Proceedings of the Institute of Radio Engineers
Volume 24, Number 3 *March, 1936*

PRESENT PRACTICE IN THE SYNCHRONOUS OPERATION OF BROADCAST STATIONS AS EXEMPLIFIED BY WBBM AND KFAB*

By

L. McC. Young

(Columbia Broadcasting System, Chicago, Illinois)

Summary—*This paper briefly covers the history of synchronization of broadcast stations in the United States and abroad. The WBZ-WBZA system, as developed by Westinghouse, is described as typical of the "derived-carrier" type of synchronization. A new system of synchronization and equipment, developed by Bell Telephone Laboratories and the Western Electric Company and used successfully by WBBM and KFAB for the past year, is described in detail. In this system the station carriers are continuously compared and continuously and automatically corrected to a reference standard frequency transmitted by wire line.*

THE synchronization of two or more radio stations as a means of securing greater coverage on a single wavelength was first suggested in 1924 by Frank Conrad of the Westinghouse Electric and Manufacturing Company. This was a very logical suggestion from one who pioneered in radio broadcasting and contributed many other developments which had advanced the art to its state at that time.

To make synchronization possible much equipment, then unknown, such as frequency control apparatus and frequency multipliers, had to be developed. In March, 1925, for the first time in the history of broadcasting a piezoelectric oscillator was installed at WBZA, Boston, for controlling its frequency (900 kilocycles) and very shortly thereafter similar equipment was installed at WBZ, Springfield, Massachusetts. The first attempts to operate WBZ and WBZA on the same frequency were made using crystals ground to zero beat. This was not very satisfactory as the crystal oscillators as developed at that time were not very stable.

By the end of 1925 many of the necessary developments such as stable frequency control and multiplier apparatus had been made in the Westinghouse laboratories.

In January, 1926, Frank B. Falknor started the work of synchronizing WBZ and WBZA. Fig. 1 is a block diagram of the original WBZ-WBZA synchronizing system. A fifty-kilocycle piezo oscillator at WBZ generated the basic frequency. From this oscillator a frequency of 900 kilocycles was derived by multiplication through three stages:

* Decimal classification: R550. Original manuscript received by the Institute, May 3, 1935. Presented before Chicago Section of the Institute, March 22, 1935.

first from 50 to 150 kilocycles, then from 150 to 450 kilocycles, and then from 450 to 900 kilocycles. The fifty-kilocycle oscillator also fed a line amplifier to the land line connected to WBZA at Boston. There similar multiplying equipment was used and a synchronized frequency of 900 kilocycles was established. Experience soon showed that fifty kilocycles was too high for transmission over open land wires as considerable losses were encountered during damp and rainy weather due to leakage between the lines. The master frequency was then lowered to twenty-five kilocycles and an additional multiplier was used at each station. The new master frequency, however, was generated by a stable tube oscillator as a piezo oscillator for that low a frequency had not been developed. This scheme was continued until November 11, 1928,

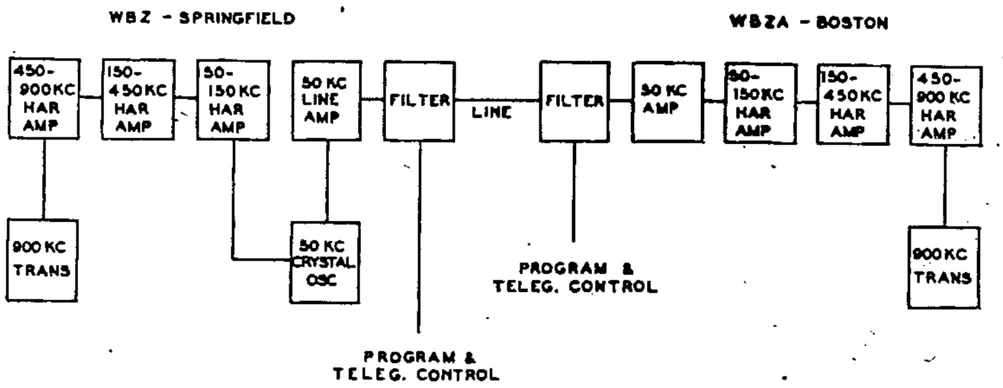

Fig. 1—Original WBZ-WBZA synchronizing system.

when the new allocation plan changed the frequency of WBZ and WBZA to 990 kilocycles and accordingly the master frequency was changed from 25 to 27.5 kilocycles.

In December, 1929, the multiplying equipment at WBZA was changed to multivibrators operating from 55 to 990 kilocycles and in addition a crystal filter was used between the multivibrator and the transmitter. This was very successful and a little later the equipment at WBZ was changed so that the transmitter operated directly from a 990-kilocycle crystal and multivibrators were used to divide the frequency from 990 to 165 kilocycles and from 165 to 27.5 kilocycles for feeding the synchronizing line.

Later the transmitter at Boston was moved to Millis, Mass., and its power was increased to fifteen kilowatts. The Springfield transmitter was reduced to one kilowatt and the call letters of the two stations were interchanged.

The synchronizing frequency of these stations has since then again been halved, to 13.75 kilocycles, for better transmission over the land line, and the system now in use is shown in Fig. 2. A 990-kilocycle crystal oscillator unit located at WBZA in Springfield controls the frequency of both stations. This is fed through a 990-kilocycle buffer amplifier and directly to the WBZA one-kilowatt transmitter. The buffer amplifier also feeds two multivibrators dividing the frequency from 990 to 110 kilocycles and from 110 to 13.75 kilocycles. The output of this last multivibrator is fed through a two-stage line amplifier, putting about fifteen watts into the line through a 13.75-kilocycle band-pass filter. At the WBZ end at Millis the line comes into a 13.75-kilocycle band-pass filter and then into a 13.75- to 27.5-kilocycle doubler, then through a 27.5-kilocycle saturated amplifier and then through a coupling tube which controls a 165-kilocycle oscillator which is coupled

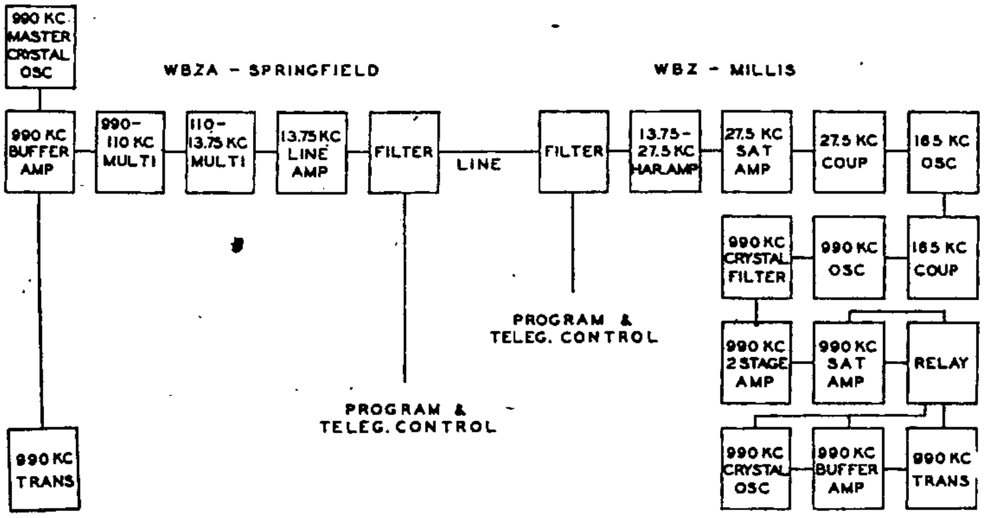

Fig. 2—Present WBZ-WBZA synchronizing system.

through another tube to a 990-kilocycle oscillator. This is fed through a 990-kilocycle cascade crystal filter and then through a two-stage 990-kilocycle power amplifier. This in turn is fed through a 990-kilocycle transmission line to a 990-kilocycle saturated amplifier, which is located on the crystal control panel of the main transmitter from which it is fed to the first stage of the transmitter. The WBZ transmitter is also equipped with the regular 990-kilocycle crystal oscillator unit.

In the event of loss of the synchronizing frequency or any of the associated amplifying equipment at the Millis end, the transmitter is operated from its own crystal oscillator unit. This is accomplished automatically by the use of a sensitive relay in the input of the 990-kilocycle saturated amplifier which controls two other relays. One connects in the crystal oscillator and the other disconnects the plate circuit of the saturated amplifier and connects it to the plate of a buffer power amplifier in the regular crystal control unit of the transmitter.

The line between Springfield and Millis is open wire with the exception of a few sections of cable. Impedance mismatches were found at these points of change from open wire to cable and from cable to open wire. The transmission characteristics of the line have been greatly improved by the use of specially designed impedence matching transformers which pass all frequencies from thirty to 14,000 cycles. In addition to the synchronizing frequency this line also carries the program and the telegraphic order circuit. A double low-pass filter with a ten-kilocycle cutoff keeps the synchronizing frequency from getting back in the speech equipment fed to the line.

In July, 1926, KDKA and KYW were synchronized experimentally by F. B. Falknor. A master frequency of five kilocycles was generated at Pittsburgh by a high precision tuning fork. This frequency was then multiplied up to 570 kilocycles through suitable harmonic amplifiers and fed to the KDKA transmitter. A 62-meter radio circuit was used to connect Pittsburgh and Chicago. The five-kilocycle frequency was amplified and used to modulate the 62-meter carrier. At Chicago the 62-meter radio was received and the five-kilocycle tone was fed through a tuning fork of substantially five kilocycles and of low damping. This was necessary to remove the fading effects and was able to take care of a 10,000-to-1 fading range. This frequency was then multiplied up to 1,020 kilocycles and fed to the KYW transmitter. This system was successful and was operated a sufficient number of times to demonstrate that the scheme could be used should there be an economic demand for it.

Falknor, in his article,[1] has given credit to the Westinghouse engineers and personnel responsible for the synchronization developments. Being the author of the paper, he has given himself much less credit than is actually due him for, as assistant to Frank Conrad, he was directly in charge of most of the synchronization developments up to the time he left the Westinghouse Company. Since that time Ralph N. Harmon and the personnel of WBZ and WBZA have carried on the developments which are now incorporated in the present scheme.

S. D. Gregory in the paper[2] which he presented before the Radio Club of America in June, 1931, gives the history of their synchronization in considerable detail, and to him this writer is indebted also for recent information concerning the present scheme as has been described.

[1] F. B. Falknor, "A history of synchronization," *Cit. Radio Call Book Mag. and Tech. Rev.*, vol. 12, pp. 38–40; March, (1931).

[2] S. D. Gregory, "Synchronization of Westinghouse radio stations WBZ and WBZA," *Proc. Radio Club Amer.*, vol. 8, pp. 79–83; August, (1931).

The National Broadcasting Company in an experimental setup in 1930 synchronized WEAF, WGY, and KDKA. A standard reference frequency was transmitted between these stations over telephone circuits. According to C. W. Horn,[3] it was found that when the stations were held in a fixed phase relation no disturbance was encountered, the mush area disappeared and an increase of field strength resulted in the areas formerly adversely affected.

WEAF and WTIC, both fifty-kilowatt stations and separated 85.5 miles, were operated synchronously for a time on 660 kilocycles. A zone of bad quality of about ten miles wide was encountered over New Haven and widening extended to the northwest.

WJZ and WBAL, separated by about 145 miles and having powers of 50 and 2.5 kilowatts, respectively, have been synchronized since March, 1931, on 760 kilocycles. These stations are controlled by an audio frequency transmitted on a wire line and the station frequency is obtained by multipliers. A common program only is used when synchronized. According to K. A. Norton,[4] in the area of equal signals between these stations slow fading is observed due to slippage and equal to the sum and difference of the field strengths. No serious distortion is found where ground waves have a ratio equal to, or greater than, three to one.

In June, 1929, WHO and WOC, separated by 153 miles, operated on the same frequency with powers of five kilowatts each. The system, developed by the Bell Telephone Laboratories, was built up on the use of two highly stabilized crystal oscillator units at the two stations. A monitoring receiver was set up at a midway point and the incoming carriers from the two stations were received and modulated by an audio frequency of a level sufficient to override the programs and then detected. The resulting audio tone was carried by land wire from the receiving point to WOC station. The level of this tone was proportional to the resultant of the combined carriers. WHO was used as a reference frequency and the frequency of WOC was corrected manually every ten minutes. This gave an average of two cycles per minute of absolute isochronism. The service rendered was about twice the service on shared time. Later, however, this scheme was abandoned and one station of fifty kilowatts was located east of Des Moines and intended to serve both areas formerly served by the two stations operating on substantially the same frequency.

Also in 1929 the Bell Telephone Laboratories made experimental

[3] C. W. Horn, "The importance of phase control in synchronizing," *Electronics*, vol. 1, p. 423; December, (1930).

[4] K. A. Norton, "Note on the synchronization of broadcast stations WJZ and WBAL," Proc. I.R.E., vol. 22, pp. 1087–1089; September, (1934).

synchronization tests, with the co-operation of the Columbia Broadcasting System, using first stations WABC and WCAU, and in the fall WABC and WHK, and a short while later WABC, WHK, and WKBW.[5] These stations were operated synchronously only for the duration of these tests.

In England, in 1925, the British Broadcasting Company operated experimentally two stations on a common wavelength.[6,7] These were 5GB, Daventry Experimental Station, and 5IT, Birmingham. They had powers, respectively, of twenty kilowatts and one kilowatt, and operated on 610 kilocycles. They were separated by a distance of 38 miles. A reference frequency station was operated at Daventry on 305 kilocycles and having a power of 2.5 kilowatts. A doubler was used at each station and supplied the transmitter frequency from the received signals from the reference frequency station. With no modulation a stationary interference pattern was found to exist. With common program, distortion was found where the field strengths were comparable. Normal reception was found where the ratio of the field strengths was equal to, or greater than five to one. If there was a carrier frequency difference of greater than five cycles an additional distortion was found and under this condition good service was only obtained where a field strength ratio of ten to one, or greater, was present. When different programs were used a field strength ratio of from 100 to 200 to one was necessary for good service.

In 1926 four stations, Edinburgh, Hull, Bradford, and Bournemouth, were operated experimentally sharing the one frequency of 1040 kilocycles, and in 1927 Bournemouth and nine of the eleven relay stations were operated on the same frequency. The system used consisted of a frequency generated at each station by a tube controlled tuning fork. These forks were made of mild steel for low damping and low coupling and had a coefficient of one eighth of a cycle per degree centigrade. These stations were kept on the same frequency by manually adjusting the forks against the received signal from one used as a standard. Coarse adjustments of up to five hundred parts in a million could be made by changing the fork temperature. Fine adjustments up to about ten parts in a million were made by adjustments of the plate voltage of the tube controlling the fork. The station frequencies were at first derived from these forks through three stages of multipliers:

[5] G. D. Gillett, "Some developments in common frequency broadcasting," Proc. I.R.E., vol. 19, pp. 1347–1369; August, (1931).

[6] P. P. Eckersley and A. B. Howe, "The operation of several broadcasting stations on the same wavelength," *Jour. I.E.E.* (London), vol. 67, pp. 772–785, (1929); *Proc. Wireless Sect.*, March 6, (1929).

[7] P. P. Eckersley, "The simultaneous operation of different broadcast stations on the same channel." Proc. I.R.E., vol. 19, pp. 175–194; February, (1931).

1000 to 10,000 cycles, and from 10,000 to 100,000 cycles, and then from 100,000 to 1,000,000 cycles. In all sixteen tubes were required and were found hard to adjust and sensitive to filament and plate voltage changes. These multipliers were later abandoned for doublers and the frequency of the forks was adjusted to 1015.625 cycles and the station frequencies of 1040 kilocycles were then derived through ten doubler stages.

In Germany the Telefunken and Lorenz Companies have developed synchronizing equipment for some of the German broadcast stations. The Telefunken Company has used a reasonably high control frequency suitable for transmission over open-wire lines. The Lorenz Company has used a lower control frequency which is suitable for use over open-wire or cable circuits. Three stations, at Berlin, Stettin, and Magdeburg were tied together with lines supplied from a 2000-cycle fork. In 1930, Cologne, Münster, and Aachen were operated on the same frequency by use of a quartz crystal maintained within ± 0.005 degree centigrade. Later Frankfurt, Trier, Freiburg, and Cassel as one chain, and Hanover, Flensburg, Bremen, and Magdeburg as another chain, were operated on a common frequency. Master control frequency for these stations was derived from a standard crystal of 1000 kilocycles and divided to 2000 cycles for a control frequency used on the connecting land lines. The stations used separate crystals and their frequencies were divided and corrected against the controlled frequency of 2000 cycles. An accuracy of one part in 10^7 to 10^8 was realized. Later forks have been developed which have maintained frequency to one part in 10^9.

In Sweden the stations at Malmo and Halsingborg have been operating on the same frequency. These are connected by land line and are arranged for operation by either a high or a low control frequency.

This covers briefly the history of synchronized broadcasting up to a year or so ago.

Successful synchronous operation of two or more broadcast transmitters demands a precision of frequency maintenance never before required in broadcasting. Not long ago it was considered quite satisfactory if broadcast stations maintained their assigned frequency within ± 500 cycles. More recently Federal Radio Commission requirements brought these limits down to ± 50 cycles. With the advent of synchronization to the broadcast problem, frequency maintenance of 0.1 cycle or less is necessary. The modern synchronizing equipment must meet and better this requirement and at the same time must be commercially operable and not require laboratory care.

WBBM at Chicago and KFAB at Lincoln, Nebraska, have been operating on the clear channel frequency of 770 kilocycles since the new allocation of frequencies went into effect in November, 1928. They have been using powers of twenty-five and five kilowatts, respectively. Under normal daytime operation the fair service area of both stations were reduced by the presence of low-frequency beats caused by the slight difference and variance of their carrier frequencies. At night it was necessary to share time. Synchronization offered these two part-time stations a means of utilizing full time on the air and at the same time of materially improving their secondary service areas. A new type of synchronizing apparatus was available commercially which was found would solve the equipment problem.

In 1932, application was made to the Federal Radio Commission for an experimental license to use this newly developed equipment to operate these stations on a common frequency using separate programs during the daytime and with a common program during the night hours in which both stations were operating.

License to operate these stations in accordance with the application was granted by the Federal Radio Commission during the latter part of 1933.

Synchronized operation of WBBM at Chicago and KFAB at Lincoln, Nebraska, was started January 27, 1934, and has continued since that time. The method and equipment are different from any other system that has been used commercially. Both were developed by the Bell Telephone Laboratories and the Western Electric Company.

Briefly, this method consists of the continuous comparison of the locally generated carrier frequency, which is to be controlled, with a standard frequency transmitted by wire line and the continuously automatic correction of the locally generated carrier to agree with the standard frequency. This method of frequency control has the distinct advantage of not interrupting the station carrier in the event of failure of any of the synchronizing equipment or of the wire line supplying the standard frequency. The only effect of such failures is the removal of the control from the carrier frequency and the dependence then upon the stability of the local oscillator to maintain this frequency. Highly stable quartz crystal oscillators are employed in this equipment and the frequency deviation which might occur during a comparatively short interruption of the control is of such a small order as still to permit synchronous operation of the stations without a serious or noticeable impairment of service to the listening public.

Fig. 3 is a block diagram of the synchronizing equipment used at these two stations. It is composed of two panels, the oscillator amplifier and the frequency regulator panel. Referring to this diagram, the four-kilocycle standard frequency is received by wire line and amplified through the four-kilocycle amplifier. This amplifier, being selective, removes considerable of the noise and extraneous frequencies which may be present in the four-kilocycle supply. This amplified four kilocycles is then fed to a harmonic generator consisting of an overloaded amplifier, the output of which contains four kilocycles and its harmonics. By means of a tuned circuit in the output of the harmonic generator the fifth harmonic of the four kilocycles is selected. This frequency, twenty kilocycles, is then used to control a ten-kilocycle multivibrator. The multivibrator, thus locked electrically in step with the four-kilocycle standard frequency, furnishes an output of ten kilo-

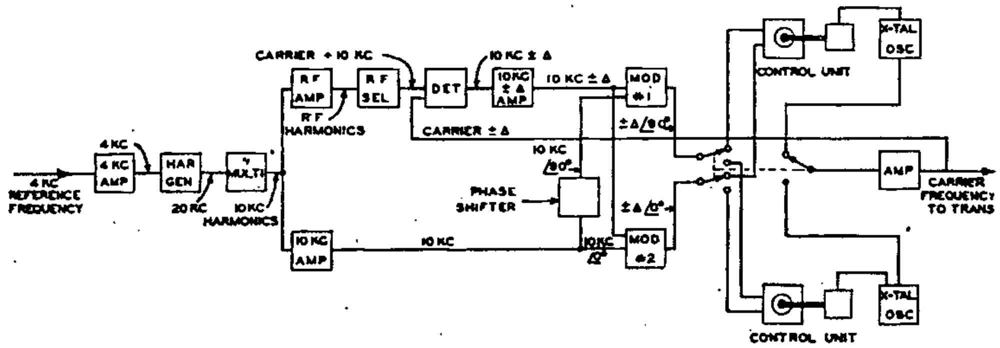

Fig. 3—Western Electric synchronizing equipment.

cycles and all the harmonics of ten kilocycles up to and through the broadcast band. The output of the multivibrator is split into two separate paths. One is fed to a highly selective ten-kilocycle amplifier and the other is fed to a broadly tuned radio-frequency amplifier.

The output of the ten-kilocycle amplifier is in turn divided. One branch supplies ten kilocycles directly to the input circuit of modulator No. 2, consisting of two tubes, biased nearly to cutoff. The other branch of the ten-kilocycle amplifier contains a phase shifting network which retards the phase of the ten-kilocycle current by ninety degrees after which it is supplied to the input of modulator No. 1. Thus the modulators Nos. 1 and 2 are each supplied at ten kilocycles, but the phase in modulator No. 1 is ninety degrees behind that in No. 2.

The output of the radio-frequency amplifier is fed through a radio-frequency selector. This selector is adjusted to select the particular harmonic ten kilocycles higher in frequency than the carrier to be controlled. This selected harmonic, having been derived from the four-kilocycle standard frequency, is therefore an absolute reference against which the carrier may be checked. The selected harmonic, together with the carrier frequency, is fed to a detector. If the carrier frequency is exactly correct, as referred to the standard, the output of the detector will be ten kilocycles which is the amount the carrier differs from the selected radio-frequency harmonic. If the carrier frequency differs from the correct value by $\pm\Delta$ cycles, the output of the detector will then be ten kilocycles $\pm\Delta$. The output of the detector is then fed through a ten-kilocycle $\pm\Delta$ amplifier. The amplified ten kilocycles $\pm\Delta$ is now fed to modulators No. 1 and 2 which are also energized with ten kilocycles $\angle 90°$ and ten kilocycles, respectively. The output of modulator No. 1 contains therefore the difference frequency between ten kilocycles and the ten-kilocycle $\pm\Delta$ or $\pm\Delta$. The output of modulator No. 2 likewise contains the difference frequency $\pm\Delta$ but $\angle 90°$ from that in No. 1 modulator as the ten-kilocycle input to modulator No. 1 was retarded ninety degrees by the phase shifting network.

It is now seen that the output of the frequency regulator panel is essentially a two-phase alternating current of frequency equal to the deviation of the station carrier from agreement with the standard frequency. This two-phase output is used to operate a small synchronous control unit which drives a variable air condenser connected in parallel with the quartz crystal of the oscillator which is to be controlled. If the frequency of the oscillator under control is higher or lower than the standard, this control unit will operate to increase or decrease the capacity across the quartz crystal as is required to bring the oscillator frequency to the proper value. When the oscillator frequency is exactly correct, Δ is equal to zero and there is no rotation of the control unit. It should be noted that the crystal oscillators and control units are in duplicate, either one of which may be thrown into service by the operation of a switch, and the carrier generated from the one in use is amplified through a two-stage buffer amplifier which prevents changes in output circuit impedence from being reflected back into the oscillator and causing frequency changes. Both the frequency regulator panel and the oscillator-amplifier panel have a separate and complete power supply consisting of filament and plate transformers and a rectifier and filter for the plate supply together with time delay relay circuits for the mercury-vapor rectifier tubes. In the oscillator panel the line voltage is supplied through voltage regulators to prevent frequency changes due to power line fluctuations.

The oscillators are calibrated as units to the assigned carrier frequency of the station. The quartz crystal in the oscillator is maintained at a constant temperature by a heater supplied with power through a three-element rectifier tube acting as a relay. The grid voltage of this tube is in phase with the plate voltage when the oscillator temperature is low and consequently current flows into the heater. When the crystal temperature reaches the proper value the contacts of a mercury thermostat close, applying an out-of-phase grid voltage to the rectifier tube, thus preventing a flow of current into the heater. The heater circuits of both oscillator units are on continuously so that both oscillator units are always maintained at the proper operating temperature.

Identical equipment such as that described is used at the transmitter of each station. Fig. 4 is a block diagram of the WBBM-KFAB synchronizing system.

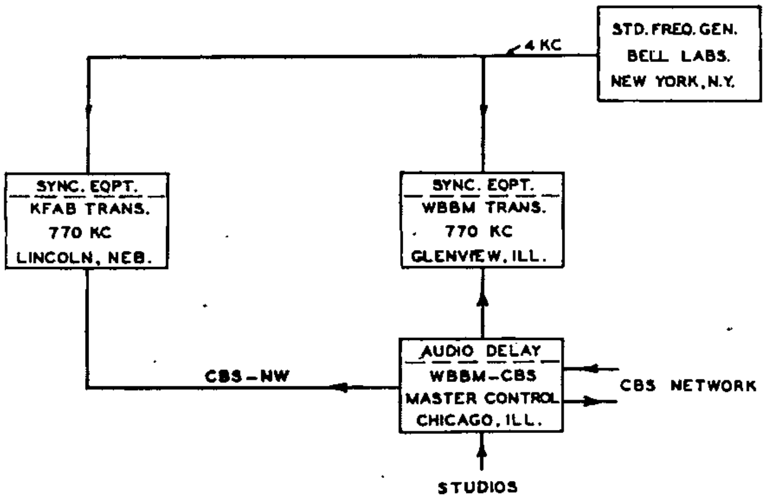

Fig. 4—WBBM-KFAB synchronizing system.

So far in the description of the method of the synchronization of WBBM and KFAB, we have concerned ourselves only with getting the two carriers in substantially perfect synchronization. When this condition is obtained and maintained, the two stations can operate during the daytime on a separate program basis with no attendant carrier interference. But when two synchronized stations operating on a common program basis are separated by more than 100 miles of wire line, another problem of extreme importance presents itself. WBBM and KFAB transmitters have a great-circle separation of about 466 miles and the shortest wire-line separation is approximately 500 miles. Time is required for the audio program material to travel over the wire lines and the program leaving Chicago does not arrive in Lincoln until twenty-six milliseconds later.

In order that no echo distortion be present in the combined radio signal as received by a broadcast listener the audio program must leave both transmitters at exactly the same time. A time displacement as small as five milliseconds in common audio from two sources may be observed as an echo by the careful listener. For perfect reception from WBBM and KFAB in the area obtaining reception through the combined signals, it is necessary that the program going to the WBBM transmitter be retarded the same as the program reaching the KFAB transmitter at Lincoln. This is accomplished by using suitable audio-frequency delay equipment in the circuit between the Chicago studio and the WBBM transmitter.

The equipment used was designed by and built under the supervision of E. L. Plotts of the WBBM engineering department. A brief description of the two types used is as follows: The first was an acoustical audio delay and, as the name implies, was constructed to use the delay in sound which occurs as it is propagated through air. The program was supplied to a dynamic horn unit of good response. In this unit the electrical energy was converted to audio energy and then attenuated through the air in a lead pipe until the desired delay was obtained. The lead pipe was acoustically terminated and the sound waves were then reconverted into electrical energy by the use of a dynamic microphone. The output of this microphone was amplified and equalized to be substantially flat from eighty to five thousand cycles. This acoustical audio delay was used successfully for about nine months.

In the meantime an electrical audio-frequency delay equipment was designed and built. This new equipment was free from most of the inherent troublesome characteristics of the acoustical delay system. It consisted of an electrical network simulating a loaded telephone line. This network was made up of T type filter with M derived end sections and was so designed as to eliminate the distortion usually present in filter networks. Fourteen amplifiers were used, one being inserted at the equivalent of each thirty-eight or thirty-nine miles of circuit. The over-all frequency characteristic is somewhat better than the present network facilities.

For over a year WBBM and KFAB have been operating experimentally on 770 kilocycles with synchronized carrier. Observations immediately following the beginning of the synchronized operation of these stations showed an interference in the received combined signals of sixty and 120 cycles appearing in a beat envelope. It was of comparatively low level and was most noticeable during the periods of low level and lulls in the program. This was due to the slight sixty-cycle hum being present in both KFAB and WBBM signals and those sixty-cycle sources of supply differing slightly in frequency. The sixty-cycle hum has been practically eliminated from both transmitters and interference from that source has been unnoticed in field observations since April 24, 1934.

The general results have far exceeded the predictions of the most optomistic technical experts concerned with the project. The total mail of the two stations containing adverse criticism has been insignificant. In the investigation of these few cases none had any just basis for criticism against the synchronized operation. For the past thirteen months, the author has spent the major portion of his time observing the operation of these stations. He has traveled over 25,000

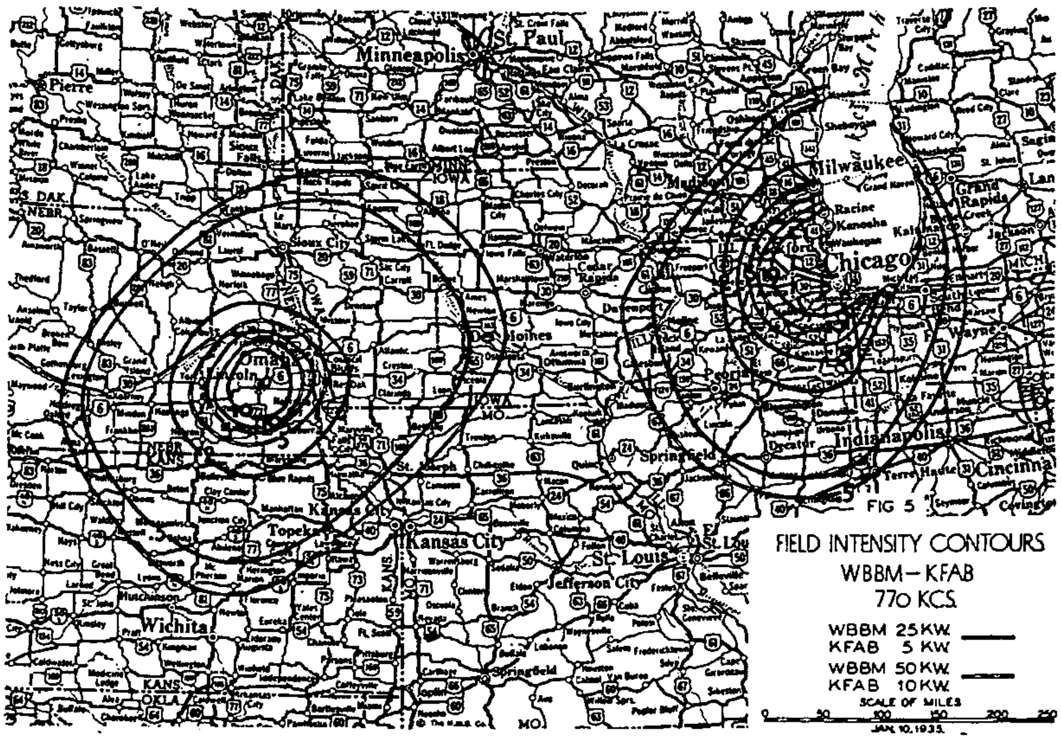

Fig. 5

miles in a field car with a field intensity measuring set, an Esterline Angus recording meter, a high fidelity Philco 800 auto radio receiver, and a standard high quality Philco 18 receiver. Daytime field strength measurements and fading records at night of synchronous operation and of WBBM alone have been made in seventy towns and cities in the area between Columbus, Ohio, and Denver, Colorado, and Duluth, Minnesota, and Tulsa, Oklahoma. During July, 1934, Iowa was combed in search of the expected mush area. Continuous observation, using the high fidelity auto receiver, was made in the field car, traveling over 1400 miles during the night periods of synchronization and common programs. No mush area was found. Very little poor quality due to fading was noticed. However, during many of the observations, several entire fifteen-minute periods would remain without appreciable fading dips, while one or both of the individual station identification announcements at the intervening breaks would show fading.

This fact, itself, indicates that in the middle area between the stations the service has been materially improved. Other observations show that the service areas of both stations have been increased. Field strength surveys of both stations have been made and are shown in Fig. 5. The dashed contour lines indicate the expected field strength pattern when the two stations operate on the recently authorized increased power. This authorization permits WBBM to operate on fifty kilowatts and KFAB to operate on ten kilowatts. Present indications are that these stations will be operating on their new power status by the middle of April. The change in power is a horizontal one and is expected in no way to change the present good synchronous operation of these stations. It is expected, however, to extend and better the service areas of both stations.

EDITOR'S NOTE:—Since the receipt of the above manuscript a paper entitled "The present-day status of broadcast synchronizing" has been published in "*Electronics,*" vol. 8, p. 174, June, (1935).