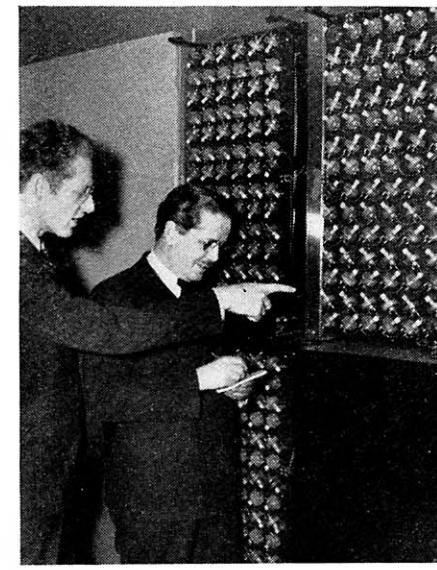
C. B. S. ROBOT TIMER

by ANGUS DUNCAN McCUSKER

Faced with the problem of delaying the signal on station KFAB to synchronize with WBBM, the CBS engineers devised a unique solution.



Row on row of impedance matching coils which delay the signal long enough to synchronize.

THOSE of us who listen to our broadcasts in the big cities rarely have anything to complain of in the way of reception from the local stations. Little do we know or care what reaches the "wide open stretches" between cities, between broadcast stations. The farmer, the rancher, and all of those who do reside in the space between cities are, however, a source of revenue to the advertisers, and hence a worry to the stations.

Recently people living between Chicago and Lincoln, Nebraska, were annoyed by a barrel-like effect that linked the WBBM or KFAB programs from either or both stations. They complained to CBS, and set in motion the engineering force. Eventually a queer contraption resulted, and the problem cleared up. RADIO NEWS presents an exclusive article on how the barrel effect was overcome.

It took twenty-three thousandths of a second for an electrical current to travel the five hundred miles of telephone wire between stations WBBM in Chicago and KFAB in Lincoln, Nebraska. Consequently, a program piped from WBBM to KFAB would go on the air just twenty-three thousandths of a second later in Lincoln than in Chicago.

Ordinarily, a delay of this kind would make no difference. But, with both stations operating on a frequency of 770 kilocycles, there was a fifty or sixty mile strip of territory between them where a receiver set at 770 kilocycles would bring in both stations.

This presented no problem of heterodyning, because the precision equipment at both stations kept both transmitters exactly on the assigned frequency. However, the overlapping area was nearly midway between the stations, and since radio waves travel with the speed of light (less than three thousandths of a second for five hundred miles), reception from KFAB coming in twenty-three thousandths of a second behind WBBM gave a hollow, barrel-like quality that is so unpleasant.

Frank B. Falknor, chief engineer of Columbia's central division, tackled the problem. The only cure was to get exact time synchronization. The problem reduced itself to delaying WBBM's broadcast by exactly twenty-three thousandths of a second. This was much more difficult than it sounded, for the delay had to be effected without reducing the tone quality of the broadcast. For this the tone frequencies ranging from 50 to 6000 cycles had to be equalized.

It was impossible to buy equipment, for the good and sufficient reason that nobody had ever faced the problem before. The nearest approach was in trans-Atlantic telephone work, where the telephone company had installed equipment to delay the voice long enough for an automatic volume control tube to function and control fading.

This meant that CBS would have to devise its own electrical equipment, a job that would take several months. In the meantime, Falknor went to work on a makeshift mechanical delay to fill in while the electrical delay was being developed and installed.

Sound travels through air at the rate of 1080 feet per second. Hence, if WBBM's program were to travel through twenty-three feet of air before reaching the mike, it would be delayed by the necessary twenty-three thousandths of a second.

Falknor had a section of lead sewer pipe cut to the proper length, and set it up with a loudspeaker at one end and a dynamic mike at the other. He killed echoes at the speaker end by installing an exponential matching unit made of an aluminum casting. It was designed to match the impedence of the speaker with that of the pipe. This functioned so well that sound leaving the speaker went into the pipe without distortion.

However, there was sound reflected from the mike diaphragm. These waves, meeting those coming from the speaker, caused a series of beats that distorted the sound picked up by the speaker.

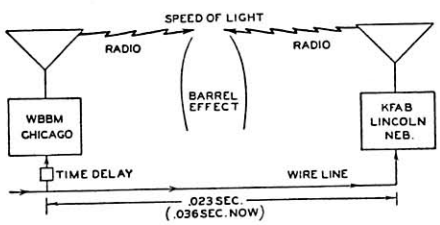
The cure for this was a terminating network of cloth placed in the pipe near the mike end. Because of the wide range of audio frequencies encountered, Falknor began by putting gauze near the center of the pipe. Working toward the mike end, he used heavier and heavier fabrics, concluding with some pieces cut from a mechanic's overalls.

This improvized dampening equipment worked quite well, but there were still humps in the sound. These were eliminated by feeding the output from the mike through electrical equalizers, one equalizer for each hump. Since each equalizer cut the total volume, an amplifier was installed after every equalizer.

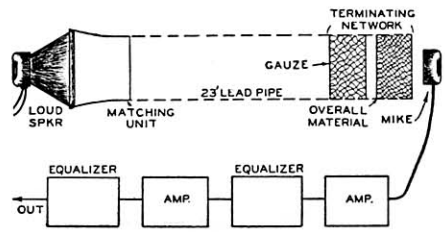
The finished contraptions worked like the diagram above. Programs were fed into the loudspeaker at the same time they left for KFAB. Sound from the speaker went through the matching unit to the lead pipe, and at the end of twenty-three thousandths of a second had reached the mike. The cloth network eliminated most echoes, but cut the entire volume enough so the mike output was fed through an amplifier. It then passed through a series of equalizers and amplifiers to eliminate all humps, and then to the transmitter. While all this was happening the identical program was traveling the wires to Lincoln, and was broadcast from KFAB at the exact instant it left the antenna of WBBM. It gave satisfactory results over a tone range from 100 to 5000 cycles from the day the two stations were synchronized, and was used for several months.

The electrical delay system that was put

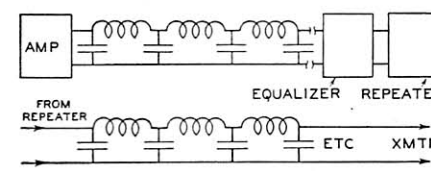
(*Continued on page* 82)



The physical problem.



The First Solution.



The Final Solution.

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No provision was made to measure the plate current to the buffer-doubler as an ordinary tuning lamp was considered sufficient for tuning that circuit. With the tuning lamp loosely coupled, the buffer-doubler tank condenser is rotated until reaching the point of greatest brilliancy which indicates that this circuit is now in resonance.

The tuning lamp method is also used to tune the grid tank circuit of the push-pull final. Due to the interaction between the buffer-doubler plate tank and amplifier grid tank it is necessary to return these two circuits. With the lamp remaining in the grid circuit of the final, retune each tank until the greatest brilliancy is obtained.

Before voltage can be applied to the final the circuit must be neutralized. With the lamp coupled to the final tank coil and the final tank condenser set to the point of greatest brilliancy the two trimmers are adjusted simultaneously until the lamp ceases to glow, care being taken to keep the two capacities approximately equal. If upon retuning the plate and grid tank circuits the bulb still glows this entire procedure must be repeated. Continue until there is no sign of r.f. in the plate circuit.

We are now ready to throw on the voltage to the final. With the meter plugged into J_2 tune the plate circuit for minimum current.

The antenna circuit may now be connected to the coupling coil L_5. This coil must be exceptionally closely coupled to the final tank coil and although it may be wound inside or outside of the plate tank the best method to obtain the necessary close coupling is to interwind the turns of the coupling coil with the turns of the plate tank coil. Further information regarding this is given in the Coil Data shown elsewhere.

To those unfamiliar with the tuning of a Pi network the following procedure should be followed. Without touching the final tuning condenser at any time set condenser C_{13} about half way and tune to minimum plate current with C_{12}. If the amplifier is not loaded to the proper value reset C_{13} to another point and retune with C_{12}. Continue until the proper loading is reached. It will be necessary to juggle the tap on the antenna coil if C_{12} does not tune to resonance or if the proper loading cannot be reached.

It might be interesting to know of some of the incidents experienced that did cause a little concern at the time, first of which was the ever-ready reply at the ham stores when shown a part needed for the rig, such as: "Is that the smallest you have," or, "Sorry, can't use it, not small enough." I'll bet at least one dealer here will be glad that this rig is finished. Then, there was the trouble experienced when trying to find a socket for the a.c. input small enough to mount beneath the power supply base. After haunting various electrical and hardware stores for quite some time with little success I found that banana jacks answered the purpose very well. Also, the evening when I decided to take the rig to the home of one of my ham friends but could find nothing suitable to carry it in until noticing my wife's favorite sewing box which answered the purpose perfectly (snitched while she wasn't looking), however, since then a carrying case has been purchased, which, according to its dimensions, was really made for this transmitter. It is made of metal and measures 15" x 7" x 6".

Plans are now being made to build a model receiver to be used with this rig. I think it can be built its comparison in size with my model rig will be much the same as the comparison between the ordinary transmitter and receiver. It can be truthfully said here that having owned and operated various rigs up to a kilowatt in power, no thrill has equalled the one received when the pure crystal note generated by this midget rig was first heard.

There is one other satisfaction, and that is: unless advised to the contrary I will consider this rig the world's smallest relay rack transmitter incorporating a power supply, four tuned circuits, and an antenna coupler, complete in every detail.

COIL DATA

For 40 meter operation using an 80 meter crystal, L1-35 turns closewound No. 28 P.E., L2-18 turns closewound No. 28 P.E., L3-18 turns closewound No. 22 P.E., L4-24 turns slightly spacewound No. 22 P.E.

For 20 meter operation using a 40 meter crystal, L1-16 turns closewound No. 28 P.E., L2-8 turns closewound No. 28 P.E., L3-8 turns closewound No. 22 P.E., L4-11 turns slightly spacewound No. 22 P.E.

For 10 meter operation using a 20 meter crystal, L1-7 turns closewound No. 28 P.E., L2-4 turns closewound No. 28 P.E., L3-4 turns closewound No. 22 P.E., L4-5 turns slightly spacewound No. 22 P.E.

Antenna coupling coil L5 to be interwound on the final amplifier tank coil with approximately one-third the turns of the tank coil.

Antenna coil L6-22 turns, 2" diameter, 2⅛" long, No. 14 wire.

Link—1 turn on 10 and 20 meters, 2 turns on 40 meters.

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Robot Timer

(*Continued from page* 47)

in permanent service has an even wider range, equalizing frequency extremes from 50 to 6000 cycles.

It is made up of filter sections having attenuation characteristics similar to ordinary telephone cable. The problems of equalization and repeating are similar to those encountered with cable.

Each filter section gives the greatest time delay possible while having the ratio of loss between the lowest and highest frequencies such that transmission at the two extremes may be equalized.

The program is fed to the first filter section. Then it goes to an equalizer, which of course reduces total volume, and then to an amplifier. From here it goes to the second filter section, etc., until it has been delayed the correct time interval.

Since the robot timer was put in service, new telephone cable between WBBM and KFAB has increased the time lag to thirty-six thousandths of a second. In the equipment now used it takes twenty filter sections to delay transmission this long, and the programs radiate from the two stations at exactly the same instant.

Thus, sometimes does the broadcast engineer face and solve problems which are "not in the book" and for which he must use his ingenuity. Falknor is modest, he says it is all in the day's work.

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