical region required.

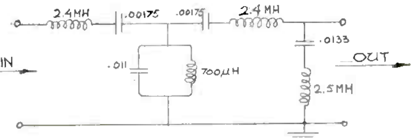


Fig. 1. 65 Kc. band pass filter designed for 500 ohm termination. It is phase linear over a plus or minus 10 kc. range.

We then developed a filter that operated at 500 ohms impedance that met our requirements. This filter had linear phase shift over a range of plus or minus 10 Kc. from the center frequency of 65 Kc. The filter had an amplitude response characteristic that was flat from plus or minus 20 Kc. from the center frequency of 65 Kc.

Along with the development of the good signal-to-noise ratio problem the second channel problem was also introduced at this time. As a result of this a filter was designed as shown in Figure 1, which permitted the reception of a 65 Kc. subchannel with peak deviation of 10 Kc. without distortion.

In choosing the frequency of the second subchannel it is obvious that the filter of the receiver which passes frequency between 45 and 85 Kc. prevented the use of a subcarrier that was close to that region.

The second channel, therefore, had to be placed a sufficient distance from the first channel to prevent interference and secondly had to be of such a frequency that its harmonics would not interfere. The addition of a second channel required a greater degree of linearity in the entire transmitting system. It was found that the method used in the transmitter for injection of the subcarriers had to be extremely linear; otherwise harmonics were produced which created interference in the receiver. A frequency of 26 Kc. was chosen for the second channel. The second harmonic of 26 is 52, and the third harmonic is 78 Kc. This placed the 65 Kc. subcarrier directly in the center between the second and third harmonic of the 26 Kc. carrier. Any non-linearity in the transmitter then produces an audio beat of 13 Kc. in the receiver. Since the audio frequency response of the subcarriers above 5,000 cycles is not required, the unwanted products that are produced above this are easily


Fig. 2. Band pass filter used in receiver is assembled on an etched circuit board. The etched circuit shows through from the rear due to translucence of material.

filtered out without affecting the quality of the desired signal.

The system problem, then, boiled itself down to one of filter design in the receivers. It will be noted in Figure 1 that the end section of the filters is a reject circuit to attenuate the unwanted subcarrier. In the case of the 65 Kc. filter the reject portion is designed for 26 Kc. and in the 26 Kc. bandpass filter the reject portion of the filter is designed for 65 Kc. This filter represents the practical approach to the problem at a cost within reason.

The 26 Kc. carrier has a peak deviation of plus or minus 6 Kc. In order to get maximum signal-to-noise ratio, the audio to this channel is cut off at 3,500 cycles. (As compared to 5,000 cps cut off on the 65 Kc. channel.) This permits a signal-to-noise ratio to be obtained that approaches within a few db. of that obtained from the 65 Kc. channel.

The two-channel system requires that the injection of the subcarriers at the transmitter is done with extreme linearity. The harmonic products of the lower subcarrier cannot be tolerated beyond a minimum value. If the injection process itself creates harmonics, the over-all result is a form of interference and noise heard in the receiver in the higher frequency subcarrier. Since the second and third harmonics of the lower subcarrier have their deviation multiplied by 2 and by 3, it can be seen that the problem becomes serious.

The auxiliary phase modulator used in the transmitting process to inject the subcarriers is called upon to do its greatest job with the lower frequency subcarrier. This is because it is a phase modulation process which becomes more sensitive and easier to deviate as the modulating frequency increases. The increase is at the rate of 6 db. per octave which means that a 65 Kc. carrier takes much less injection voltage than a 26 Kc. carrier does. The auxiliary phase modulator is therefore adjusted for greatest possible linearity while injecting the 26 Kc. subcarrier. If operating correctly an injected sinewave at 26 Kc. will appear at the receiver also in the form of a sinewave without showing any signs of harmonic distortion.

If the unwanted subcarrier appears at the limiting grid in the subcarrier portion of the receiver it will generate rich harmonics at this point. These harmonics then are amplified along with the desired subcarrier and appear at the detection process.

Although considerable experimentation has taken place towards obtaining three subchannels in the system, it has been found that to do so would necessitate a narrow swing of each channel and the signal-to-noise ratio obtainable without interference from the other channels would be far too inadequate for commercial purposes. There is some possibility that a system using AM subcarriers would be more attractive in this direction. Similar to the telephone transmission system a single sideband suppressed carrier subcarrier could be used and placed quite close to other subcarriers. However, this approach would necessitate expensive filters and an absolutely linear system throughout. It would also prevent the use of limiters in the system and thus present more noise problems.

Using subcarriers of 26 Kc. and 65 Kc. has proven itself at many installations that have been in actual operation throughout the country in the past two years. The most common application has been to use the 65 Kc channel for a background music service and the 26 Kc. channel for storecasting.

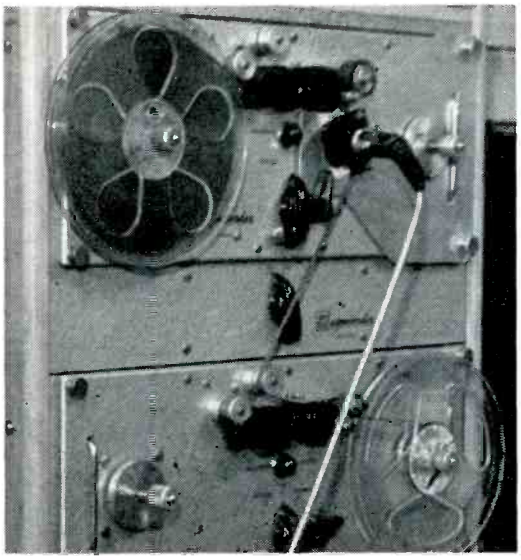
Quite a bit of interest has been developing toward the use of a multiplex subcarrier for one of the channels of a stereo system. Our organization has done considerable collaboration with Mr. Murray Crosby of Crosby Laboratories, Inc., in the testing and experimentation of a high fidelity wide deviation subcarrier operating at a center frequency of 50 Kc. It was shown conclusively by many on air tests that a subcarrier operating at this frequency with a deviation of plus or minus 25 Kc. could be picked up at the receiver with all of the fidelity and low noise characteristics as the main channel. In other words, it had response from 50 to 15,000 cycles and noise of 60 db. below 100 per cent modulation reference. When a subcarrier of this type was combined with the sum and difference system that Mr. Crosby invented it permitted an FM station to transmit stereo programs without deteriorating from the enjoyment of the same program over a regular FM receiver that was not equipped with an auxiliary multiplex adaptor for the second part of the stereo programs.

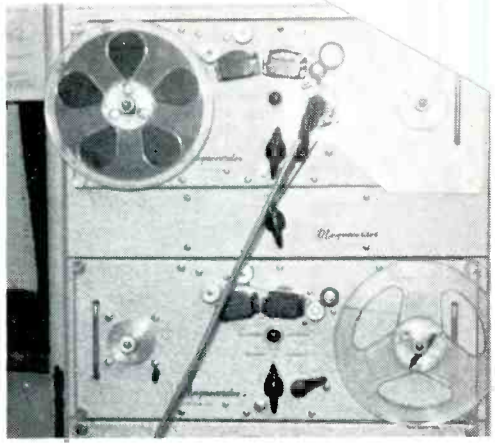
From this discussion it can be seen that a receiver equipped with a filter for the 26 Kc. or 65 Kc. would not respond very favorably when tuned in to the station that was transmitting a 50 Kc. subcarrier of the type required for stereo.

On the other hand, if the stereo type of multiplex adaptors that permit reception of the 50 Kc. wide deviation subcarrier are standardized they in turn will get very unsatisfactory reception from a station that is transmitting the 26 and 65 Kc. channels for background music or other private purposes.

This has been one of the strong points in favor of the high fidelity stereo multiplex channel since it offers a form of privacy to be maintained and preserved for those stations which desire to use their facilities for the private nature of Subsidiary Communications Authorization.

It can also be seen from the technical explanation shown here that if a system is adopted that permits one of the two subchannels to be used for stereo, the public will be denied a true stereo system, since it is impossible to get the full frequency response that is desired into either one of the two channels (although more than adequate for background music application). It is also impossible to get as good signal-to-noise ratio as is available in the single channel approach. As most broadcast engineers are aware, the Commission has before it now many petitions describing quite a few different plans for multiplex stereo. Since most of the plans include the use of multiplex in one form or another the problem before the Commission now is to decide just how well the public should be served with stereo by radio. The facts outlined in this article should point up the basic problems which indicate that fidelity and low noise can only be obtained at the expense of bandwidth. This problem is not new to the industry since it also was the reason for allocating so much frequency space to the FM band when FM broadcasting was first authorized.





AN INEXPENSIVE ECHO EFFECT

By
L. J. CARLSON*

This article may be of some help to the engineer whose budget is limited and who has a need for an echo effect that will approach some degree of satisfaction. While this method is not new, its application to equipment that may be available can be made with the least amount of effort.

The description that follows will give some ideas that can be applied to other recorders. Where two Magnecorder type PT6 mechanisms can be mounted together, one under the other, this method is fairly simple. A combination of idlers and extension arms could be fashioned to make this principle work on one unit if necessary.

In order to mount a playback head close to the record head, take a piece of aluminum, cut it out and shape to mount on the right side of the recorder so that the extra playback head can be supported up under and as close to the main drive spindle as will still make threading of the tape possible. Two holes are drilled to mount the aluminum plate under the two knurled mounting screws on the right end of the top PT6 panel, one hole 2¼ inches in diameter is made to clear the take-up reel hub plate; also, cut a slot to clear the collapsible handle. Mount the extra playback head (I used a spare Magnecorder playback head) with the plug connections facing away from the panel; this way the adapter plate can easily be mounted and removed whenever needed.

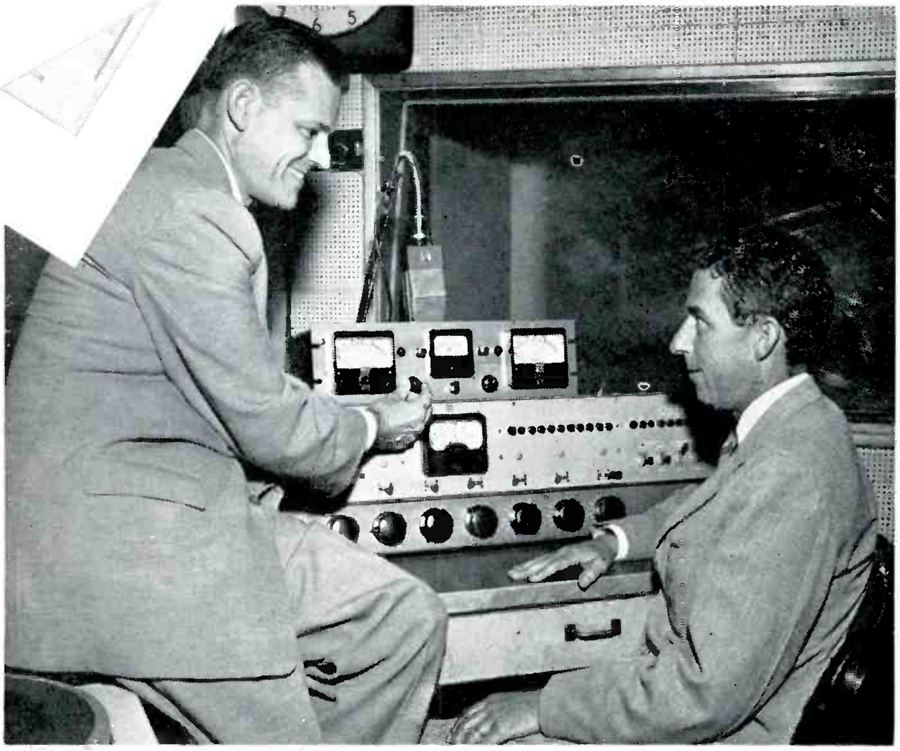
The output of the extra playback head is fed into one of the microphone inputs on the console and the amount of echo or reverberation can be controlled with that attenuator control. Some mismatch here is not too noticeable.

The top recorder mechanism is used to record the material on the tape and is operated as usual when recording on this unit; the bottom mechanism is only used to pull the tape through and for best results should be used with the 15″/sec. drive spindle and idler.

It is necessary to thread the tape in such a way as to prevent as much drag as possible. The supply reel is put on the top unit, the tape is threaded directly from the supply reel over the erase and record-playback heads, then over the extra playback head (do not thread the tape through the drive spindle of this unit), down to the top idler of the bottom unit, under the record-playback head shield plate, through the drive spindle and onto the take-up reel of the bottom unit.

With the selector switch in position to record on the top unit, start the bottom unit rolling first, then the top unit. Feeding the material from the console into the top unit and with the microphone attenuator brought up gradually to feed the material back from the extra head into the usual record head, the amount of echo or reverberation desired can be controlled while monitoring. If too much feedback is used it will soon be evident that the amount of signal starts to build up and if allowed to continue may damage some of the circuitry.

*Chief engineer, KENT, Shreveport, Louisiana.



W. H. Collins of Electro-Plex demonstrating their new Multiplex Modulation Monitor to Jerry McCarthy, station manager of WTOA-FM and head of Mercer Music Co., in Trenton, N. J.

A MODULATION MONITOR

Recent expansion of the FM multiplexing program has created requirements for new electronic equipment and instruments. Reference is made particularly to FM radio station needs for an adequate monitoring device as well as frequency verification for the sub-carriers. Equipment available until very recently allowed only monitoring of the main channel, leaving largely to guess the injection and deviation of the sub-carrier.

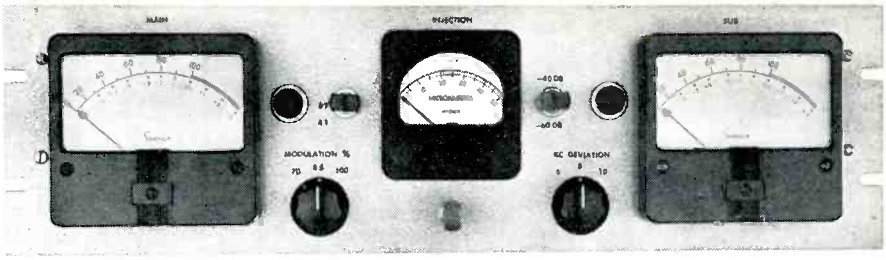
Through the development of the 8-A Modulation monitor by the Electro-Plex Corp., precise indications of modulation levels and injection may be obtained.

Before going further with a description of the functions of the monitor, it might be well to explain "injection" and "modulation" insofar as they concern our interest in multiplexing. It may be assumed that the basic functions of FM transmission are understood in that audio program content, when impressed upon a transmitter, causes frequency variations over a prescribed band-width as set by good engineering practice and F.C.C. rules. These limits today dictate a transmitting channel of 200 KC for each FM broadcasting station. The frequency deviation is ± 75 KC for 100 per cent modulation, leaving a 25 KC guard band at the upper and lower limits of the channel. This means that an audio tone transmitted over a station at 100 per cent modulation, located say, at 100 MC, deviates the carrier from 99.925 MC to 100.075 MC.

Since total frequency deviation is the thing we are most interested in, an understanding and an analysis of this function becomes of paramount importance. An instrument to detect and evaluate its complex functions had to be developed.

For the sake of clarity, we must understand that the multiplex sub-carrier is merely another frequency that we want to transmit along with the audio program. It does not vary in intensity as the spoken word or musical program, but is constant, just as if 1000 cycles were being transmitted along with the regular program. The 1000 cycle tone, being audible, would naturally be heard, and destroy the transmission. However, a constant tone at 32.5 KC, 41 KC or 67 KC, which are the sub-carrier frequencies in use today, are inaudible, and when transmitted simultaneously with the audio program, do not disturb its character.

The amount of frequency deviation allowed the sub-carrier is an important factor, and the space it requires (depending upon its intensity) must be considered. Room must be made for it within the prescribed FM channel of 150 KC band-width. This obviously means that the main channel modulation must be reduced by the amount the



8A modulation monitor designed for FM multiplexing.

FOR FM MULTIPLEXING

By WILLIAM H. COLLINS, Electro-Plex Corp.

sub-carrier frequency is modulating the main carrier.

A confusing element in this matter is the fact that per cent modulation and kilocycle deviation are often treated separately without the realization that they are actually tied firmly together. From Figure 1 and the charts that follow, graphical representation of these two elements is given.

When one or more sub-carriers are employed, modulation levels become extremely important to avoid cross-talk, distortion and over-modulation. Of particular importance is the modulation level of the main channel. Practices to date have prescribed that the operator in the control room now fix 70 to 85 per cent as the new level of main channel modulation. This, in effect, merely has meant that the audio gain control of the transmitter has been set at a slightly lower level so that the modulation peaks will not rise above

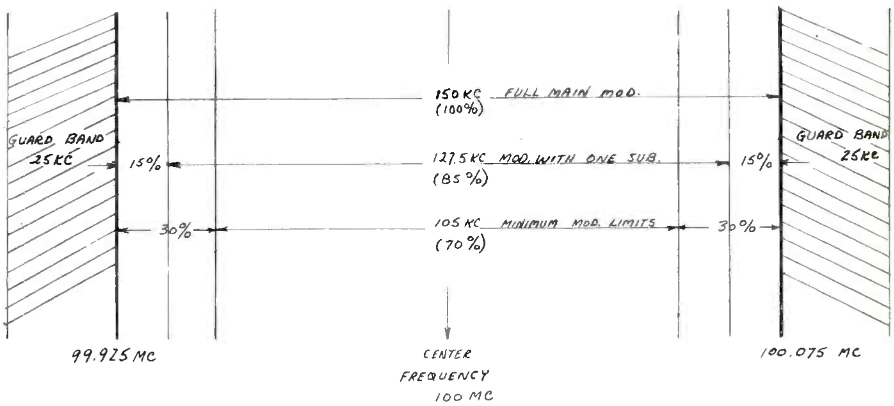


FIG. 1

THE RELATION OF PERCENT TO DEVIATION IN KC.

MAIN CHANNEL		SUB-CHANNEL	
Modulation (Per Cent)	Corresponding total deviation in KC	Injection (Per Cent)	Resultant total frequency deviation of main channel by sub-carrier in KC
100	150 KC	10	15 KC
90	135 KC	15	22.5 KC
80	120 KC	20	30 KC
70	105 KC	30	45 KC
60	90 KC	40	60 KC
50	75 KC	50	75 KC

ALLOWABLE SUB-CHANNEL MODULATION LEVELS FOR VARIOUS INJECTIONS

Sub-channel Injection (Per Cent)	Corresponding KC deviation of main channel by sub-carrier	Allowable audio modulation of sub-channel in KC*
5	7.5 KC	4 KC
10	15. KC	8 KC
15	22.5 KC	10 KC
20	30. KC	20 KC
25	37.5 KC	25 KC
30	45. KC	35 KC

*Estimated

Figure 2

Chart showing the relationship of percentages and kilocycles deviation inter-related between main channel and sub-carrier.

the new, desired level.

This is often a very difficult thing to do after "riding gain" for many years at full 100 per cent. Higher levels are bound to be attained occasionally resulting in periodic break-through of the main channel into the sub-carrier. Aggravating this condition is the older type of modulation indicator which does not have the proper ballistics, therefore not reading peaks as they actually exist, but some reasonable average.

Enough ground has been covered here to stipulate now that "injection" is the intensity of the super-audible sub-carrier frequency related in per cent to the 150 KC band-width of the entire FM channel. Or, put another way, the "injection" factor is the relative amount that the super-audible "sub-carrier" is modulating the main carrier. This level is controlled by the amount of sub-carrier frequency that we allow to be "injected" from the sub-carrier generator. Injection percentages up to 30 per cent are allowed by the F.C.C. for multiplex programming.

As in the case of the main channel, the super-audible sub-carrier can be modulated with an audio program. This action is what produces the second program on the FM station, which is inaudible to the main channel listener, and is called multiplexing.

However, the audio deviation of the sub-carrier is but a small per cent of that available on the main channel by virtue of the great differences in the frequencies and band-widths of each. It has been determined that ± 8 KC deviation closely approximates the maximum modulation level consistent with audio frequency response and low distortion.

Summing up these functions, we find that in the case of single sub-carrier use, the injection can be approximately 20 per cent; and in the case of two sub-carriers, 15 per cent each, or a total of 30 per cent. We also find that the audio modulation of these sub-carriers must be limited to ± 6 KC. Slightly higher modulation may be used in the case of using only one sub-carrier, which of course improves the signal to noise ratio and increases the ratio between possible main channel cross-talk and sub-channel audio.

Through the use of this new modulation monitor, a new "100 per cent modulation" of the main channel, on the meter, can be set by an indexing control on the panel. For example, 100 per cent on the meter can now correspond to an actual 70 per cent or 85 per cent depending upon the selector switch setting dictated by the number of sub-carriers in use. In the same manner, modulation levels of the sub-carrier can be pre-set and observed on a second VU meter. A key is provided on the panel for instantly selecting either of two sub-carriers and determining their functions.

The other important element concerned in multiplex broadcasting is the injection percentage mentioned above. Another meter is provided which constantly indicates the injection in percentage. Actually, this meter is a sensitive D.C. voltmeter which registers the sub-carrier injection as a constant voltage. This voltage is derived after the filter sections in the multiplex demodulator circuits.

The monitor is also equipped with a means of aurally monitoring any of the programs involved. Its circuits terminate in 600 ohms which may be bridged across an amplifier for control room listening. A three-position key allows this function. Concurrent to selection, an indicator light adjacent to the proper VU meter lights, to designate which program is being heard.

As mentioned previously, investigation has disclosed that current broadcasting with one sub-carrier will allow an injection of 15 per cent to 20 per cent. This means that the main channel modulation must be reduced to approximately 85 per cent of its former deviation. The

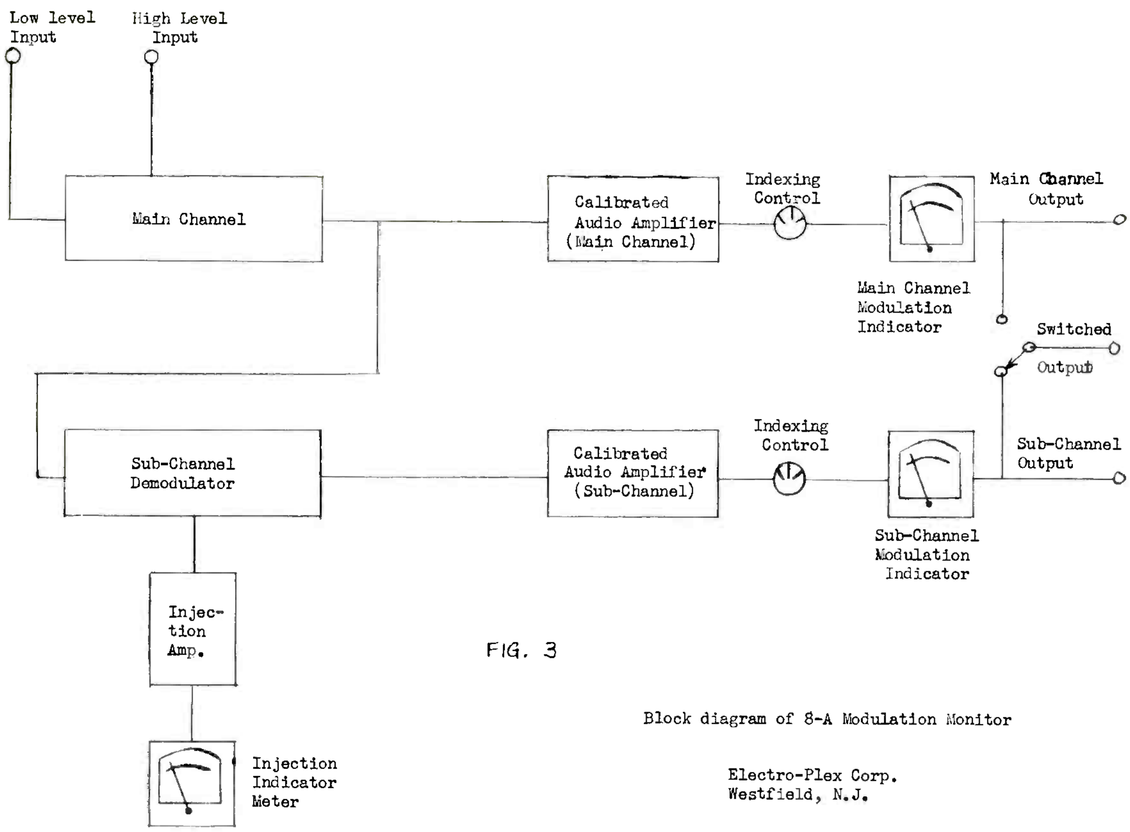


FIG. 3

Block diagram of 8-A Modulation Monitor

Electro-Plex Corp.
Westfield, N.J.

15 per cent sub-carrier is modulated by the second audio program at ± 6 KC to ± 8 KC. The chosen deviation of the sub-carrier is now referred to as 100 per cent. Until now, there has been no means of constantly monitoring this signal, the practices in tape and disc recording being largely relied upon to keep the modulation within the prescribed limits. However, with the future use of musical programs having greater dynamic range and frequency response, visual monitoring becomes more and more important.

In the interests of better signal-to-noise ratios, greater injection may be employed up to the maximum of 30 per cent as set by the F.C.C. When using this maximum injection, with correspondingly greater deviation, the main channel modulation must be reduced to 70 per cent.

In view of the instantaneous amplitudes which are generated by wide-band program content on the main channel, particular attention had to be paid to the speed of the VU meters. The highly damped meters normally used for modulation indicators tended to smooth out the peaks giving an averaged indication of the audio program. In multiplex work, a more accurate indication of volume peaks must be provided. The 8-A modulation monitor employs exceedingly fast acting meters with ballistic characteristics of .15 second for the pointer to reach 0 DB or 100 per cent modulation.

The monitor was designed expressly for control of the modulation levels of the FM station and does not employ frequency monitoring circuits. It was felt that this phase of station control could be left to the frequency monitor which already forms a necessary part of the transmitting equipment. However, a *sub-carrier* frequency monitor is in work at Electro-Plex which is being designed as a companion piece to the modulation monitor. The operation of this instrument will be dealt with in a future article.

Mechanical Considerations

Due to its compactness of size, the monitor may be used in the master console of the radio station or placed on top of the audio console at eye level. The unit measures 19 inches wide by 5¼ inches high and is 13½ inches deep. It is constructed on a relay rack panel and may also be mounted in the multiplex exciter rack, if desired.

R.F. pick-up is obtained by connection to the output of the main channel exciter. The desirability of also using the monitor at a remote point from the FM transmitter has been considered and two inputs are therefore provided. The second input has a much higher gain at R.F. frequencies.

To round out the versatility of the monitor, provision has been made so that it may be used by an FM station prior to installing multiplex equipment. A position of the main channel indexing switch will allow full 100 per cent modulation of the carrier.

Crosstalk Measurements

Another feature of the monitor is its ability to read directly on the sub-carrier VU meter the amount of cross-talk from the main channel appearing in the sub-carrier.

Such measurements are taken

A	B	C	D	E	F	G
Main Channel Modulation	Total Main Channel Deviation in Kilocycles	Relative Drop in DB From 100%	Relative Noise Level Increase Over Ambient	Sub-Carrier Injection in %	Corresponding Total Deviation of Main Channel By Sub-Carrier	Allowable Sub-Carrier Deviation With Audio Modulation*
100%	150 KC	0	0	0	0	0
90%	135 KC	— ¾ DB	6.25%	10%	15 KC	± 4 KC
85%	127.5 KC	—1½ DB	12.50%	15%	22.5 KC	± 5 KC
70%	105 KC	—3 DB	25.00%	30%	45 KC	±10 KC
**60%	90 KC	—4½ DB	37.50%	40%	60 KC	±15 KC
**50%	75 KC	—6 DB	50.00%	50%	75 KC	±25 KC

*Estimated, based on current practice.
**Such low levels of main channel modulation are not used or anticipated. They are merely included as items of academic interest.

Complete picture of transmitter adjustment may be derived by reading across, left to right, in a single horizontal column.

Figure 4

From Figure 4 it may be seen how the spectrum for an FM transmitter is divided to provide area for the sub-carrier, and how the exact amount (percentage) of this channel is derived. Columns A and E will always total 100%. Correspondingly, columns B and F will always total 150 KC or the maximum usable station channel band-width. Note that in all cases except column G, the full channel of 150 KC is being considered rather than ±75 KC. From column C, the relative drop in DB below 100% modulation of the main channel is shown as a function of reducing the main channel modulation to accommodate a multiplied sub-carrier.

with the modulation removed from the sub-carrier. A key may then be depressed causing the main channel modulation to show on the sub-channel meter, if cross-talk exists. Two levels are available: one representing 40 DB below and another at 60 DB down. The cross-talk level may be read directly in DB on the VU meter. This feature of the monitor proves of considerable value in the tuning-up operations of the transmitter and the sub-carrier exciter.

Calibration of the Monitor

Without calibration of the monitor, it merely becomes an arbitrary indicating device. Through the use of highly accurate FM signal generators and calibrated sweep oscillators, the adjustments of the monitor are set at the factory. Allowing for aging of the tubes, calibration adjustments are provided.

In the 100 per cent modulation of the main channel indexing switch, exactly ± 75 KC deviation of the carrier will cause the meter to read 100 per cent. Likewise, in the 85 per cent position of the switch, the same reading is indicated with ± 63.75 KC deviation. Dropping to 70 per cent modulation, 100 per cent on the meter now equals ± 52.5 KC deviation.

The tables in Fig. 2 may prove of interest in showing the relationship between deviation, injection of subcarriers and modulation.

Monitor Circuitry

(See Fig. 3.) A main channel section employs two R.F. input connections, one for operation off the output connection of the exciter and the other, with additional gain, allowing the use of the monitor at a remote position from the transmitter.

Following this, a multiplex demodulator circuit is used having two filters, one for each of two subcarriers, 41 KC and 67 KC. The 41 KC filter has been specially designed to include 32.5 KC for those stations still using this frequency. The detector employs a new circuit recently developed by the company for wide range sub-carrier use. It displays less than ¼ per cent distortion over the range of deviation encountered in present day multiplexing.

The take-off for the injection indicator occurs directly after the filters and consists of a rectifier circuit to convert the sub-carrier frequencies to D.C. for indication on a meter. The injection is a linear function and the percentage is read directly on the meter.

The audio circuits are conventional excepting the fact that they are calibrated to achieve accurate indications on the VU meters. The output level is 0 VU in 600 ohms. Three outputs are provided: Main channel, sub-channel and a switched output.

It is hoped through the development of the monitor and other associated instruments, that more accurate multiplex broadcasting may be achieved and that the problems currently surrounding the broadcasters may be minimized.

Future articles will embrace selective muting, a sub-carrier frequency monitor, multiplex receiver design, propagation of the multiplex signal and installation techniques for multiplex receivers.

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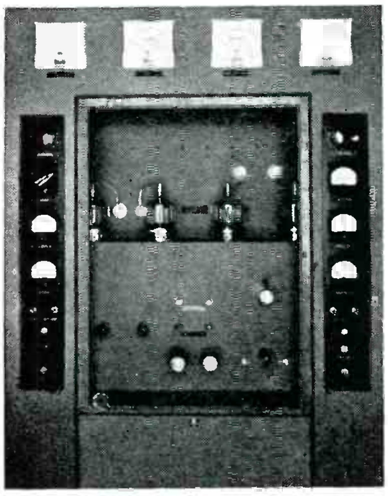
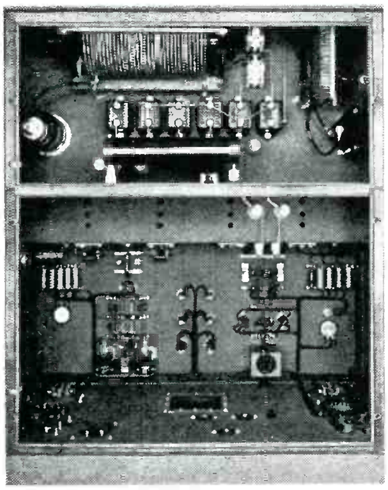
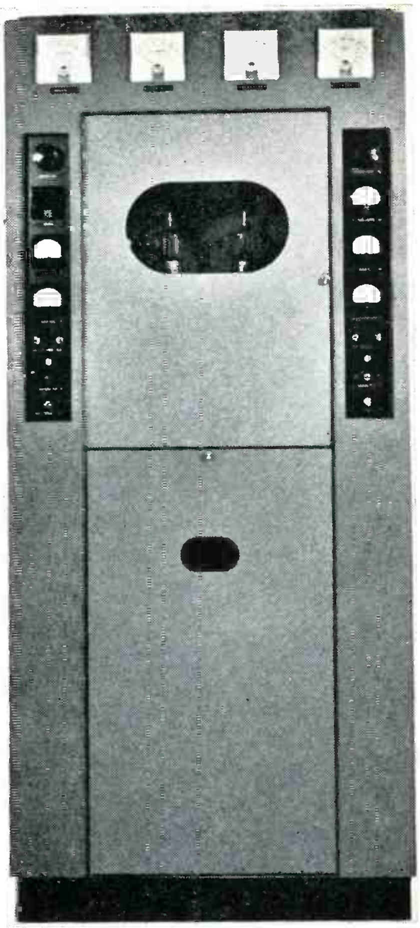


All audio and R.F. tubes are removable from upper door. Each critical circuit is separately metered.



Vacuum variable tank condenser, output circuitry, and accessibility of components are shown.



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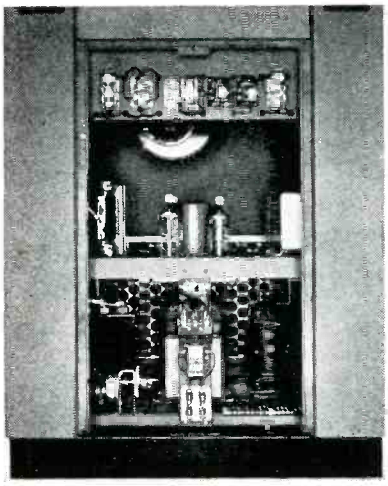
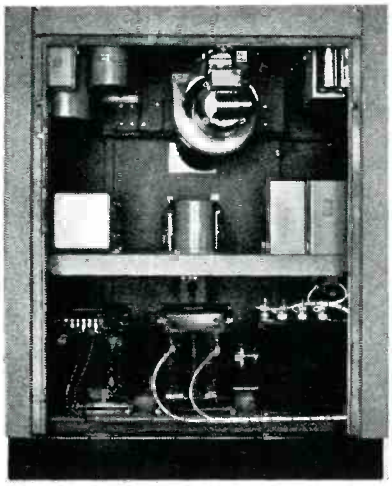


Relays are in a dust-free location. All components and circuit terminals are in convenient locations.



Heavy-duty rectifier components, constant voltage filament transformer, and modulation transformer are mounted in lower compartment.

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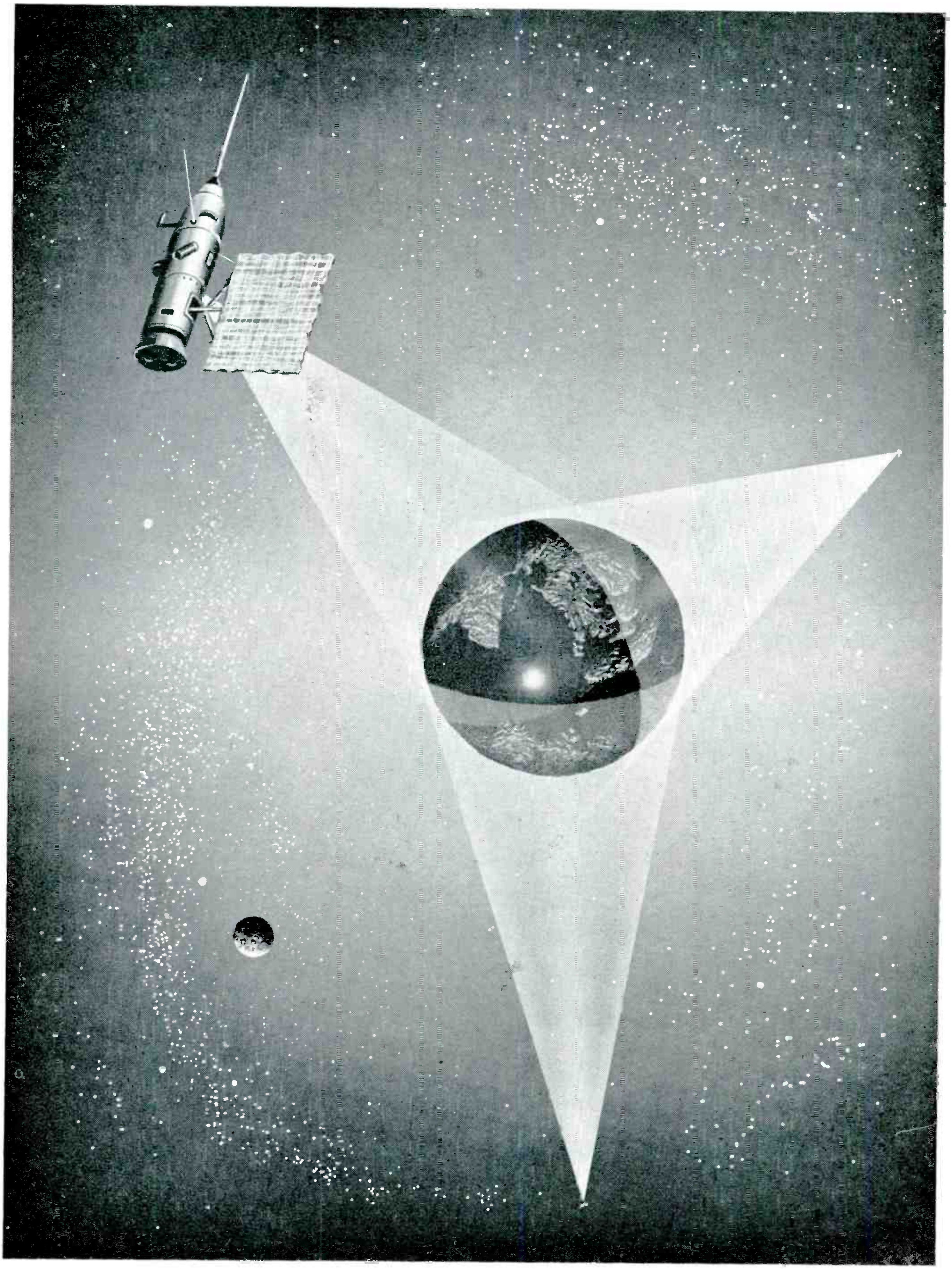
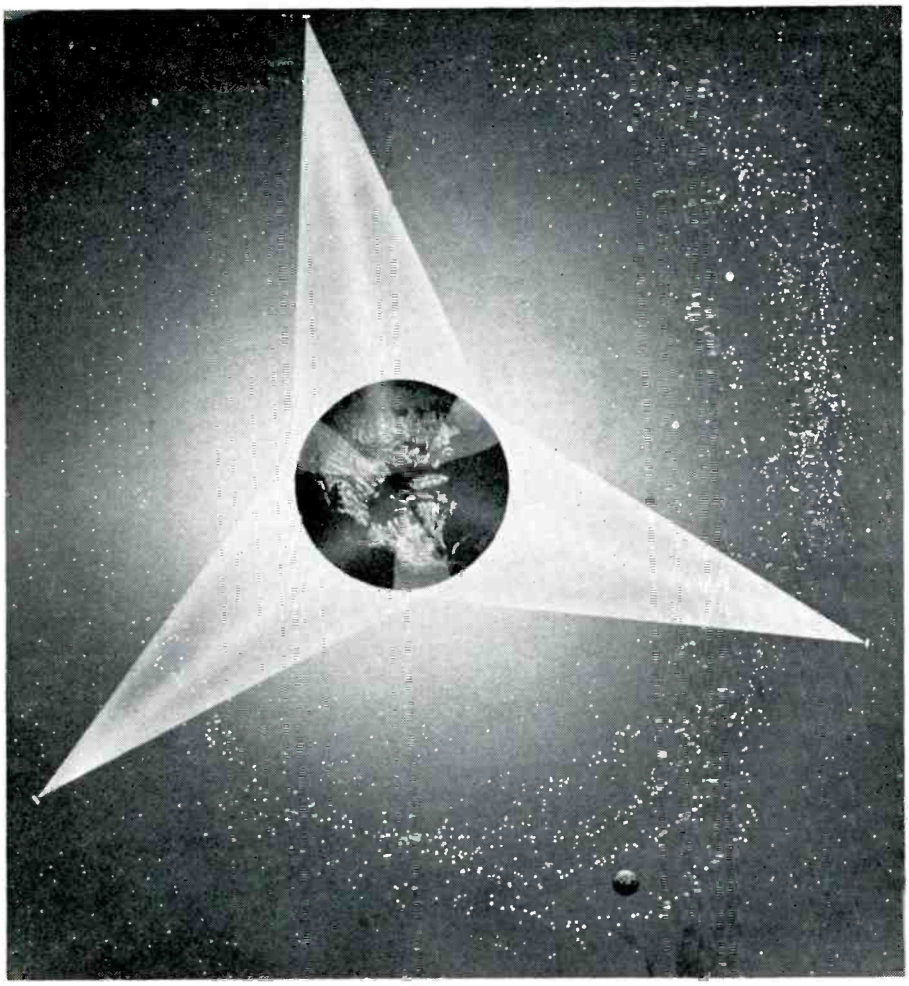


WORLD-WIDE TELEVISION

By HENRI G. BUSIGNIES
President, ITT Laboratories

Reprinted from "Industrial Research Magazine"



"EARTH NET" system would blanket the entire globe from three satellites launched in an equatorial orbit. The overlap areas would be planned to coincide with ground stations. These would "see" two satellites at the same time, reducing the need for inter-satellite communications. The proposed screen of plastic slats at left contains solar cells to produce 1,000 watts—both to transmit power and to charge the batteries for the shadow portion of the orbit.

WITHIN a generation, world-wide television will be as commonplace as continental TV is today.

In many instances, space satellite transmission of television and other signals will tie into existing methods of communication—the pathways of exchange of intelligence. One of these pathways—relatively new in itself — is "over-the-horizon" transmission.

The start of this year saw a dramatic demonstration of how O/H, linking two nations across a broad expanse of sea, brought to the people of the United States the stirring climax of Cuban revolution. Cameras on the streets of Havana transmitted the live picture, at the moment it was happening, to the U. S. via the O/H link between Cuba and Florida.

Less than two years ago, this kind of instantaneous communication of living history from Cuba could not have been possible. Even today, it is the only operation of its kind in the world. It was made possible by tropospheric O/H transmission, a development that has many other applications.

Beyond the Line of Sight

O/H is a sort of big brother of microwave communication over line-of-sight paths, a method which now is a familiar, conventional means of transmission within the United States and elsewhere in the world of telephony, radio and television programs. One essential difference between line-of-sight and O/H, of course, is the former's limitation; its effective range is approximately 30 miles. But a broadband, tropospheric communication system may span 250 miles or more.

O/H can be used effectively not only for television (it has demonstrated a very high efficiency), but also for such manifold purposes as high-quality telephone circuits, transmission of facsimiles, and the operation of pipelines by remote control.

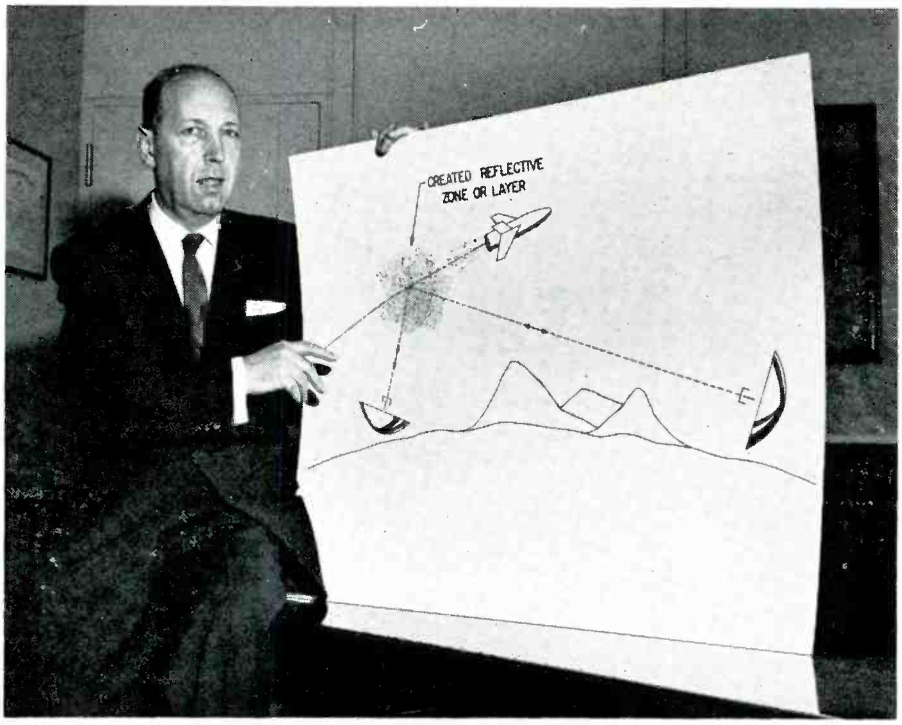
The Cuba-Florida link makes use of tropospheric forward scatter of microwaves far beyond the optical horizon. Some signals, beamed upward and forward from a powerful transmitter, pass through the troposphere, some 10 miles up, and move out into space, but other signals are scattered forward to be detected by sensitive receivers, amplified, and retransmitted to a television station that broadcasts the program.

Tropospheric scatter, which occurs relatively close to earth, produces signals of usable quality over distances of a few hundred miles. Because it is applicable to a wide range of frequencies, it is possible to obtain a large number of channels for such wide-band communications as multichannel telephony as well as television.

The troposphere is not a smooth mirror, fixed in space. Rather, it is a broad region from which electromagnetic waves are scattered in an irregular manner, varying from one moment to the next. This turbulence, or irregularity, poses a problem because a single transmission over one O/H microwave path can be affected by short-term fading. This is overcome, however, by operating two or more transmissions in parallel, and the received signals are combined to give one smooth signal of commercial quality.

This principle is inherent in the operation of the 185-mile Cuba-Florida link, developed by IT & T, and now operated with AT & T.

Like giant, modern-day screens of the drive-in movie theaters—which they resemble at first glance—two 60-foot paraboloid antennas rear their heights at each end of the Cuba-Florida link. Each antenna receives and transmits simultaneously.



COMMUNICATION CAROM — A long distance communication system employing man-made clouds as microwave reflectors was patented recently by Henri Busignies, president of ITT Laboratories, Nutley, N. J., research division of International Telephone & Telegraph Corp. Clouds of metallic chaff or ionized materials could be expelled through aircraft exhaust, as shown in drawing. System would increase range and improve quality of radio signal.

This means transmission on a single frequency is received from the troposphere over two paths, so in the event of fading on one path, the signal still is received on the second. Similar results are obtained by using frequency diversity (in which the signal is transmitted on two different frequencies).

On the Cuba-Florida link, which operates on 10-kw of power, in the 700-900 megacycle range, both space and frequency diversity systems are used — quadruple diversity — to assure best possible reception. Each antenna feeds into two receivers, then into a combiner, which automatically produces a high-quality, commercial signal.

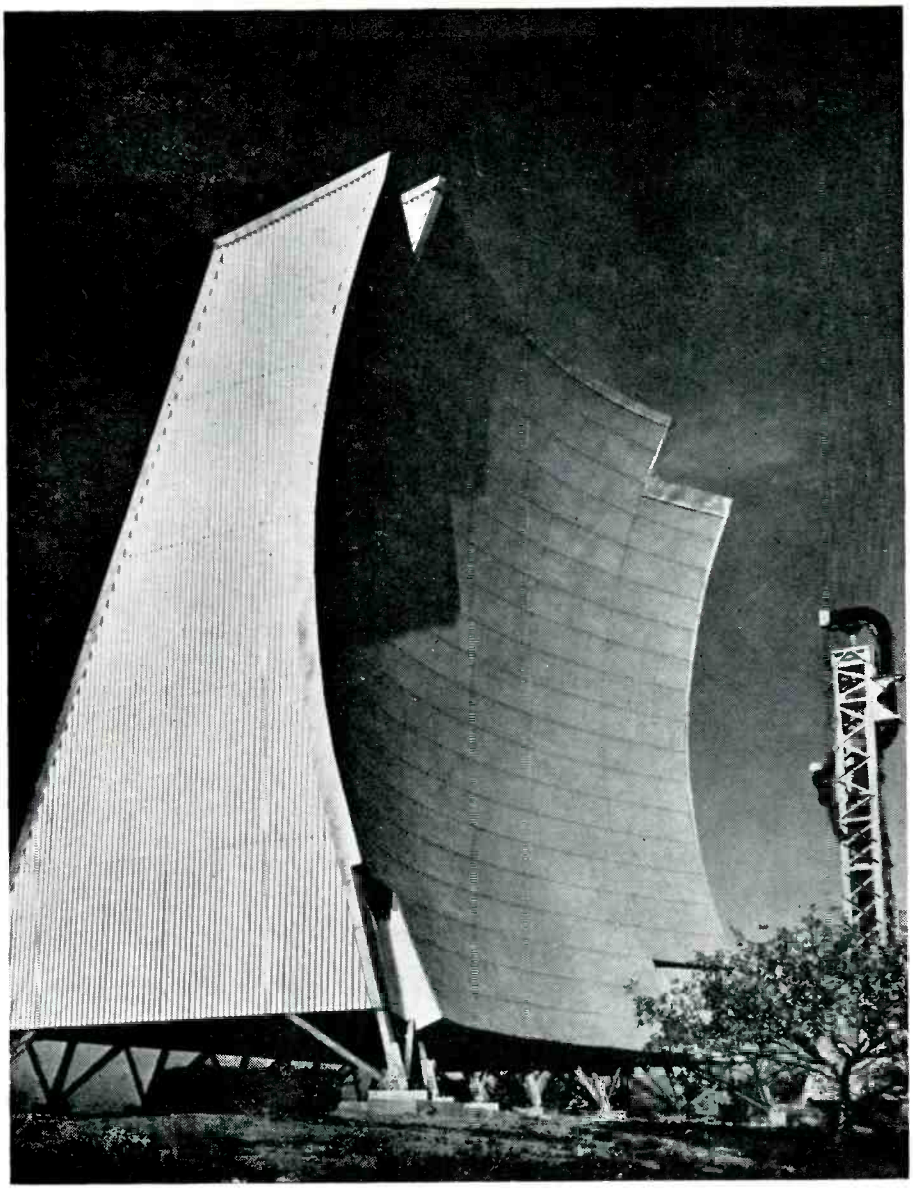
Applications of O/H

Operating in the ultra-high frequencies, O/H extends man's ability to jump electronically over areas that have been communications blocks before: great stretches of water, impenetrable jungles, morasses incapable of providing a solid base of construction, and the many remote and mountainous regions of the world.

This opens up a new vista for many undeveloped sections of the world, and lowers operating costs in out-of-the-way places. Maintaining manpower at pumping stations of a desert pipeline, for example, represents a considerable cost factor. Housing must be created for the crews; food and water must be delivered at regular intervals.

O/H transmitters and receivers could be installed at intervals of a hundred miles or so. These transmitters would relay constant information on the rate of flow of oil or gas through the line. The headquarters then could electronically order any pumping station to speed up, slow down, or stop, as the need arises.

All this would be accomplished without a human hand at the pumping station controls, with consequent savings in construction of buildings to house maintenance personnel, in food and water supplies and in the cost of personnel. This is only one demonstration of how O/H can function efficiently and achieve economies in inaccessible areas.



"WHITE ALICE"-type antennas, 60-feet high, are used in the broad-band, over-the-horizon microwave link for the first direct television service between Florida and Cuba. In Alaska, the White Alice system not only provides a defense network, but is accelerating expansion of the new state.

It may seem a far cry to relate O/H to something so common as the movements of tourists. Yet the changing habits of the traveling public create pressures that have a definite relationship.

Anticipating this, consideration now is being given by one Mexican company to the establishment of a new communications link by O/H. The system would leap some 180 miles across the Gulf of California from La Paz, near the southern extremity of Lower California, to Culiacan on the mainland of Mexico. From Culiacan the communication link could feed into existing lines northward to the U. S.

There are other examples of how the movement of peoples, even on a transient basis, creates a need for better communications.

In one area of Mexico, one company is in the process of developing new fields which lie in tangled jungle country. Existing very-high-frequency radio communication has proved unreliable because of high degree of fading. A considerable amount of vital information is flown from the field by small planes to the company's headquarters some 250 to 350 miles away. This is slow and uneconomic. Consideration thus is being given to an O/H jump across the jungle in one hop.

Technically, it now is possible to extend transmission of television to South American nations. The question is one of economics, of need and demand. Mexico, for instance, has considered establishing an over-water link with the United States, in addition to moving across land to the north.

This could be realized by O/H links from Mexico City to Yucatan, then by water hop to Cuba, tieing in with the already existing Cuba-Florida link. Similarly, Mexico City could be joined with the United States by a series of O/H stations, providing 200 voice channels, stretching across 1,500 land miles to the border.

The Arctic DEW Line

O/H plays an important defense role as an integral part of the Distant Early Warning System stretching across the Arctic. This DEW line of defense against enemy aerial attack extends its electronic arms 3,000 miles from Cape Lisburne on the northwestern shores of Alaska to Cape Dyer on the east coast of Baffin Island. The western anchor faces Siberia; the eastern terminus looks across Davis Strait toward Greenland.

One of the great advantages of O/H transmission in this ingenious system of defense is that it is well-protected against jamming by the enemy. It is not readily susceptible to injection of false information into the transmission, a vital prerequisite.

When the DEW line was established, its function was to detect, from 200 miles away, strategic bombers moving at 600 mph. New moves are underway now to improve the detection system to enable even earlier discovery of supersonic planes.

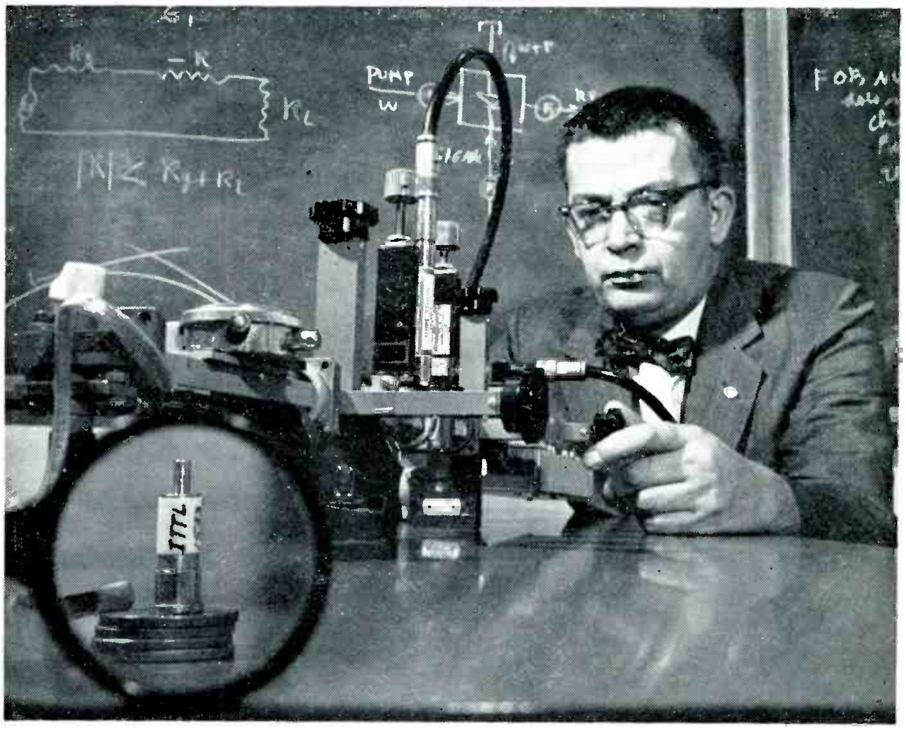
Alaska can boast of a statewide communications system that employs the O/H technique. This is the $140-million Integrated Communications System, Alaska—more commonly known by its code name, "White Alice." It provides not only a defense network, but also a public communications facility throughout rugged, inaccessible areas.

Before the development of this network, large areas were without telephone or telegraph service. A message for Fort Yukon might reach Fairbanks and wait there a week or more for a bush pilot to fly it to its final destination only 180 miles north. Now, within minutes, it is possible to reach New York from the most remote points in Alaska. This kind of improved communication will have great influence in accelerating expansion of the state.

Development of oil discoveries on the Kenai peninsula is one good example. Swift communications make possible replacement of vital equipment at the time it's needed. And the advance of communications has helped in the growth of communities where less than three years ago there was little sign of human life.

The importance of O/H as an integral part of military communications is emphasized in other parts of the world.

A case in point is the need for reliable communications among the European nations of the North Atlantic Treaty Organization. NATO has commissioned the Supreme Headquarters Allied Powers Europe (SHAPE) to build a new command communication network of tropospheric and conventional line-of-sight radio stations from



William Sichak, director of Radio Communications at ITT Laboratories, Nutley, examines the newly developed "low-noise" or parametric amplifier for over-the-horizon microwave radio links. Heart of the amplifier is a minute silicon diode, perched atop a "penny-platform" in the foreground. According to Sichak, the amplifier can add one hundred miles to existing radio links or cut transmitter power requirements 90 per cent. The device can "turn up the volume" in a radio receiver without amplifying noises within the equipment itself. Sichak, who is in charge of radio communication activities at the International Telephone & Telegraph Corp., lives at 24 Evelyn Place, Nutley, with his wife and two daughters.

Paris northward by way of England and Denmark to northern Norway, and southward by way of Italy and Greece to eastern Turkey, with feeder lines from Germany, Belgium, and other key points along the way.

Project ACE HIGH

Prime contractor for planning, engineering, and installing the new system, known as Project ACE HIGH, is International Standard Electric Corp., ITT's overseas management subsidiary. Hycon Eastern Inc., under a directed sub-contract, serves as an independent engineering consultant to SHAPE.

The building of the complete SHAPE network has been described as a "complex and challenging assignment" because of the varied sources of supply, the vast and sometimes rugged terrain it must cross, the necessary adjustments of international radio frequencies, conflicting local and national interests, and employment of personnel from many countries. When completed, it will be the largest integrated military communication system ever designed and constructed as a single project; it will be the largest tropospheric scatter system in the world; and it will provide instant communication among a multiplicity of nations.

O/H also is being used to link American air bases in Spain and in Spanish Morocco — an across-the-water hop over the Straits of Gibraltar. This 215-mile ITT-developed system carries both telephony and telegraphic messages. Similarly, the first O/H voice circuit in Europe came into being in September, 1957, between Spain and Italy, connecting Sardinia and Minorca, a distance of 230 miles over the Mediterranean Sea.

Underway now are new developments — and plans — which can increase the effectiveness of O/H still further. Only recently, ITT labs obtained a patent on a system to create man-made reflectors high above the earth.

An Artificial Ionosphere

Under this system, "mirror" zones or layers would be created by shooting reflective material from earth by cannon or guided missile — or by carrying the material aloft by balloons or airplanes and releasing it. These materials could include metallic chaff, nitric oxide, or ionized gas.

Still another method would use a powerful emitter of very short waves to ionize a zone in the atmosphere. When nitric oxide is released in daytime, sunlight acts upon it to form a dense cloud of electrified particles, creating a reflective layer. This reflective layer can be tracked from earth and replenished as the need arises. So, the reflective layer can be controlled.

Such a system would increase the range of existing transmission and improve it by overcoming tropospheric interference.

ITT also has developed a new low-noise "parametric" amplifier. It frequently will enable an O/H hop to be extended another hundred miles, because it can increase the received signal without increasing radio noise.

This development, utilizing a new silicon diode, can promote other economies. As an alternative to increasing the range of the signal, for example, the parametric amplifier enables a cut in broadcast power by as much as 90% while still maintaining the same service. Furthermore, the amplifier has significant applications to receiving signals from space satellites.

When the Pioneer IV space probe was launched past the moon and toward an orbit around the sun, the parametric amplifier added more than 150,000 miles to the range of equipment at Redstone Arsenal used to track it.

These were experimental trackings for comparison purposes. Shortly after launching, the Redstone station, without the parametric amplifier, could not pick up the Pioneer signal after 50,000 miles. With the amplifier, the space probe was tracked for 37 hours to a distance of 215,000 miles when the tracking test was discontinued. At that time the signal strength was weaker than — 158 dbm (decibels relative to one milliwatt). The strongest signal received at Redstone was — 143 dbm.

Much data already have been transmitted from space to earth: on the composition of "near space," the density of micrometeorites, temperature controls, and even biological information on the Russian dog Laika.

The band of intense radiations discovered recently through satellite probes by Dr. James A. Van Allen, University of Iowa space scientist, is related closely to the aurora borealis. Now the puzzle of what causes auroras which blackout long-distance radio transmission practically is solved.

Weather by Television

In recent years, radar has played an important role in plotting the advance of tornadoes, hurricanes, and other storms. But the achievement has been minor compared to the potential in satellites.

With TV satellites scanning the earth, or in "fixed" positions with respect to it, meteorologists will be able to view the total interplay of natural forces simultaneously. The economic value would be enormous. One estimate made by a congressional committee is that better weather predictions resulting from this kind of observation would result in savings of about $4 billion a year in the U. S. alone. These savings would be effected in improved planning of crops, distribution of weather-affected goods at a time and place where they'd have the greatest demand, and better warnings of hurricanes and other storms.

A project initiated by the Advanced Research Projects Agency has as its goal the launching of a meteorological satellite to orbit about 300 miles above the earth. Observations of weather-in-the-making would be made by compact television cameras developed by Radio Corp. of America. The pictures would be stored on video tape, then transmitted to earth on command from a ground station. Within a few minutes after the pictures have been taken they would be available for use with other information collated by a data processing center, then immediately distributed, within an hour or so.

Satellites also hold the prospect of better navigation. The scientists of the Applied Physics Laboratory at Johns Hopkins University and at the Naval Ordnance Test Station at China Lake, Calif., are developing a system utilizing a three-foot satellite in a polar orbit about 1,000 miles above the earth. A transponder inside the satellite is planned to receive, amplify, and retransmit a radio signal.

A ship's navigator, referring to a table listing the satellite's position at any given time, would know when the satellite was within range of the surface craft. A signal broadcast from the ship would be rebroadcast by the satellite.

Then, by checking the table for position of the satellite and measuring echo time of the returned signal, the navigator could plot a line-of-position. By making a second observation a short time later, he could establish his location. The system will eliminate dependence on star sighting, a present disadvantage during the daytime and on overcast nights.

The 3-Satellite System

Global communications via satellites might well be achieved within two or three years. One proposal that shows promise is ITT's "Earth Net Dialing" system for telephone and TV transmission.

The successful orbiting of the 8,500-pound Atlas was dramatic demonstration of the use of voice channels from a space satellite — the forerunner of tomorrow's network, operating even farther out in space. The Defense Department hopes to launch the first of such satellites perhaps by late 1960, followed by others to create the space network.

Such a network could be achieved by establishing three unmanned satellites 22,300 miles in space. They would be launched in an equatorial orbit, and spaced 120 degrees apart. At the prescribed altitude, the satellites would appear to be in fixed positions relative to the earth because their angular speed would be made equal to that of the earth. Signals from each satellite would blanket almost half the earth (as illustrated on page 17), each overlapping the other.

This system might be capable of handling 30,000 one-way voice circuits, or 15,000 two-way voice circuits, plus three television networks. It also would be capable of transmitting facsimile, high-speed code, or teletype messages.

Since each hemisphere would overlap another, stations in these overlap regions would act as inter-hemisphere relay points.

Ground stations in the overlap areas would be able to "see" two satellites at the same time, and to communicate with them directly, receiving messages from them and servicing other ground stations in two adjacent hemispheres.

These overlap areas would coincide with regions of high communication activities on earth. By establishing the ground stations in the overlap areas, the need for inter-satellite communication is reduced, since there will be immediate access to two-thirds of the earth via any two satellites from ground positions in the overlap areas.

As part of this world-wide system, a central switching control center would be established. Stations in each hemisphere continually would feed information into this center, electronically describing the status of their circuits. The data could be analyzed swiftly by a digital computer. Then the center would send commands to the sending station to use specific circuits for its message and at the same time tell the receiving station what circuits it must use for the incoming call. Thus evaluation, commands to the stations, and completion of the call would be accomplished within seconds from any part of the world.

Solar Batteries

The satellites might be powered by solar energy collected with a 10 x 10-foot flat square of plastic slats. The slats, hinged at the edges, could contain solar cells to produce 1,000 watts of energy. This source also would charge small batteries to provide power through the small part of the orbit when the satellites are in shadow.

Transmitting power would be in the area of 50 to 100 watts. Signals would be received and transmitted by small antennas bolted to the bottom of the satellites. These would be oriented constantly by ionic or plasma motors toward the earth. The antennas, with a beam width of 25 degrees, would operate on a typical carrier frequency of perhaps 6,000 megacycles. The total bandwidth available to give overall service, including television, could extend readily beyond 100 megacycles.

The use of a three-satellite system in relatively fixed position to earth presents a universal solution to world-wide communications that a single satellite cannot offer.

Other Satellite Systems

A single satellite of a delayed-transponder type would suffice only for a so-called "mail delivery" system. The satellite would receive and store a message as it travels over New York. As it passes over Paris, for instance, it would deliver its message on command. If the recipient were on hand — and the reply could be sent to the satellite immediately, then that answer could be delivered to New York — again by command — an hour and a half later.

This delayed system would be acceptable for relay either by voice or by letter-message, but not for instantaneous transmission of television, teletype, or two-way voice communication.

It also has been suggested that passive satellites in a fixed position to earth would be effective. But some control system would be indispensable to prevent their drift, or else a large number of them would have to be in orbit to insure availability, either at 22,300 miles or circling the earth at shorter distances. Since the satellites would act only as reflectors, this would require large transmitted power by earth stations in the region of 100 kilowatts or even megawatts, depending on the capacity of the system.

But whether passive or active, these space stations would have relatively light weight. The size of the entire payload would be less than that of an office desk. It is this miniaturization — this ability to launch them with existing rockets — that promises an early answer to the quest for global communications.

A METHOD OF COMPATIBLE STEREOPHONIC BROADCASTING FOR FM STATIONS

By

ELLWOOD W. LIPPINCOTT*

THE METHOD or system of compatible stereophonic broadcasting to be described is outlined in Figure 1. This system has several several outstanding features which make it superior to other systems or methods. They are:

(1) Complete compatibility with monaural receivers.

(2) Full fidelity in both right and left channels.

(3) Improved signal to noise ratio.

(4) Greater range or coverage.

(5) Simplicity.

(6) Lower costs.

Two separate amplifiers have fed into their inputs the right and left channels of a stereophonic pickup. The outputs of these two amplifiers are connected in parallel but controlled by an electronic switch which alternately feeds to the modulator of the transmitter a small pulse or sample of the audio of each channel of the stereophonic pickup. Switching between the two channels is at a rate faster than the frequency of the highest audio signal to be transmitted (about 15,000 cycles), in practice about 100,000 cycles.

The alternate samplings of the two channels are fed into the broadcast transmitter. Thus, the signal broadcast contains information from both the right and the left channels of the stereophonic pickup in equal amounts and, because of this, is compatible on any FM radio receiver tuned to the transmitting frequency.

At the receiving end the discriminator output of alternate right and left channel pulses is fed to the grids or inputs of a two amplifier-speaker system. An electronic switch operating at the same switching frequency as the switch at the transmitting point feeds alternate samples or pulses of recovered audio to the amplifier-speaker chains for reception of right and left channels.

The electronic switch at the re-

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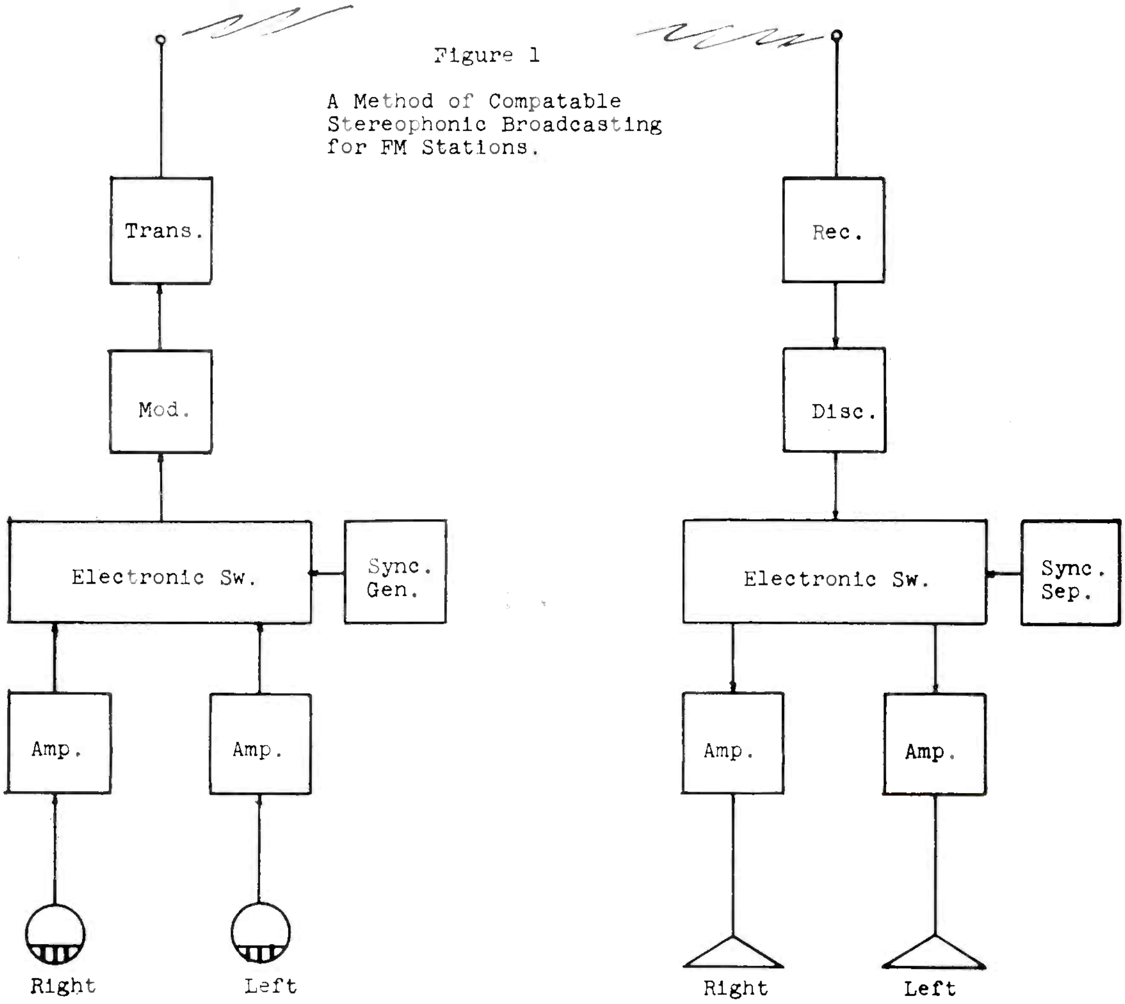

Figure 1

A Method of Compatable Stereophonic Broadcasting for FM Stations.

ceiving point must operate in synchronization with the switch at the transmitting point or the stereo effect will be lost. Synchronizing of the transmitting and receiving switches is accomplished by connecting a sync. generator into the transmitter and a sync. separator into the receiver.

This synchronization makes it possible to distribute the proper pulse for its duration to the proper channel in the amplifier-speaker system, thus recovering the full stereo effect at the receiving position. Any FM receiver without the stereo adapter, consisting the electronic switch and the sync. separator, would receive the transmitted signal in full fidelity as a two microphone monaural pickup of the program material.

In the method just described the signal-to-noise ratio remains exactly the same whether broadcasting stereophonically or monaurally as both the right and left channel information can modulate the transmitter 100 per cent for a 75 Kc swing. Therefore, the full coverage pattern of the broadcast transmitter can be maintained whether broadcasting stereophonically or monaurally.

Both the right and left channels of the transmitted signal would be capable of handling the full frequency range of 30 to 15,000 cycles for true high fidelity.

The simplicity of the system dictates a minimum cost at both the transmitting and receiving ends.

Further, if desired, additional programming by one or two multiplex channels could be broadcast along with the stereo programs at some loss of the high signal-to-noise ratio on the main channel but permitting both stereo and additional multiplex services such as background music or storecasting.

AMENDMENTS AND PROPOSED CHANGES OF REGULATIONS

DAYTIME BROADCAST STATIONS

Report on Inquiry Into Hours of Operation

In the matter of inquiry into the advisability of authorizing standard broadcast stations to operate with facilities licensed for daytime operation from 6:00 a.m. or local sunrise (whichever is earlier) to 6:00 p.m. or local sunset (whichever is later); Docket No. 12729.

1. On January 12, 1959, the Commission instituted an inquiry pursuant to section 403 of the Communications Act of 1934, as amended, in the above entitled matter (FCC 59-11; 24 F.R. 375) with reference to the hours of operation of broadcasting stations licensed to broadcast during the daytime hours, i.e., between local sunrise and sunset. The Notice of Inquiry invited the filing of comments by interested parties concerning the service gains and losses which would result from permitting daytime stations to operate from 6:00 a.m. to 6:00 p.m. regardless of any nighttime skywave interference occurring during this time segment. The sixteen issues set forth in the Notice are attached as Appendix III. The time for filing comments was set for April 8, 1959, and was, upon petition, extended to May 8, 1959. Comments were filed by the later date.

2. Earlier the Commission had given consideration in a rule making proceeding (Docket No. 12274) to a petition of the Daytime Broadcasters Association requesting that the rules be amended to license daytime stations to extend their broadcasting during such nighttime hours as may occur between 5:00 a.m. and 7:00 p.m. Denying the petition, the Commission decision (FCC 58-891; 23 F.R. 7488, September 19, 1958) held the record conclusively demonstrated, in view of the tremendous losses which would result to the existing radio service throughout the United States from the operation contemplated by the petition as compared with the much smaller amount of new services which would be provided in some locations, that the proposal failed "to accord with the statutory standards governing radio broadcast services". Thereafter, the Inquiry herein was instituted simultaneously with a denial in part and dismissal in part (FCC 59-10) of the petitioner's request for reconsideration of that action. The petitioner's request for reconsideration had also requested, as an alternative to the earlier petition, the licensing of daytime stations to operate during such nighttime hours as may occur between 6:00 a.m. and 6:00 p.m., the time segments considered herein.

3. Under the Communications Act of 1934, as amended, the Commission may, with certain exceptions not relevant here, grant licenses only upon written applications which are required to set forth, among other things, the hours of the day during which it is proposed to operate the station. Each initial license granted for a station and each renewal of license which is granted specifies the hours during which the station is authorized to operate and the hours so specified, with the exception of certain provisions of the existing rules as discussed below, are the maximum hours during which any station may be operated under its license. In accordance with § 3.23 of the rules, standard broadcast applications may now be filed and stations may be licensed for various hours of operation which include:

(1) Specified hours which permits operation during the exact hours specified in the license;

(2) Sharing time, which permits operation during the hours shared with one or more other stations using the same channel;

(3) Daytime, which permits operation during the hours between average monthly local sunrise and sunset;

(4) Limited time which permits operation during daytime and until local sunset if located west of the dominant station on the channel, or if located east thereof, until sunset at the dominant station and, in addition, during nighttime hours if not in use by the dominant station or stations on the channel; and

(5) Unlimited time, which permits operation without a maximum limit as to time.

4. Prior to April 13, 1940, the rules and regulations for the licensing of broadcasting stations (section 84) which had first been promulgated by the Federal Radio Commission defined the term daytime as the period of time between 6:00 a.m. and local sunset. Thus the rules then provided that the broadcast day for daytime stations began at 6:00 a.m. However, during the winter months, this was considerably prior to local sunrise, causing rather serious interference due to nighttime propagation conditions prevailing, while during the summer months sunrise occurred considerably before 6:00 a.m. This rule was amended on April 13, 1940 (5 F.R. 1449), to specify local sunrise in place of 6:00 a.m. However, § 3.87 of the rules adopted June 10, 1940, contains provisions which permit program transmissions prior to local sunrise, beginning at 4:00 a.m. local standard time by daytime stations, except certain Class II stations, with their authorized daytime facilities where such operation does not cause undue interference. See Music Broadcasting Company v. Federal Communications Commission, 95 U.S. app. D.C. 12, 217 F. (2d) 339, 11 Pike & Fischer R.R. 2025 (1954): and In re Music Broadcasting Company, *et al.*, 15 Pike & Fischer R.R. 547.

5. The differences in station interference between daytime and nighttime operation are well recognized, and comprehensive reference has been made thereto in the Notice of Inquiry. Briefly, and of greatest import here, skywave service and interfering signals are propagated over great distances respectively, at night on the clear and shared standard broadcast channels, as distinguished from the essential absence thereof during most daytime hours of the solar diurnal arc. This fundamental difference in natural radio conditions is an appropriate consideration in carrying out the provisions of the Communications Act which provide for efficient, fair, and equitable distribution of radio service.

6. The Notice of Inquiry stated with respect to the increasing number of daytime stations:

The licensing of daytime stations has increased from 84 in 1946 to approximately 1,400 in 1958. Approximately 650 applications seeking daytime facilities are pending, ranging in power up to 50 kw. In addition, more than 350 applications for unlimited time operation are pending which propose, by use of directional antennas and reduced power, the avoidance of transmissions of interfering skywave signals during non-daytime hours. The filing of both kinds of applications is continuing at a substantial rate.

and:

All parties are hereby placed on notice that the Commission in its deliberations on this matter will take into consideration the applications for new daytime and fulltime station.

The number of standard broadcast stations authorized as of March 1, 1959, listed by type of channel and hours of operation, is shown in the attached Appendix II.

7. Substantial engineering data were filed showing the service gains and losses. Much of the data have been tabulated and are attached as Appendix I. It shows that, if all present daytime stations were to extend their hours of operation from 6:00 a.m. to 6:00 p.m. there would be substantial losses of existing groundwave services, new white areas would be cre-

ated in the vicinity of communities which are now served by unlimited time stations on the same frequencies, the resulting service areas of the daytime stations would be meager, and skywave service would be lost. While the losses would be most severe in rural and small urban communities a substantial number of regional stations would not even serve the entire community to which they are licensed. The effects of "6 to 6" operation do not differ appreciably, during the time segments involved, from the 5:00 a.m. to 7:00 p.m. operation considered in Docket No. 12274.

8. It is shown by the data that the interference to the present service would not terminate at 6 o'clock except for areas in the Pacific standard time zone even though the interfering stations ceased their operation at 6 o'clock local standard time. This results from the time zone changes whereby 6 o'clock in the Central Time Zone is 7 o'clock Eastern Standard Time; 6 o'clock in the Mountain Time Zone is 8 o'clock Eastern Standard Time and 7 o'clock Central Standard Time; and 6 o'clock in the Pacific Time Zone is 9 o'clock Eastern Standard Time, 8 o'clock Central Standard Time, and 7 o'clock Mountain Standard Time. Thus, a station operating until 6 o'clock in the Pacific Standard Time Zone would transmit skywave interfering signals which would endure until 6 o'clock, 7 o'clock, 8 o'clock, or 9 o'clock, local time, depending upon the location of the service areas affected. Considering the operation of interfering stations in each time zone, the duration of interference to existing service would thus extend from local sunset to 9 p.m. Eastern Time, 8 p.m. Central Time, 7 p.m. Mountain Time and 6 p.m. Pacific Time. The correlate of this sequence would occur during the pre-sunrise morning hours, beginning at 3 a.m. Pacific Time.

9. Data currently available are necessarily confined to interference resulting from the operation of existing stations. The prospective effects are necessarily somewhat speculative. The rate of increase of daytime stations and applications clearly shows a strong continuing demand and in addition the eventual lifting of the freeze will undoubtedly accelerate the filing of daytime applications. It thus appears, based on present licensing and reasonable expectancy of future development, that until 9 p.m. Eastern Standard Time all skywave service would be entirely destroyed and groundwave service severely limited on most of the 107 standard broadcast channels. (Only the six local channels would be unaffected.)

10. The views and opinions expressed in the proceedings are substantially similar to those expressed earlier in Docket No. 12274. The Daytime Broadcasters Association, however, now urges "That the Commission—on an interim and experimental basis—authorize the operation of daytime only stations from 6 a.m. or local sunrise (whichever is earlier) to 6 p.m. or local sunset (whichever is later) for a period of two years." In support it is urged that the basic problem may in this manner be resolved "not by theoretical data but by the actual results." No reason appears, however, to question the accuracy of the physical and engineering data on which the Commission's rules are bottomed, and no further showing has been made to bolster the views expressed earlier that additional hours should be granted daytime stations on the basis of present need for local service despite the resulting interference.

11. Other parties commenting have made the point that the specified hours of operation now provided by § 3.23 of the rules are not delimited to the daytime or nighttime hours. Thus applications filed under the existing rules may propose operation from 6 a.m. to 6 p.m. It is urged that the present rules are thus entirely adequate for the determination on a case by case basis of the merits of any application proposing operation during these hours. The Commission could in this manner appropriately evaluate the extent of the service proposed and the interference which may be caused. This, it is asserted, is necessary in any event in view of the fact that the merits of the present daytime operations have been evaluated solely under daytime transmission conditions with no other evaluations to meet the statutory tests for licensing.

12. The Notice of Inquiry stated:

In the pleading and comments filed heretofore in Docket No. 12274, DBA and other advocates of extended hours for daytime stations have asserted that there is a large unsatisfied need for local service during pre-sunrise and post-sunset hours. Of particular significance, states DBA, is the fact that in the United States 913 communities, with a total population of more than 7,300,000, have available to them no locally licensed radio outlet other than daytime-only stations.

13. With further reference to the communities referred to in the Notice of Inquiry, one party filing comments supplied additional data secured through a more detailed study of the records publicly available which show that the problem concerning adequacy of nighttime radio service to the people residing in these communities is not so severe as might appear from a more cursory examination. The detailed data show that a count of the communities listed totals 912: that 357 or 39.1 per cent with a population total of 1,761,622 do not receive nighttime groundwave service from any stations; that 218 or 23.9 per cent with a population total of 1,684,026 receive nighttime groundwave service from one station; that 337 or 37 per cent with a population total of 5,218,854 receive nighttime groundwave service from two or more stations; and that many of the communities are nearby suburbs of well-served metropolitan areas.

14. As there is no practicable basis for increasing the number of standard broadcast channels, the only way in which more stations could be accommodated to provide additional services during the additional hours would be to increase the number of stations on these channels or by extending the hours of existing daytime stations. Under the Communications Act, however, and in principle it is clear that such should not be done at the expense of the broadcasting services now being effectively rendered during these hours, which would result in a severe loss of broadcasting service to the public. This is not to say, of course, that local nighttime operation might not be licensed in various of these communities where applications to be filed proposing operation which meets the appropriate criteria with reference to interference and other considerations whereby the Commission might find that the nighttime operations proposed could serve the public interest or could better serve the public interest than would other pending proposals.

15. The Notice of Inquiry posed the consideration:

Would it be feasible for daytime stations, if operating after sunset, to reduce power sufficiently at sunset and before sunrise to limit interference to other stations to the daytime level? If so, how much service would be provided with such reduced radiation?

The data, however, show that in the main the resulting interference would preclude the affording of a satisfactory measure of service by daytime stations if operating after sunset even with no reduction in power. Any substantial reduction in power during these hours designed to reduce the degree of the interference which would be caused to the groundwave service of unlimited time stations would further diminish the coverage of the daytime stations. The greater susceptibility of skywave service to interference and the great distances to which such service extends in the absence of interference makes exceedingly problematical any benefits which might be secured to skywave service through power reduction by the interfering stations. Thus it appears that power reduction poses only an extremely limited potential for alleviating the inetrference problem. Moreover, under the existing rules, Class II, III and IV stations may be licensed to operate with power as low as 0.25 kilowatts, 0.5 kilowatts, and 0.1 kilowatts, respectively and, with the exception of the Class IV stations, these stations may make use of directional antennas for the reduction of interference by limiting radiation in certain directions, although permitting full radiation in other directions in order to provide maximum service. Thus the provisions of the present rules appear adequate in this respect.

16. With reference to the proposal set out in paragraph 10 above, that experimental operation should be authorized during the time segments here considered, for a period of two years, and the view expressed in support thereof that an asserted deficiency in the Commission's licensing of hours of operation of standard broadcast stations would thereby be corrected; we believe it appropriate to observe that somewhat similar arguments of deficiency in the applicability of the Commission's rules and engineering standards for the licensing of stations have been made by some parties in other proceedings with reference both to the hours during the sun's nocturnal arc with which this proceeding concerned and to other time segments of the broadcast day, and these arguments have been or will be ruled upon in those proceedings. Finally, we believe it appropriate to observe, in view of the broad and widespread nature of the suggestion which has been made for experimental operation, that in those cases where experimentation may be warranted and desirable, for reasons not present here, the experimentation should be appropriately limited in scope and duration and so pointed in purpose as to secure the desired data with a minimum of disruption of the existing radio services which are otherwise in the public interest. We believe the general and universal basis for experimental operation suggested here fails also to meet that standard.

17. In the issues pointing out a number of problems involved, in the Notice of Inquiry, several issues were designed to solicit meaningful consideration in certain areas which would be brought into focus only in the event that it should otherwise appear some extended hours of operation would be meritorious. Examples of these are the effects upon the CONELRAD operation, upon the development of FM broadcasting, and upon the operations of stations in other North American countries. These and other similar issues require no resolution in view of our decision herein.

18. The Notice of Inquiry posed for consideration:

(a) What effect would the new services gained have on reception of needed and valuable programs by persons who are advantaged by such reception, including emergency and weather information, farm information, national and local news, programs and announcements concerning local affairs and local organizations?

(b) What effect would the limitation of service through destructive interference have upon access to events of national and regional interest and to programs of a type which cannot be originated by local communities, and other needed and valuable transmissions now available under the existing allocation rules?

19. Upon a careful review of the comments which have been filed, and a review of our decision in Docket No. 12274, we conclude that the losses of standard broadcast radio service, both groundwave and skywave, in the various areas affected, which would result from an extension of the hours of operation of stations licensed for daytime operation must be determinative herein. We are unable to find an expression of any local need which is impossible of substantial fulfillment under existing rules for station licensing and which is so great or so pressing as to warrant widespread disruption of the existing radio service now enjoyed thereunder and relied upon daily by millions of citizens. Particularly, would it be undesirable and unwarranted to permit such disruption in those instances where the result as shown by the data would simply be the taking of regular service from rural farm areas and from small urban communities, which need radio vitally, and giving more stations—serving less area—to city and principal urban areas which are already relatively well supplied not only with standard broadcast programs but with other facilities for relaxation, intellectual stimulus, information and recreation. Moreover, this conclusion is strongly reinforced by a comparison of the 1,761,622 persons in 357 communities, now receiving only skywave service, who would gain in lieu thereof a local groundwave service, with the 25,631,000 persons in 1,727,000 square miles, now receiving skywave service, who would lose entirely the standard broadcast radio service now available to them.

20. On the basis of the data now available we find that there is no warrant for inaugurating rule making looking toward extended hours for daytime stations on a general or universal basis and we canclude that the Inquiry herein should be, and it is hereby terminated.

Remote Control Operation

In the matter of amendment of § 3.66 (Broadcast Service) of the Commission's rules and regulations.

1. The Commission has before it for consideration its order in the above-entitled proceedings, released on April 25, 1958, and a petition for reconsideration thereof filed on May 26, 1958, by the International Brotherhood of Electrical Workers.

2. The April 25th order amended § 3.66 (c) (4) of the rules relating to the remote control operation of Broadcast stations with directional antennae and/or power in excess of 10 kw to permit lower power than that required by the rule on certification by a CONELRAD Field Supervisor that the lower power is satisfactory for CONELRAD service.

3. Petitioner contends that insofar as the order provided for the lowering of the minimum power requirement, it is substantive in nature, and is therefore defective in that it does not meet the requirements of section 4 of the Administrative Procedure Act because it neither was preceded by a rule making proceeding, nor included a finding that notice and public procedure thereon were impracticable, unnecessary or contrary to the public interest. Petitioner requests that upon reconsideration the Commission vacate the order complained of and conduct such further proceedings, in accordance with law, as the Commission deems just and appropriate.

4. A review of this petition and the order to which it is directed indicates that the amendment to § 3.66 (c) (4) of the rules is in fact substantive in nature, and that the requirements of section 4 of the Administrative Procedure Act have not been fully met. We have, accordingly, decided to vacate the order, and to issue, concurrently with this decision, a Notice of Proposed Rule Making looking toward the same substantive amendment to this rule, but affording interested parties an opportunity to comment on this proposed amendment. In view of the fact that petitioner has not attacked the substance of this amendment; and in view of the fact that a number of authorizations for remote control operation have been issued to stations participating in the CONELRAD program which would not meet the minimum power requirements of § 3.66 (c) (4) but for the amendment; and in view of the importance of the CONELRAD program to the defense of this nation, we are of the opinion that the public interest would be served by our staying the effective date of this vacating order until the Commission has had an opportunity to evaluate such comments as may be filed in response to the Notice of Proposed Rule Making.

5. In view of the foregoing: *It is ordered,* That the petition filed on May 26, 1958, by the International Brotherhood of Electrical Workers for reconsideration of the Commission's Memorandum Opinion and Order of April 25, 1958, is hereby granted and that order is hereby vacated. *And it is further ordered,* That the effective date of the vacating of this order is hereby stayed, on the Commission's own motion, pending its action on a Notice of Proposed Rule Making issued on July 29, 1959, in the matter of amendment of § 3.66 (Broadcast Service) of the Commission's Rules Relating to Remote Control Authorizations.

F.C.C. REGULATIONS

REVISED UP TO PUBLISHING TIME.

SUBPART A—STANDARD BROADCAST STATIONS

DEFINITIONS

§ 3.1 *Standard broadcast station.* The term "standard broadcast station" means a broadcasting station licensed for the transmission of radiotelephone emissions primarily intended to be received by the general public and operated on a channel in the band 535-1605 kilocycles.

§ 3.2 *Standard broadcast band.* The term "standard broadcast band" means the band of frequencies extending from 535 to 1605 kilocycles.

§ 3.3 *Standard broadcast channel.* The term "standard broadcast channel" means the band of frequencies occupied by the carrier and two side bands of a broadcast signal with the carrier frequency at the center. Channels shall be designated by their assigned carrier frequencies. The 107 carrier frequencies assigned to standard broadcast stations shall begin at 540 kilocycles and be in successive steps of 10 kilocycles.

§ 3.4 *Dominant station.* The term "dominant station" means a class I station, as hereinafter defined, operating on a clear channel.

§ 3.5 *Secondary station.* The term "secondary station" means any station except a Class I station operating on a clear channel.

§ 3.6 *Daytime.* The term "daytime" means that period of time between local sunrise and local sunset.

§ 3.7 *Nighttime.* The term "nighttime" means that period of time between local sunset and 12 midnight local standard time.

§ 3.8 *Sunrise and sunset.* The terms "sunrise and sunset" mean, for each particular location and during any particular month, the time of sunrise and sunset as specified in the instrument of authorization.

§ 3.9 *Broadcast day.* The term "broadcast day" means that period of time between local sunrise and 12 midnight local standard time.

§ 3.10 *Experimental period.* The term "experimental period" means that time between 12 midnight and local sunrise. This period may be used for experimental purposes in testing and maintaining apparatus by the licensee of any standard broadcast station on its assigned frequency and with its authorized power, provided no interference is caused to other stations maintaining a regular operating schedule within such period. No station licensed for "daytime" or "specified hours" of operation may broadcast any regular or scheduled program during this period.

§ 3.11 *Service areas.* (a) The term "primary service area" of a broadcast station means the area in which the groundwave is not subject to objectionable interference or objectionable fading.

(b) The term "secondary service area" of a broadcast station means the area served by the skywave and not subject to objectionable interference. The signal is subject to intermittent variations in intensity.

(c) The term "intermittent service area" of a broadcast station means the area receiving service from the groundwave but beyond the primary service area and subject to some interference and fading.

§ 3.12 *Portable transmitter.* The term "portable transmitter" means a transmitter so constructed that it may be moved about conveniently from place to place, and is in fact so moved about from time to time, but not ordinarily used while in motion. In the standard broadcast band, such a transmitter is used in making field intensity measurements for locating a transmitter site for a standard broadcast station. A portable broadcast station will not be licensed in the standard broadcast band for regular transmission of programs intended to be received by the public.

§ 3.13 *Auxiliary transmitter.* The term "auxiliary transmitter" means a transmitter maintained only for transmitting the regular programs of a station in case of failure of the main transmitter.

§ 3.14 *Technical definitions* — (a) *Combined audio harmonics.* The term "combined audio harmonics" means the arithmetical sum of the amplitudes of all the separate harmonic components. Root sum square harmonic readings may be accepted under conditions prescribed by the Commission.

(b) *Effective field.* The term "effective field" or "effective field intensity" is the root-mean-square (RMS) value of the inverse distance fields at a distance of 1 mile from the antenna in all directions in the horizontal plane.

(c) *Operating power.* "Operating power" is the power that is actually supplied to the radio station antenna.

(d) *Maximum rated carrier power.* "Maximum rated carrier power" is the maximum power at which the transmitter can be operated satisfactorily and is determined by the design of the transmitter and the type and number of vacuum tubes used in the last radio stage.

(e) *Plate input power.* "Plate input power" means the product of the direct plate voltage applied to the tubes in the last radio stage and the total direct current flowing to the plates of these tubes, measured without modulation.

(f) *Antenna power.* "Antenna input power" or "antenna power" means the product of the square of the antenna current and the antenna resistance at the point where the current is measured.

(g) *Antenna current.* "Antenna current" means the radio-frequency current in the antenna with no modulation.

(h) *Antenna resistance.* "Antenna resistance" means the total resistance of the transmitting antenna system at the operating frequency and at the point at which the antenna current is measured.

(i) *Modulator stage.* "Modulator stage" means the last amplifier stage of the modulating wave which modulates a radio-frequency stage.

(j) *Modulated stage.* "Modulated stage" means the radio-frequency stage to which the modulator is coupled and in which the continuous wave (carrier wave) is modulated in accordance with the system of modulation and the characteristics of the modulating wave.

(k) *Last radio stage.* "Last radio stage" means the oscillator or radio-frequency-power amplifier stage which supplies power to the antenna.

(l) *Percentage modulation (amplitude).* "Percentage modulation" with respect to an amplitude modulated wave means the ratio of half the difference between the maximum and minimum amplitudes of the amplitude modulated wave to the average amplitude expressed in percentage.

(m) *Maximum percentage of modulation.* "Maximum percentage of modulation" means the greatest percentage of modulation that may be obtained by a transmitter without producing in its output harmonics of the modulating frequency in excess of those permitted by these regulations.

(n) *High level modulation.* "High level modulation" is modulation produced in the plate circuit of the last radio stage of the system.

(o) *Low level modulation.* "Low level modulation" is modulation produced in an earlier stage than the final.

(p) *Plate modulation.* "Plate modulation" is modulation produced by introduction of the modulating wave into the plate circuit of any tube in which the carrier frequency wave is present.

(q) *Grid modulation.* "Grid modulation" is modulation produced by introduction of the modulating wave into any of the grid circuits of any tube in which the carrier frequency wave is present.

(r) *Blanketing.* Blanketing is that form of interference which is caused by the presence of a broadcast signal of 1 v/m or greater intensity in the area adjacent to the antenna of the transmitting station. The 1 v/m contour is referred to as the blanket contour and the area within this contour is referred to as the blanket area.

ALLOCATION OF FACILITIES

§ 3.21 *Three classes of standard broadcast channels*—(a) *Clear channel.* A clear channel is one on which the dominant station or stations render service over wide areas and which are cleared of objectionable interference within their primary service areas and over all or a substantial portion of their secondary service areas.

(b) *Regional channel.* A regional channel is one on which several stations may operate with powers not in excess of 5 kilowatts. The primary service area of a station operating on any such channel may be limited as a consequence of interference to a given field intensity contour.

(c) *Local channel.* A local channel is one on which several stations operate with powers not in excess of 1 kilowatt daytime, and 250 watts nighttime. The primary service area of a station operating on any such channel may be limited as a consequence of interference to a given field intensity contour.

NOTE: The power ceiling for Class IV stations under the North American Regional Broadcasting Agreement (NARBA) is 250 watts. The Agreement between the United States of America and the United Mexican States Concerning Radio Broadcasting in the Standard Broadcast Band would permit daytime operation of Class IV stations with a maximum power of 1 kilowatt in all areas of the United States more than 100 kilometers (62 miles) from the United States/Mexican border. Pursuant to the U. S./Mexican Agreement and informal coordination with the other NARBA signatories, the Commission will consider applications proposing the use of daytime power in excess of 250 watts by a Class IV station providing such station is located more than 100 kilometers (62 miles) from the U. S./Mexican border, or, if located in the State of Florida, providing that such station is not located south of 28 degrees north latitude and between 80 and 82 degrees west longitude.

§ 3.22 *Classes and power of standard broadcast stations*—(a) *Class I station.* A Class I station is a dominant station operating on a clear channel and designed to render primary and secondary service over an extended area and at relatively long distances. Its primary service area is free from objectionable interference from other stations on the same and adjacent channels, and its secondary service area free from interference except from stations on the adjacent channel, and from stations on the same channel in accordance with the channel designation in § 3.25 or § 3.182. The operating power shall be not less than 10 kilowatts nor more than 50 kilowatts. (Also see § 3.25 (a) for further power limitation.)

(b) *Class II station.* A Class II station is a secondary station which operates on a clear channel (see § 3.25) and is designed to render service over a primary service area which is limited by and subject to such interference as may be received from Class I stations. A station of this class shall operate with power not less than 0.25 kilowatt nor more than 50 kilowatts. Whenever necessary a Class II station shall use a directional antenna or other means to avoid interference with Class I stations and with other Class II stations, in accordance with § 3.182.

(c) *Class III station.* A Class III station is a station which operates on a regional channel and is designed to render service primarily to a metropolitan district and the rural area contiguous thereto. Class III stations are subdivided into two classes. (The term "metropolitan district" as used in this paragraph is not limited in accordance with the definition given by the Bureau of the Census but includes any principal center of population in any area.)

(1) *Class III-A station.* A Class III-A station is a Class III station which operates with power not less than 1 kilowatt nor more than 5 kilowatts and the service area of which is subject to interference in accordance with § 3.182.

(2) *Class III-B station.* A Class III-B station is a Class III station which operates with a power not less than 0.5 kilowatt, and not more than 1 kilowatt night and 5 kilowatts daytime, and the service area of which is subject to interference in accordance with § 3.182.

(d) *Class IV station.* A Class IV station is a station operating on a local channel and designed to render service primarily to a city or town and the suburban and rural areas contiguous thereto. The power of a station of this class shall not be less than 0.1 kilowatt and not more than 0.25 kilowatt nighttime, and 1 kilowatt daytime, and its service area is subject to interference in accordance with § 3.182.

§ 3.23 *Time of operation of the several classes of stations.* The several classes of standard broadcast stations may be licensed to operate in accordance with the following:

(a) Unlimited time permits operation without a maximum limit as to time.

(b) Limited time is applicable to Class II (secondary stations) operating on a clear channel only. It permits operation of the secondary station during daytime, and until local sunset if located west of the dominant station on the channel, or if located east thereof, until sunset at the dominant station, and in addition during night hours, if any, not used by the dominant station or stations on the channel.

(c) Daytime permits operation during the hours between average monthly local sunrise and average monthly local sunset. Daytime stations operating on local channels with a power of 0.1 kilowatt or 0.25 kilowatt may, upon notification to the Commission and to the Engineer in Charge of the radio district in which they are located, operate at hours beyond those specified in their license.

(d) Sharing time permits operation during hours which are so restricted by the station license as to require a division of time with one or more other stations using the same channel.

(e) Specified hours means that the exact operating hours are specified in the license. (The minimum hours that any station shall operate are specified in § 3.71.) Specified hours stations operating on local channels with a power of 0.1 kilowatt or 0.25 kilowatt, except those sharing time with other stations may, upon notification to the Commission and the Engineer in Charge of the radio district in which they are located, operate at hours beyond those specified in their license.

§ 3.24 *Broadcast facilities; showing required.* (a) Applications for new stations or for modifications of existing authorizations shall be filed on FCC Form 301; for licenses, on FCC Form 302; for renewal of licenses, on FCC Form 303.

(b) An authorization for a new standard broadcast station or increase in facilities of an existing station will be issued only after a satisfactory showing has been made in regard to the following, among others:

(1) That the proposed assignment will tend to effect a fair, efficient, and equitable distribution of radio service among the several states and communities.

(2) That objectionable interference will not be caused to existing stations or that if interference will be caused the need for the proposed service outweighs the need for the service which will be lost by reason of such interference. That the proposed station will not suffer interference to such an extent that its service would be reduced to an unsatisfactory degree. (For determining objectionable interference, see §§ 3.182 and 3.186.)

(3) That the applicant is financially qualified to construct and operate the proposed station.

(4) That the applicant is legally qualified. That the applicant (or the person or persons in control of an applicant corporation or other organization) is of good character and possesses other qualifications sufficient to provide a satisfactory public service.

(5) That the technical equipment proposed, the location of the transmitter, and other technical phases of operation comply with the regulations governing the same, and the requirements of good engineering practice. (See technical regulations of this subpart and § 3.188.)

(6) That the facilities sought are subject to assignment as requested under existing international agreements and the rules and regulations of the Commission.

(7) That the population within the 1 v/m contour does not exceed 1.0 per cent of the population within the 25 mv/m contour: *Provided, however,* That where the number of persons within the 1 v/m contour is 300 or less the provisions of this subparagraph are not applicable.

(8) That the public interest, convenience, and necessity will be served through the operation under the proposed assignment.

(c) In order to minimize harmful interference at the National Radio Astronomy Observatory site located at Green Bank, Pocahontas County, West Virginia, and at the Naval Radio Research Observatory at Sugar Grove, Pendleton County, West Virginia, an applicant for authority to construct a new standard broadcast station or for authority to make changes in the frequency, power, antenna height, or antenna directivity of an existing station within the area bounded by 39°15′ N on the north, 78°30′ W on the east, 37°30′ N on the south, and 80°30′ W on the west shall, at the time of filing such application with the Commission, simultaneously notify the Director, National Radio Astronomy Observatory, P. O. Box No. 2, Green Bank, West Virginia, in writing, of the technical particulars of the proposed station. Such notification shall include the geographical coordinates of the antenna, antenna height, antenna directivity if any, proposed frequency, type of emission, and power. In addition, the applicant shall indicate in his application to the Commission the date notification was made to the observatory. After receipt of such applications, the Commission will allow a period of twenty (20) days for comments or objections in response to the notifications indicated. If an objection to the proposed operation is received during the twenty-day period from the National Radio Astronomy Observatory for itself or on behalf of the Naval Radio Research Observatory, the Commission will consider all aspects of the problem and take whatever action is deemed appropriate.

§ 3.25 *Clear channels; Class I and II stations.* The frequencies in the following tabulations are designated as clear channels and assigned for use by the Classes of stations given:

(a) To each of the channels below, except as provided in paragraph (e) of this section, there will be assigned one Class I station and there may be assigned one or more Class II stations within the continental limits of the United States operating limited time or daytime only: 640, 650, 660, 670, 700, 720, 750, 760, 770, 780, 820, 830, 840, 870, 880, 890, 1020, 1040, 1100, 1120, 1160, 1180, 1200, and 1210 kc. There also may be assigned to these frequencies Class II stations operating unlimited time in Alaska, Hawaii, Virgin Islands and Puerto Rico which will not deliver over 5 microvolts per meter groundwave day or night or 25 microvolts per meter 10 per cent time skywave at night at any point within the continental limits of the United States. The power of the Class I stations on these channels shall not be less than 50 kw.

(b) To each of the channels below there may be assigned Class I and Class II stations: 680, 710, 810, 850, 940, 1000, 1030, 1060, 1070, 1080, 1090, 1110, 1130, 1140, 1170, 1190, 1500, 1510, 1520, 1530, 1540, 1550, and 1560 kilocycles.

NOTE: Class I and II stations on 1540 kc shall deliver not over 5 microvolts per meter groundwave or 25 microvolts per meter 10 per cent time skywave at any point of land in the Bahama Islands, and such stations operating nighttime (i.e., sunset to sunrise at the location of the Class II station) shall be located not less than 650 miles from the nearest point of land in the Bahama Islands.

(c) For Class II stations which will not deliver over 5 microvolts per meter groundwave or 25 microvolts per meter 10 per cent time skywave at any point on the Canadian border and provided that such stations operating nighttime (i.e., sunset to sunrise at the location of the Class II station) are located not less than 650 miles from the nearest Canadian border, 540, 690, 740, 860, 990, 1010, and 1580 kilocycles.

NOTE 1: See § 2.104 (a) of this chapter with respect to use of 540 kc.

NOTE 2: A station on 1010 kilocycles shall also protect a Class I-B station at Havana, Cuba.

(d) In continental United States, for Class II stations which operate daytime only with power not in excess of 1 kilowatt and which will not deliver over 5 microvolts per meter groundwave at any point on the Mexican border, and in Alaska, Hawaii, Puerto Rico, and the Virgin Islands, for Class II stations which will not deliver over 5 microvolts per meter groundwave or 25 microvolts per meter 10 per cent time skywave at any point on the said border: 730, 800, 900, 1050, 1220 and 1570 kilocycles.

NOTE 1: See North American Regional Broadcasting Agreement, Havana, 1937 (Appendix I, Table IV) for use of 1050 kc by a station in New York.

NOTE 2: See agreement with Mexico for further use of 1220 kc.

(e) On the frequency 770 kilocycles two Class I stations may be assigned.

§ 3.26 *Regional channels: Classes III-A and III-B stations.* The following frequencies are designated as regional channels and are assigned for use by Class III-A and III-B stations: 550, 560, 570, 580, 590, 600, 610, 620, 630, 790, 910, 920, 930, 950, 960, 970, 980, 1150, 1250, 1260, 1270, 1280, 1290, 1300, 1310, 1320, 1330, 1350, 1360, 1370, 1380, 1390, 1410, 1420, 1430, 1440, 1460, 1470, 1480, 1590, and 1600 kilocycles.

NOTE: See North American Regional Broadcasting Agreement for special provisions concerning the assigning of Class II stations in other countries of North America to 560, 570, 590, 630, and 1270 kcs. Such stations shall be protected from interference in accordance with appendix II, table I, of said agreement.

§ 3.27 *Local channels: Class IV stations.* The following frequencies are designated as local channels and are assigned for use by Class IV stations: 1230, 1240, 1340, 1400, 1450, and 1490 kilocycles.

§ 3.28 *Assignment of stations to channels.* (a) The individual assignments of stations to channels which may cause interference to other United States stations only, shall be made in accordance with the provisions of this part for the respective classes of stations involved. (For determining objectionable interference, see §§ 3.182 and 3.186.)

(b) In all cases where an individual station assignment may cause interference with or may involve a channel assigned for priority of use by a station in another North American country, the classifications, allocation requirements and engineering standards set forth in the North American Regional Broadcasting Agreement shall be observed.

NOTE: Pending action with respect to ratification and entry into force of the North American Regional Broadcasting Agreement, Washington, 1950 (referred to herein as NARBA), and the Agreement between the United States of America and the United Mexican States Concerning Radio Broadcasting in the Standard Broadcast Band (referred to herein as the U. S./Mexican Agreement) no assignment for a standard broadcasting station will be made which would be inconsistent with the terms of these agreements, except for the power ceiling permitted for Class IV stations on local channels, pursuant to § 3.21 (c).

On an interim basis while protection by countries not signatory to the NARBA continues for assignments in the United States, no assignment for a standard broadcast station will be made which would cause objectionable interference to a duly notified station in a North American country which is not signatory to the NARBA (i.e., Mexico and Haiti). For purposes of this paragraph, interference will in general be determined, in accordance with the engineering standards in use at the time of the expiration of the Interim Agreement (Modus Vivendi), Treaties and Other International Acts Series 1553. In particular, the existence or absence of interference resulting from skywave signal transmission will be determined by the use of Figures 1 and 6 (a) of § 3.190 and the "50 per cent exclusion" method of calculating RSS interference described in § 3.182. Figure 1 of § 3.190 will be utilized in connection with curve No. 1 of Figure 6 (a) of § 3.190 in the determination of 50 per cent skywave signals. Figure 1 of § 3.190, converted for radiation of 100 mv/m at angles above the horizontal by the use of curve No. 1 of Figure 6 (a) of § 3.190 and the vertical radiation pattern for a 0.311 y antenna in Figure 5 of § 3.190, will be used with the highest value of antenna radiation occurring at any pertinent angle between the limits described by curves No. 4 and No. 5 of Figure 6 (a) of § 3.190 in the determination of 10 per cent skywave signals. The Mexican and Haitian stations considered to be duly notified will be those notified and accepted in accordance with past agreements, and those subsequently notified in substantial accordance with the procedures and understandings that have pertained thus far.

Engineering standards now in force domestically differ in some respects from those specified for international purposes and must be observed in appropriate cases. For example, the engineering standards specified for international purposes will be used to determine (1) the extent to which interference might be caused by a proposed station in the United States to a station in another North American country and (2) whether the United States should register an objection to any new or changed assignment notified by another North American country. The domestic standards in effect in the United States will be used to determine the extent to which interference exists or would exist from a foreign station where the value of such interference (1) enters into a calculation of the service to be rendered by a proposed operation in the United States or (2) enters into the calculation of the permissible interfering signal from one station in the United States towards another United States station.

In general, an application for a standard broadcast station assignment the grant of which would be consistent with provisions of the NARBA and would not cause objectionable interference to a duly notified station in a North American country not signatory to the NARBA, will be considered and acted upon by the Commission in accordance with the established procedure for action upon such applications even though the NARBA may not yet have entered into force. However, in particular cases such applications may also present considerations of an international nature which require that a different procedure be followed. In such cases the procedure to be followed will be determined by the Commission in the light of the special considerations involved.

Special provisions of a procedural nature respecting the consideration of applications for standard broadcast station assignments pending action with respect to ratification and entry into force of NARBA, 1950, and respecting the consideration of applications the grant of which would cause objectionable interference to duly notified stations in countries not signatory to the NARBA, are set out in a note to Part 1 of this chapter, Subparts D and G.

(c) Upon showing that a need exists, a Class II, III, or IV station may be assigned to a channel available for such class, even though interference will be received within its normally protected contour; *Provided:* (1) No objectionable interference will be caused by the proposed station to existing stations or that if interference will be caused, the need for the proposed service outweighs the need for the service which will be lost by reason of such interference; and (2) primary service will be provided to the community in which the proposed station is to be located; and (3) the interference received does not affect more than 10 per cent of the population in the proposed station's normally protected primary service area. However, in the event that the nighttime interference received by the proposed station would exceed this amount, then an assignment may be made if the proposed station would provide either a standard broadcast nighttime facility to a community not having such a facility or if 25 per cent or more of the nighttime primary service area of the proposed station is without primary nighttime service.

§ 3.29 *Class IV stations on regional channels.* No license will be granted for the operation of a Class IV station on a regional channel: *Provided, however,* That Class IV stations presently authorized to operate on regional channels will not be required to change frequency, or power, but will not be protected against interference from Class III stations.

§ 3.30 *Station location and program origination.* (a) Except as provided in paragraph (b) of this section, each standard broadcast station will be licensed to serve primarily a particular city, town, or other political subdivision which will be specified in the station license and the station will be considered to be located in such place. Unless licensed as a synchronous amplifier transmitter, each station shall maintain a studio, which will be known as the main studio, in the place where the station is located provided that the main studio may be located at the transmitter site whether or not the transmitter site is in the place where the station is located. A majority (computed on the basis of duration and not number) of a station's programs or in the case of a station affiliated with a network ⅔ of such station's non-network programs, whichever is smaller, shall originate from the main studio or from other studios or remote points situated in the place where the station is located.

(b) Stations will be licensed to serve more than one city, town, or other political subdivision only where a satisfactory showing is made that each such place meets all the requirements of the rules and regulations of this subpart with respect to the location of main studios, that the station can and will originate a substantial number of local live programs from each such place; and that the requirements as to origination of programs contained in paragraph (a) of this section would place an unreasonable burden on the station if it were licensed to serve only one city, town, or other political subdivision. A station licensed to serve more than one place shall be considered to be located in and shall maintain main studios in each such place. With respect to such station the requirements as to origination of programs contained in paragraph (a) of this section shall be satisfied by the origination of programs from any or all of the main studios or from other studios and remote points situated in any or all of the places in which the main studios are located.

(c) The transmitter of each standard broadcast station shall be so located that primary service is delivered to the borough or city in which the main studio is located in accordance with the rules and regulations of this subpart.

§ 3.31 *Authority to move main studio.* The licensee of a station shall not move its main studio outside the borders of the borough or city, state, district, territory, or possession in which it is located, unless such move is to the location of the station's transmitter, without first securing a modification of construction permit or license. The licensee shall promptly notify the Commission of any other change in location of the main studio.

§ 3.32 *Special experimental authorizations.* (a) Special experimental authorization may be issued to the licensee of a standard broadcast station in addition to the regular license upon informal application therefor and upon a satisfactory showing in regard to the following, among others:

(1) That the applicant has a program of research and experimentation which indicates reasonable promise of contribution to the development and practical application of broadcasting, and will be in addition to and advancement of the work that can be accomplished under its regular license.

(2) That the experimental operation and experimentation will be under the direct

supervision of a qualified engineer with an adequate staff of engineers qualified to carry on the program of research and experimentation.

(3) That the public interest, convenience, and necessity will be served by granting the authorization requested.

(b) In case a special experimental authorization permits additional hours of operation, no licensee shall transmit any commercial or sponsored program or make any commercial announcement during such time of operation. In case of other additional facilities, no additional charge shall be made by reason of transmission with such facilities.

(c) A special experimental authorization will not be extended after the actual experimentation is concluded.

(d) The program of research and experimentation as outlined in the application for a special experimental authorization shall be adhered to in the main unless the licensee is authorized to do otherwise by the Commission.

(e) The Commission may require from time to time a broadcast station holding such experimental authorization to conduct experiments that are deemed desirable and reasonable.

(f) A supplemental report shall be filed with and made a part of each application for an extension of a special experimental authorization and shall include statements of the following:

(1) Comprehensive summary of all research and experimentation conducted.

(2) Conclusions and outline of proposed program for further research and development.

(3) Comprehensive summary and conclusions as to the social and economic effects of its use.

§ 3.33 *Antenna systems; showing required.* (a) An application for authority to install a broadcast antenna shall specify a definite site and include full details of the antenna design and expected performance. (Site - to - be - determined applications which were on file prior to October 28, 1953, may be granted conditioned upon the filing within 60 days of such grant of an application for modification of permit specifying a site conforming to Commission's rules and standards.)

(b) All data necessary to show compliance with the terms and conditions of the construction permit must be filed with the license application. If the station is using a directional antenna, a proof of performance must also be filed.

§ 3.34 *Normal license period.* (a) All standard broadcast station licenses will be issued for a normal license period of three years. Licenses will be issued to expire at the hour of 3:00 a. m., e. s. t., in accordance with the following schedule and at three-year intervals thereafter:

(1) For stations located in Delaware and Pennsylvania, August 1, 1957.

(2) For stations located in Maryland, District of Columbia, Virginia, West Virginia, October 1, 1957.

(3) For stations located in North Carolina, South Caroline, December 1, 1957.

(4) For stations located in Florida, Puerto Rico and Virgin Islands, February 1, 1958.

(5) For stations located in Alabama and Georgia, April 1, 1958.

(6) For stations located in Arkansas, Louisiana and Mississippi, June 1, 1958.

(7) For stations located in Tennessee, Kentucky and Indiana, August 1, 1958.

(8) For stations located in Ohio and Michigan, October 1, 1958.

(9) For stations located in Illinois and Wisconsin, December 1, 1958.

(10) For stations located in Iowa and Missouri, February 1, 1956.

(11) For stations located in Minnesota, North Dakota, South Dakota, Montana and Colorado, April 1, 1956.

(12) For stations located in Kansas, Oklahoma, Nebraska, June 1, 1956.

(13) For stations located in Texas, August 1, 1956.

(14) For stations located in Wyoming, Nevada, Arizona, Utah, New Mexico and Idaho, October 1, 1956.

(15) For stations located in California, December 1, 1956.

(16) For stations located in Washington, Oregon, Alaska, Guam and Hawaii, February 1, 1957.

(17) For stations located in Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont, April 1, 1957.

(18) For stations located in New Jersey and New York, June 1, 1957.

(b) When an application is granted by the Commission necessitating the issuance of a modified license less than 60 days prior to the expiration date of the license sought to be modified, and an application for renewal of said license is granted subsequent or prior thereto (but within 30 days of expiration of the present license) the modified license as well as the renewal license shall be issued to conform to the combined action of the Commission.

§ 3.35 *Multiple ownership.* No license for a standard broadcast station shall be granted to any party (including all parties under common control) if:

(a) Such party directly or indirectly owns, operates or controls another standard broadcast station, a substantial portion of whose primary service area would receive primary service from the station in question, except upon a showing that public interest, convenience and necessity will be served through such multiple ownership situation; or

(b) Such party, or any stockholder, officer or director of such party, directly or indirectly owns, operates, controls, or has any interest in, or is an officer or director of any other standard broadcast station if the grant of such license would result in a concentration of control of standard broadcasting in a manner inconsistent with public interest, convenience, or necessity. In determining whether there is such a concentration of control, consideration will be given to the facts of each case with particular reference to such factors as the size, extent and location of areas served, the number of people served, classes of stations involved and the extent of other competitive service to the areas in question. The Commission, however, will in any event consider that there would be such a concentration of control contrary to the public interest, convenience or necessity for any party or any of its stockholders, officers or directors to have a direct or indirect interest in, or be stockholders, officers, or directors of, more than seven standard broadcast stations.

Note: 1. The word "control" as used herein is not limited to majority stock ownership, but includes actual working control in whatever manner exercised.

2. In applying the foregoing provisions to the stockholders of a corporation which has more than 50 voting stockholders, only those stockholders need be considered who are officers or directors or who directly or indirectly own 1 per cent or more of the outstanding voting stock.

§ 3.36 *Special field test authorization.* (a) Upon a showing that a need exists, a special test authorization to operate a portable or regularly authorized transmitter may be issued to persons desiring to make field intensity surveys to determine values of soil conductivity, or other factors influencing radio wave propagation, in particular areas or paths for the period necessary to conduct the survey. Such authorization may be granted upon the following conditions:

(1) No objectionable interference will result to the operation of other authorized radio services; in this connection, the power requested shall not exceed that necessary for the purposes of the test.

(2) The carrier will be unmodulated except for half-hourly voice identification.

(3) The plate power *(Ep x Ip)* of the final stage of the transmitter shall not exceed authorized test power and the antenna current shall be maintained at a constant value for each phase of the test.

(4) The test equipment shall not be permanently installed, unless such installation has been separately authorized. Mobile units shall not be deemed permanent installations.

(5) The equipment must be operated by or under the personal direction of either a licensed radiotelephone first-class or second-class operator.

(6) A report, under oath, containing the measurements, their analysis and other results of the survey shall be filed with the Commission within sixty (60) days from the termination of the test authorization. The measurements taken shall be sufficiently complete, in accordance with § 3.186, so as to permit a determination of the inverse distance field at 1 mile in pertinent directions.

(7) The plate voltage *(Ep)* and plate current *(Ip)* of the final stage of the transmitter shall be logged at half-hour intervals and at any time that such power is changed. Certified copies of such log notations shall be submitted to the Commission with the required report.

(8) Operation shall conform to the requirements of Subpart G of this part.

(b) The test equipment, installation and operation thereof need not comply with the requirements of Commission rules and standards except as specified in this section: *Provided however,* That the equipment, installation and operation shall be consistent with good engineering principles and practices.

(c) No authorization shall be issued unless the applicant for such authorization is determined to be legally qualified. Requests for authorization to operate a transmitter under this section shall be made in writing, signed by the applicant under oath or affirmation (with no special form provided, however), and shall set forth the following information:

(1) Purpose, duration and need for the survey.

(2) Frequency, plate power and time of operation.

(3) A brief description of the test antenna system and its estimated effective field and its proposed location.

(4) In the case of a directional test antenna, an estimate of the maximum fields expected to be radiated in the direction of pertinent broadcast stations.

(5) In the case of a person who is not a licensee or permittee of this Commission the information required by section II of FCC Form 301.

(d) The authorization may be modified or terminated by notification from the Commission if in its judgment such action will promote the public interest, convenience or necessity.

§ 3.37 *Minimum separation between stations.* A license will not be granted for a station on a frequency of ±30 kc from that of another station if the area enclosed by the 25 mv/m groundwave contours of the two stations overlap, nor will a license be granted for the operation of a station on a frequency ±20 kc or ±10 kc from the frequency of another station if the area enclosed by the 25 mv/m groundwave contour of either one overlaps the area enclosed by the 2 mv/m groundwave contour of the other.

§ 3.39 *Indicating instruments—specifications.*

(a) Instruments indicating the plate current or plate voltage of the last radio stage (linear scale instruments), shall meet the following specifications:

(1) Length of scale shall be not less than 2 3/10 inches.

(2) Accuracy shall be at least 2 per cent of the full scale reading.

(3) The maximum rating of the meter shall be such that it does not read off scale during modulation.

(4) Scale shall have at least 40 divisions.

(5) Full scale reading shall not be greater than five times the minimum normal indication.

(b) Instruments indicating antenna current, common point current, and base currents shall meet the following specifications:

(1) Instruments having logarithmic or square law scales.

(i) Shall meet same requirements as paragraph (a) (1), (2) and (3) of this section for linear scale instruments.

(ii) Full scale reading shall not be greater than three times the minimum normal indication.

(iii) No scale division above one-third full scale reading (in amperes) shall be greater than one-thirtieth of the full scale reading. (Example: An ammeter meeting requirement (i) having full scale reading of 6 amperes is acceptable for reading currents from 2 to 6 amperes, provided no scale division between 2 and 6 amperes is greater than one-thirtieth of 6 amperes, 0.2 ampere.)

(2) Radio frequency instruments having expanded scales.

(i) Shall meet same requirements as paragraph (a) (1), (2) and (3) of this section for linear scale instruments.

(ii) Full scale reading shall not be greater than five times the minimum normal indication.

(iii) No scale division above one-fifth full scale reading (in amperes) shall be greater than one-fiftieth of the full scale reading. (Example: An ammeter meeting the requirement (i) is acceptable for indicating currents from 1 to 5 amperes, provided no division between 1 and 5 amperes is greater than one-fiftieth of 5 amperes, 0.1 ampere.)

(iv) Manufacturers of instruments of the expanded scale type must submit data to the Commission showing that these instruments have acceptable expanded scales, and the type number of these instruments must include suitable designation.

(c) A thermocouple type ammeter meeting the requirements of paragraph (b) of this section shall be installed in the antenna circuit so as to indicate the antenna current. In the case of directional antennas the same type of ammeters shall be installed to indicate the common point current and the base current of each tower. (The ammeter may be so connected that it is short circuited or open circuited when not actually being read. If open circuited, a make-before-break switch must be employed.)

(d) Remote reading antenna ammeter(s) may be employed and the indications logged as the antenna current, or in the case of directional antenna, the common point current and base currents, in accordance with the following:

(1) Remote reading antenna, common point or base ammeters may be provided by:

(i) Inserting second thermocouple directly in the antenna circuit with remote leads to the indicating instrument.

(ii) Inductive coupling to the thermocouple or other device for providing direct current to indicating instrument.

(iii) Capacity coupling to thermocouple or other device for providing direct current to indicating instrument.

(iv) Current transformer connected to second thermocouple or other device for providing direct current to indicating instrument.

(v) Using transmission line current meter at transmitter as remote reading ammeter. See subparagraph (7) of this paragraph.

(vi) Using indications of phase monitor for determining the antenna base currents or their ratio in the case of directional antennas, provided that the base current readings are read and logged in accordance with the provision of the station license, and provided further that the indicating instruments in the unit are connected directly in the current sampling circuits with no other shunt circuits of any nature. The meters in the phase monitor may utilize arbitrary scale divisions provided a calibration curve showing the relationship between the arbitrary scale and the scale of the base meters is maintained at the transmitter location.

(vii) Using indications of remote control equipment provided that the indicating instruments are capable of being connected directly into the antenna circuit at the same point as, but below (transmitter side), the antenna ammeter. The meter(s) in the remote control equipment may utilize an arbitrary scale division provided a calibration curve showing the relationship between the arbitrary scale and the scale of the antenna ammeter is maintained at the remote control point. The meter(s) in the remote control equipment must be calibrated once a week against the regular meter and the results thereof entered in the operating log.

(2) Remote ammeters shall be connected into the antenna circuit at the same point as, but below (transmitter side), the antenna ammeter(s), and shall be calibrated to indicate within 2 per cent of the regular meter over the entire range above one-third or one-fifth full scale. See paragraphs (b) (1) (i), (iii) and (b) (2) (i), (iii) of this section.

(3) The regular antenna ammeter, common point ammeter, or base current ammeters shall be above (antenna side) the coupling to the remote meters in the antenna circuit so they do not read the current to ground through the remote meter(s).

(4) All remote meters shall meet the same requirements as the regular antenna ammeter with respect to scale accuracy, etc.

(5) Calibration shall be checked against the regular meter at least once a week.

(6) All remote meters shall be provided with shielding or filters as necessary to prevent any feed-back from the antenna to the transmitter.

(7) In the case of shunt excited antennas, the transmission line current meter at the transmitter may be considered as the remote antenna ammeter provided the transmission line is terminated directly into the excitation circuit feed line, which shall employ series tuning only (no shunt circuits of any type shall be employed) and insofar as practicable, the type and scale of the transmission line meter should be the same as those of the excitation circuit feed line meter (meter in slant wire feed line or equivalent).

(8) Remote reading antenna ammeters employing vacuum tube rectifiers or semi-conductor devices are acceptable, provided:

(i) The indicating instruments shall meet all the above requirements for linear scale instruments.

(ii) Data are submitted under oath showing the unit has an over-all accuracy of at least 2 per cent of the full scale reading.

(iii) The installation, calibration and checking are in accordance with the requirements of this paragraph.

(9) In the event there is any question as to the method of providing, or the accuracy of the remote meter, the burden of proof of satisfactory performance shall be upon the licensee and the manufacturer of the equipment.

(e) Stations determining power by the indirect method may log the transmission line current in lieu of the antenna current provided the instrument meets the above requirements for antenna ammeters, and further provided that the ratio between the transmission line current and the antenna current is entered each time in the log. In case the station is authorized for the same operating power for both day and nighttime operation, this ratio shall be checked at least once daily. Stations which are authorized to operate with nighttime power different from the daytime power shall check the ratio for each power at least once daily.

(f) No instrument, the seal of which has been broken, or the accuracy of which is questionable, shall be employed. Any instrument which was not originally sealed by the manufacturer that has been opened shall not be used until it has been recalibrated and sealed in accordance with the following: Repairs and recalibration of instruments shall be made by the manufacturer, by an authorized instrument repair service of the manufacturer or by some other properly qualified and equipped instrument repair service. In either case the instrument must be resealed with the symbol or trade-mark of the repair service and a certificate of calibration supplied therewith.

(g) Since it is usually impractical to measure the actual antenna current of a shunt excited antenna system, the current measured at the input of the excitation circuit feed line is accepted as the antenna current.

(h) Recording instruments may be employed in addition to the indicating instruments to record the antenna current and the direct plate current and direct plate voltage of the last radio stage provided that they do not affect the operation of the circuits or accuracy of the indicating instruments. If the records are to be used in any proceedings before the Commission as representation of operation with respect to plate or antenna current and plate voltage only, the accuracy must be the equivalent of the indicating instruments and the calibration shall be checked at such intervals as to insure the retention of the accuracy.

(i) The function of each instrument shall be clearly and permanently shown on the instrument itself or on the panel immediately adjacent thereto.

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THIS SECTION CONTINUED NEXT MONTH

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INDUSTRY NEWS

Foto-Video Elects Frank Marx to Board

Frank Louis Marx has been elected a director of Foto-Video Laboratories, Inc., engineers and manufacturers of television, radar, and other electronic equipment. Mr. Marx is vice-president in charge of engineering, American Broadcasting Co.

At the special stockholders' meeting, Albert J. Baracket, president, reported that for the six months ending June 30, sales volume is running twice that of the corresponding 1958 period.

Mr. Marx's professional beginning in radio and broadcasting dates from early in 1924 when he became an operator-engineer for WPAB and WRCV at Norfolk, Va. In 1929, he came to New York as chief engineer for WMCA, New York City. He became technical advisor of WJZ (Blue Network) in 1944, then director-general of engineering of ABC in 1945. He was elected an ABC vice-president in 1948.

Mr. Marx is a consultant of various technical committees in radio and broadcasting, is a senior member of the Institute of Radio Engineers, and a member of several other engineering and scientific organizations. He is also a member of the Washington, D. C., Professional Engineering Society. He now resides in Hartsdale, New York.

Audio Engineering Society Holds Convention-Exhibit in October

The Eleventh Annual Convention and Professional Equipment Exhibit of the Audio Engineering Society, to be held at the Hotel New Yorker, October 5-9, will be the largest and most newsworthy in the Society's history, Harry L. Bryant, chairman of the convention committee has announced.

Technical papers from all over this country as well as Europe and South America already have been submitted for presentation. Papers will cover the newest theories, developments and achievements in the audio field, and will include a thorough discussion of stereo. Because virtually 100 per cent of the audio industry will be represented by papers, there will be the broadest possible coverage of sound recording and reproduction.

This year's convention also will include a "repeat performance" of the highly successful "noiseless" exhibit of professional audio equipment introduced at the convention last year. The number of displays in the professional exhibit, a showcase by which equipment makers can reach their most important audience, promises to triple that of 1958.

G-R Sound-Vibration Instrument Exhibit in West Germany Acoustics Conference

The General Radio Co., West Concord, Massachusetts, will display its complete line of sound meters and analyzers during the Third International Congress for Acoustics, which will be held in Stuttgart, West Germany, September 1-8, 1959.

The exhibition, sponsored by the State-Trade Institute of Baden-Wuerttemberg, will feature only acoustical measuring instruments, which will be grouped in accordance with their specific applications.

GPL Names Squires to Western Sales Post

The appointment of John Squires as western regional manager has been announced by N. M. Marshall, associate director for sales, industrial products division, General Precision Laboratory Inc., Pleasantville, New York.

Mr. Squires, formerly a member of the company's New York district sales staff, will be located at GPL's western area office, 180 N. Vinedo Avenue, Pasadena, California. His sales responsibility will include the states of Arizona, California, Colorado, Idaho, New Mexico, Montana, Nevada, Oregon, Washington, Utah and Wyoming.

Prior to joining GPL in 1957, Mr. Squires was sales manager for the industrial television division of Pye Limited. In his new post, he will direct the sales of the complete line of GPL broadcast, industrial, institutional, and military television equipment.

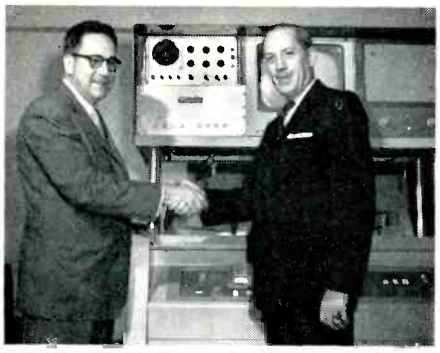
General Precision Laboratory is a subsidiary of General Precision Equipment Corp.

First Public Use of Microwave Link

The arrival of the Queen of England at St. Johns, Newfoundland, on her current visit to North America marked the first public transmission of television pictures over a new 524-mile-long microwave radio system linking St. Johns to Sidney, Nova Scotia, and thence to the rest of North America.

Supplied by Standard Telephones & Cables Limited, an affiliate of International Telephone & Telegraph Corp., the system includes what is believed to be the world's longest over-water microwave link, a 70-mile path across Cabot Strait between Nova Scotia and Newfoundland.

The microwave chain of 23 stations provides 600 two-way telephone circuits apart from its capacity to carry TV pictures in either direction.



John F. White (right), president of the National Educational Television and Radio Center, congratulates Neal K. McNaughten, manager of Ampex Corp.'s Professional Products Division, after signing an order for approximately $2,500,000 of Ampex Videotape television recorders. The Center is purchasing the recorders for 43 U. S. educational television stations. Deliveries start in August.

Ampex Corp., manufacturer of the Video-tape television recorder, has been appointed sole authorized distributor in the United States of Marconi television cameras, television equipment and broadcasting equipment.

The agreement was announced jointly by officials of Ampex and Marconi's Wireless Telegraph Co., Ltd.

Under terms of the arrangement, Ampex also will be authorized distributor in the United States for the range of television camera tubes manufactured by the English Electric Valve Co., Ltd. The latter firm makes the 4½-inch image-orthicon tube used in the Marconi Mark IV camera.

A device on the Marconi Mark IV camera system can provide for immediate switching among three picture standards.

Similarly, the Ampex Videotape television recorder will be available with the "Inter-Switch" for tape recording television programs and commercials in these various picture standards.

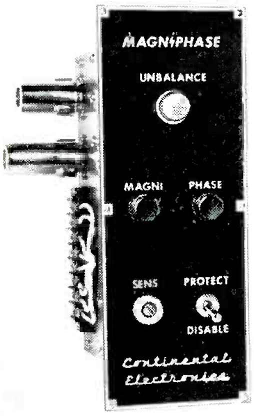
Among the Marconi equipment to be distributed under the agreement between the English firm and Ampex are the Mark IV television cameras, camera control units, power supplies, studio cabinets, portable cases, lenses (from 35 mm. to 80 inches), switchers, switchable synchronising generators, intercommunication equipment, remote control equipment, master and waveform monitors, diascopes, camera tripods, camera heads, stabilizing amplifiers, video mixers, distributing amplifiers, sweep generators and other test equipment.

WILLIAM E. SIRVATKA

Andrew California Corp. of Claremont, California, announces the appointment of William E. Sirvatka as sales engineer, responsible for technical application engineering of antenna systems. Prior to this appointment, Mr. Sirvatka was sales engineer for Jack & Heintz, Inc., 1953-59; sales engineer for Bodine Electric Co., 1950-53; and design engineer for Pioneer Service & Engineering Co., 1947-50. Prior, he was a communications officer aboard the *U.S.S. Cleveland*.

Mr. Sirvatka received his B.S.E.E. from Illinois Institute of Technology, and continued graduate work there and at John Marshall Law School. He is a member of AIEE and AES.

PRODUCT NEWS



MAGNIPHASE LINE PROTECTION SYSTEM

Continental Electronics Mfg. Co.
Dallas, Texas

Magniphase is an all-electronic device used to protect radio frequency transmission lines, antennas and antenna tuning equipment from damage due to line faults, arcs or overloads. An arc is usually caused by lightning, which in itself may do little damage. The major damage occurs if the transmitter is allowed to remain on and continue to supply sustaining energy to this arc. This energy may be a small per cent of the transmitter's total output and damage may be done, therefore, before it is detected by ordinary transmitter overload devices.

The new Magniphase system detects an arc at any point in the antenna system, and conveys this information to the transmitter, squelching the transmitter output. The total job is done in a matter of microseconds, yet the device provides adequate and reliable protection to the transmission line and antenna system components. Immediately self-restoring, the transmitter interruption goes unnoticed on the air.

The Magniphase system is designed for use with any transmitter operating in the standard broadcast band, with output power of from 5 to 50 KW, and into impedances of from 50 to 250 ohms. Two coupler types are available which are basically the same except for power handling capacities. One is for use with power levels of up to 10 KW, the other for levels up to 500 KW.

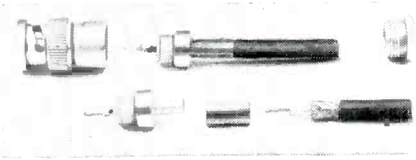
NEW PRECISION IMAGE ORTHICON

Radio Corporation of America
30 Rockefeller Plaza
New York 20, New York

A new television camera tube (RCA-7513) for high-quality performance in color television cameras and black-and-white cameras has been introduced by the RCA Electron Tube Division.

The new image orthicon features precision construction. This construction includes accurate alignment of each section of the tube with respect to the tube axis and maintenance of a high degree of uniformity for the location of all electrodes and interelectrode spacings. Because of the precision construction, the three images produced within a color camera are practically identical in geometry.

In order to take full advantage of the precision capabilities of the 7513, the color camera should employ deflecting yokes and focusing coils having precision construction and precision axial alignment with respect to each 7513. The resultant effect is excellent registration producing both a superior color-television picture and a high-quality picture when viewed on a black-and-white TV receiver.



QUICK-ASSEMBLY BNC COAXIAL RF PLUG USES CRIMPING TECHNIQUE

Cannon Electric Co.
3208 Humboldt Street
Los Angeles 31, California

The BNC coaxial RF plug uses a crimping technique to attach the outer cable braid to the plug. The quick-assembly design of this plug minimizes the number of component parts to be handled. Quick-assembly BNC's can be quickly taken apart for visual inspection, provide confined contact, and mate with all standard BNC plugs and jacks.

The exploded views in the photograph above show the cable already crimped to the plug (upper portion) and the component parts prior to crimping (lower portion). The three parts shown in the lower portion of the photograph are assembled to comprise the central unit shown in the upper portion. To assemble cable to plug, a ferrule is slipped over the juncture of cable and plug, and crimping pressure is applied to this ferrule with a special pre-set crimping tool. The setting of the tool assures that proper pressure will automatically be applied. The center conductor of the RF cable is soldered to the plug in the normal manner.

The Cannon Quick-assembly BNC Series includes plugs, jacks, and right-angle plugs to fit RG-58C/U, 59B/U, and 122/U cables.

G-R TUBE-TRANSISTOR BRIDGE

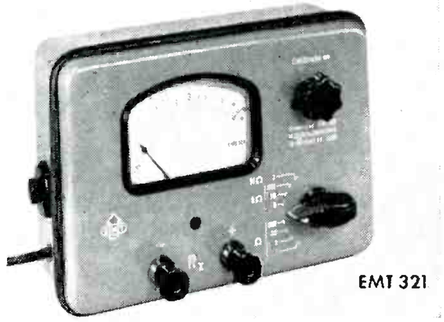
General Radio Company
West Concord, Mass.

A direct-reading, dual-purpose v-t bridge (Type 1661-A) with an amplification-factor (u) range of 0.001 to 10,000, which can be used to measure not only low-frequency dynamic coefficients of tubes, but also of transistors, over wide ranges of values under a variety of operating conditions, has been announced by General Radio Company, West Concord, Massachusetts.

The bridge, designed to operate in the 270-400 cps or 1000-cps frequency range, makes use of ac null-measurement techniques, with special consideration to phase shift and capacitance errors to insure a wide-operating range.

Independent vacuum-tube measurements can be made on forward and reverse voltage-amplification factor, resistance and transconductance; the transconductance of a tube having a high grid-to-plate capacitance value can be measured without error from this capacitance. A switching arrangement permits sequential measurement of both sections of twin triodes, twin pentodes, etc., without the need for reconnection of patch cords, an attractive production-testing feature. For tests with self-biasing cathode resistors in circuits—now required for several tube types—a panel switch has been provided to select the tube section and also to connect the cathodes to a system of three pairs of binding posts; thus the self-biasing resistors can be connected to the separate cathodes or to the cathodes in parallel.

In transistor applications, the bridge can be used to determine short-circuit conductance parameters—including the hybrid-input impedance (*hi*) parameter—and the forward and reverse-voltage ratios—including hybrid (*hr*) parameter. The short-circuit current-ratio factors (*hf*, *A* and *B*) can be determined from the ratio of two conductance measurements. Other open-circuit parameters can be calculated from the short-circuit parameters.



EMT 321 DIRECT READING OHMMETER

Electronic Applications
194 Richmond Hill Avenue
Stamford, Connecticut

An extremely wide range ohmmeter which measures resistance from 10 milliohms to 100 megohms with negligible loading of the measured circuit. Accuracy is 2 per cent of full scale. The case is finished in light grey, size 8 7/16 x 6⅛ x 4⅝. Weight, approximately 4 pounds.

V-43A STABILIZING AND CLAMPING AMPLIFIER

Foto-Video Laboratories, Inc.
Cedar Grove, New Jersey

A new Television Stabilizing Amplifier for monochrome signals mounts in only 5¼" of rack space, and draws less than 200 mils. of regulated B+. The equipment provides two independent video signal outputs plus clipped sync output to drive a local genlock or sync slave.

Very low peak-to-peak input signal levels down to 0.25 V. p-p can be successfully used with this equipment. The FOTO-VIDEO V-43A Stabilizing Amplifier features 10 mc. bandwidth with frequency response flat to 8 mc. (± 0.25 db.) and transient response providing less than 1 per cent overshoot and a maximum of 1 per cent tilt on a 60 cps square wave. Differential gain is less than 0.25 db. and differential phase less than 0.3 degrees.

A fast-acting, noise-immune keyed clamp maintains black level constant in spite of disturbances on the input signal. The keyed clamper effectively removes a hum component as great as 50 per cent of the peak-to-peak video.

Model V-43A Stabilizing Amplifier will clip and re-insert remote sync or insert local sync. The very effective keyed clamp circuit makes the unit particularly useful at the receiving end of long video cable runs. All controls are front panel mounted, and an 8-Pin Jones plug provides connection to a remote control panel available as an accessory item.

THE A. V. C. AMPLIFIER
Amplifier Corp. of America
398 Broadway
New York 13, New York

Amplifier Corp. of America, 398 Broadway, New York, N. Y., has developed and put into production an automatic volume control amplifier which maintains a constant output within ± 1 db with input changes of 30 db. Exceedingly rapid automatic gain reduction prevents syllable clipping and slow automatic gain increase avoids automatic control at syllabic frequencies.

The A. V. C. Amplifier basically consists of a two stage push-pull circuit. The operating conditions of the input stage have been carefully determined so as to provide optimum limiter action with minimum distortion. The input may be connected directly either to a balanced 600 ohm line (with either or neither side grounded) or it may be bridged across a 600 ohm line without upsetting line impedance.

Used in connection with radio broadcast transmitters, telephone circuits, public-address installations, wired music systems, factory and department store paging systems. This versatile, low distortion amplifier has a great many other applications including automatic fading between two signals and for compression or expansion (or both) of any program material.

For broadcast application, the gain control feature automatically keeps modulation at peak levels without exceeding modulation limits and eliminates the element of human error. For public address and paging system applications automatic compensation is made within maximum limits of 40 db, or 100 to 1 in signal voltage to keep the output level constant (within 2 db) so as to adequately compensate for drastic change in input volume caused by variable distances between announcer and microphone.

Its use will also economize on power requirements for modulation and paging systems by operating modulation devices and public address amplifiers at top levels without blasting. All the advantages of a higher powered modulating and calling system are experienced with no additional power consumption or cost, except for the initial purchase price of the A. V. C. Amplifier.

An On-Off switch, a Meter Transfer switch and an attenuator are its only controls. A special double-scale meter is made to serve two functions, for output level (VU) readings and for indicating the degree of attenuation at any given instant.

Its frequency response is rated at ± 1 db from 20 to 20,000 cps. It has an over-all gain of 35 to 38 db with a signal-to-noise ratio of 60 db. Its rated power output is 6 milliwatt at 2 per cent total distortion. Maximum distortion is less than 5 per cent under conditions of full 30 db compression. An adjustable gain reduction and gain increase speed control enables variation in its attack and release timing. Equipped with a self-contained power supply which is designed for 110/220 volts, 50/60 cycles with a power consumption of 30 watts. Housed in a ventilated and shielded cabinet designed for standard rack-panel mounting. Dimensions: Width 19 inches; height 7 inches; depth 8¾ inches. Net weight 25 lbs. Direct factory net price $245.00.

Complete technical specifications and direct factory prices may be obtained by writing to the manufacturer.

VIDEO TAPE PRICE REDUCTION
Minnesota Mining & Mfg. Co.
St. Paul, Minnesota

Quantity price reduction of $33.95 per 64-minute reel of "Scotch" brand video tape has been announced by Minnesota Mining & Manufacturing Co. (3M), now the world's only maker of the tape.

Second cost-saving to be passed along to the video tape user by the St. Paul firm within a year, the new decrease trims the net price of the standard hour-long reel of tape from $282.90 to $248.95, when bought in lots of 48 or more.

First video tape price cut of the past year marked a drop of $23.87—from $306.77 to the now further reduced $282.90 per hour reel.

Constantly improving production methods, lowering factory waste, were credited with making possible this latest economy.

RCA DEVELOPMENTAL NUVISTOR TRIODE TUBE
Radio Corporation of America
30 Rockefeller Plaza
New York 20, New York

Immediate availability of the RCA developmental Nuvistor small-signal triode tube to electronic equipment manufacturers on a limited sampling basis has been announced by the RCA Electron Tube Division.

The new electron tube, featuring a revolutionary design, promises improvements in quality, performance, reliability, and flexibility of installation. It utilizes a metal envelope, weighs 1/15 of an ounce and has an over-all length of 0.79 inch and a diameter of 0.43 inch. The tube is particularly useful as a radio-frequency amplifier tube or as a local oscillator tube in a wide variety of compact equipment designs for entertainment, industrial, and military applications.

A small-signal tetrode and a beam power tube of the Nuvistor design for entertainment, industrial, and military applications are under development and will be available on a sampling basis at a later date.

Nuvistors are pointed toward eventual use in automation equipment, electronic computers and business machines, communications equipment, mobile military equipment, closed-circuit TV equipment, AM and FM radios, TV receivers, phonographs, and high-fidelity audio equipment.

CLASSIFIED

Advertising rates in the Classified Section are ten cents per word. Minimum charge is $2.00. Blind box number is 50 cents extra. Check or money order must be enclosed with ad.

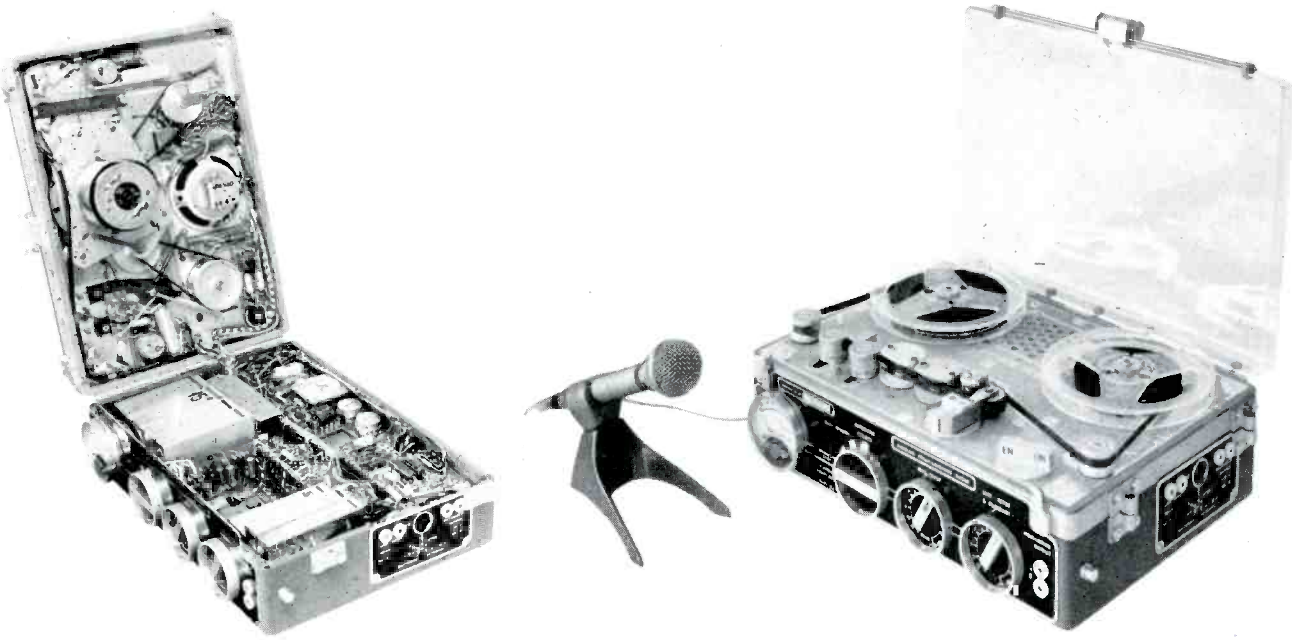
EQUIPMENT WANTED

Several RCA OP-6 and OP-7 remote amplifiers in good condition. Al Pierce, WBBM-TV, Chicago, Illinois.

PERSONNEL

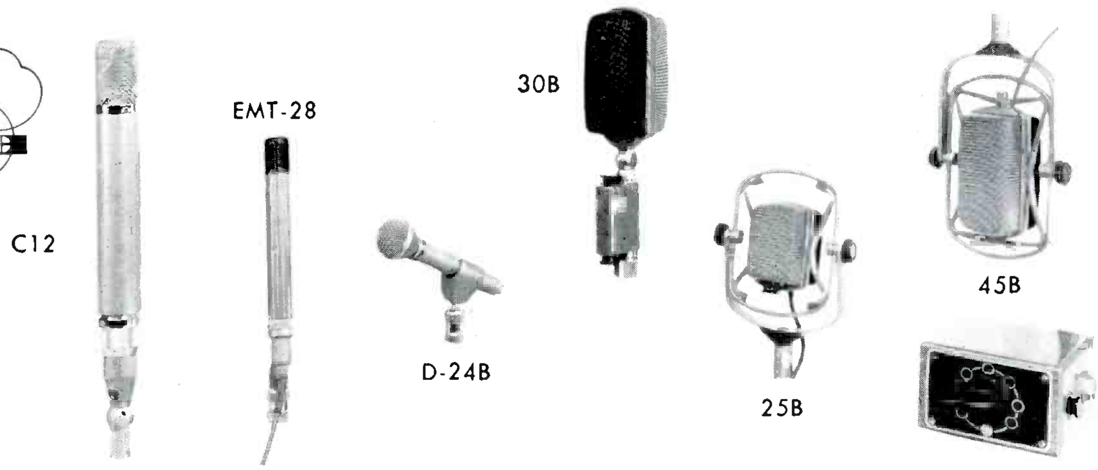
Wise station managers and chief engineers insist on RERB registration of all new personnel. RERB investigation before hiring reduces hiring hazards. Radio-TV Employee Reference Bureau, P. O. Box 333, Tacoma, Wash.

NAGRA (Swiss) Model III Transistorized Tape Unit



Model III B operates at 15, 7½, and 3¾ ips. Response, Noise, Wow & Flutter within primary NAB Standards. Self-contained, 15 lbs, normal flashlight batteries. Takes 7 inch reels. Two mixing inputs. Balanced (6 VU) output. Monitor speaker. Accessories include pre-amp for condenser microphones and a 4 position transistorized mixer. Film synch. heads easily attached.

AKG



An AKG combination of one D-30 B, one D-24 B, and either one C-28 or C-12 provides a high concentration of talent. *Variable Cardioid, Bi- and Omnidirectional.* Condenser types use premium 12AY7 (6072) in microphone body for easy field replacement. Pre-amp has extraordinarily smooth and extended low frequency response. COMPARE THESE ON A PERFORMANCE BASIS.

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Electronic Applications

194 Richmond Hill Avenue, Stamford Conn.

72 different wipes, at your fingertips