How Radio Wire Lines are Equalized

Technical Practice in England and America—Details of the Operation of American Broadcasting Stations—The Rôle of the Engineer in Radio—Comment of Interest to Broadcasters and the Public

"AS THE BROADCASTER SEES IT"

By CARL DREHER

Drawings by Stuart Hay

THE elementary theory of loss of high frequencies in audio transmission over wire lines and cables, and simple methods of correction or equalization were discussed in the May RADIO BROADCAST. The treatment of this subject will now be continued with a description of a number of types of equalizers in common use in broadcasting.

First, however, it should be understood that in line correction, as in politics, there is no universal remedy or panacea. Each case requires individual treatment, depending on the nature and length of the circuit, terminal apparatus, and transmission requirements. Open wire lines, consisting of wires strung on crossarms fastened to poles, require the least degree of correction, since the capacity is relatively low. Such lines, of course, are not as reliable in sleet or wind as aërial or subterranean cables, in which a large number of pairs are bunched and encased in some suitable protective covering, such as lead, or insulating fabrics possessing the requisite mechanical strength. On the other hand, a cable, with the two sides of a pair in contact (insulation to insulation, that is) and also close to other conductors has a much higher capacity per unit length than an open wire pair with the two wires separated by several inches or feet of air. As a result, the attenuation, or loss of energy, is much greater for a given distance, and likewise the loss of higher frequencies is not as easily corrected.

In one instance a 225-mile circuit between two cities, almost all open wire, has a "cable equivalent" of 12 miles. That is, this actual 225-mile run of open wire corresponds to 12 miles of standard cable, with a resistance of 88 ohms and capacity of 0.054 microfarads per loop mile, and the 12 miles of standard cable may be used as its equivalent in all calculations. Another circuit between the two cities contains 23 physical miles of cable, in three sections, the rest being open wire. This circuit has a cable equivalent of 40 miles, and is correspondingly harder to equalize. The type of cable is also a factor. In the second case cited above, the cable sections are what is known as five-pair, 14 gauge paper lead cable, which means that there are five pairs of wires, size No. 14 B. & S. copper, the wires insulated from each other by paper covering, with a lead sheath over all.

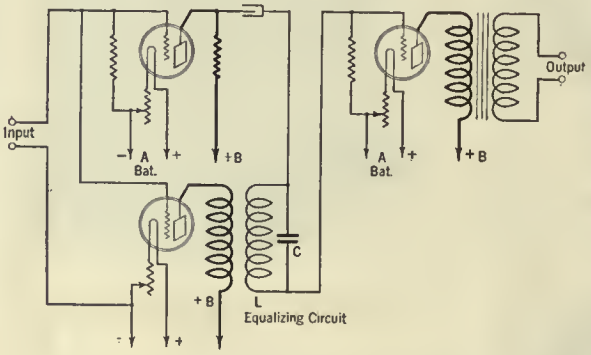


FIG 2

The Weinberger amplifier "flat" to 4000 cycles and "rising" from 4000 to 10,000 cycles

The only type of cable adaptable to broadcasting use is "paired" cable, in which the two wires of a circuit are twisted, and sometimes shielded, to avoid inductive interference from other circuits. "Straight-laid" cable, in which the circuits are not isolated in this way, cannot be used for audio transmission. Even a short section will ruin an otherwise quiet line.

Fig. 1 shows a type of equalizer disclosed in an article on "The Design of a Broadcasting Station," by A. G. D. West, Assistant Chief Engineer of the British Broadcasting Company, published in the *Year Book of Wireless Telegraphy and Telephony* (The *Wireless World, London*). This is designed to equalize between 50 and 8000 cycles per second, and represents English practice in this field. The range of the variables is not given.

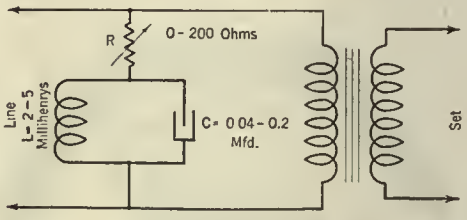


FIG. 3

Shunt equalizer for radio wire lines common in the United States

Fig. 2 shows a correcting amplifier designed by Mr. Julius Weinberger to give a characteristic, flat up to 4000 cycles, and rising from 4000 to 10,000 cycles. This is described in Mr. Weinberger's "Broadcast Transmitting Stations of the Radio Corporation of America," *Proceedings of the Institute of Radio Engineers* Vol. XII, No. 6, Dec., 1924. The rising characteristic is derived from the resonant circuit LC, tuned to 10,000 cycles, with a capacity C equaling 0.00025 mfd.

The simple shunt equalizer used generally in this country is shown in Fig. 3. A typical range of constants is given. The theory of operation is simple. The coil-condenser circuit is resonant to some high audio frequency, say 5000 cycles. Across its terminals it presents a very high impedance to currents of this order of frequency, so that it has little effect on their strength and they pass on undiminished to the input equipment. For currents of low frequency, the coil L is practically a short circuit. The combination is therefore an equalizer, dropping out the excess of low notes and retaining the high. The series resistance R regulates the de-

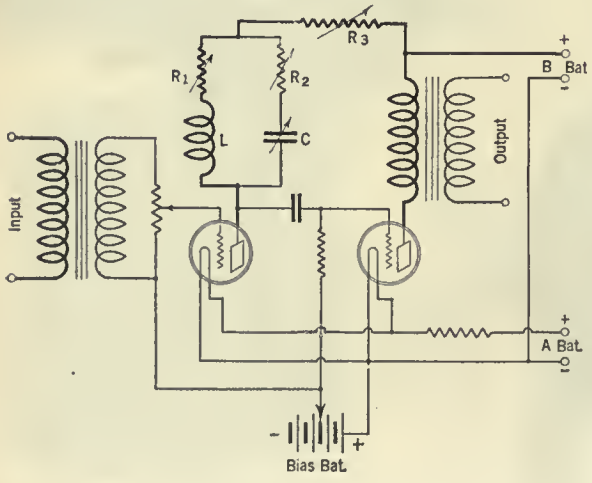


FIG. 1

British practise in line equalizing

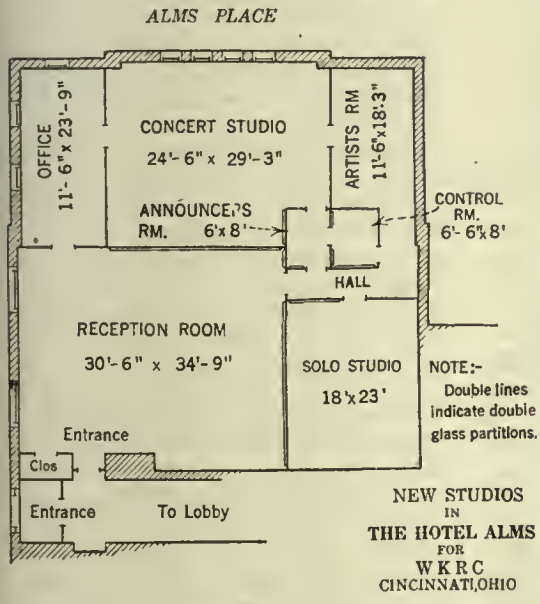
gree of equalization. When the entire resistance is out, leaving the shunt circuit bridged directly across the line, equalization is at a maximum. So is the loss in signal strength, which must be compensated for by amplification.

Among the Broadcasters

WKRC

THE sketch shows the new studio layout of WKRC of Cincinnati, in the north wing of the new Hotel Alms. The 125-foot towers are on the roof of the building. It is said that the arrangement shown was not decided on until two of the officials of the staff had visited twenty-six broadcasting stations in the United States.

The space occupied by the WKRC layout



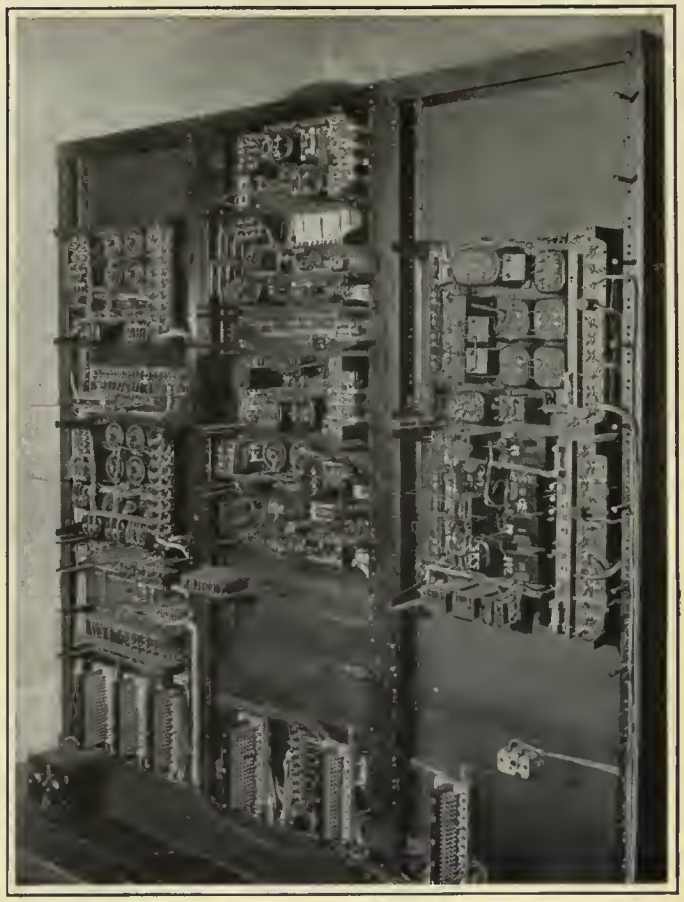
is about 3600 square feet. This area includes a large orchestration studio, solo studio, control room for the studio director and announcer, a separate operating control office, a private office for the studio director and engineer, a promenade, artists' lounge room, and a large reception hall. Both studios and the announcer's control office are glass-enclosed to permit visitors to watch the broadcasting.

The ceilings of both studios are to be sound-proofed with felt. The walls will be constructed of double thicknesses of sound insulating material, so that each studio will be effectively isolated. The finish will be white, and the acoustic composition used will give the effect of blocks of caen stone. Italian period furniture, suitable draperies and paintings will complete the arrangement.

WENR

OUR photograph of the new downtown studio of WENR, operated by the All-American Radio Corporation, located in the Kimball Hall Building, Chicago, is not printed to show the two pretty girls and Frank Westphal, the studio director and announcer, but to give technically inclined readers an opportunity to observe the method used to reduce the reverberation time of the studio. Instead of deadening the room by means of drapes, an equivalent acoustic effect has been secured by means of the solid absorbing material used for the walls.

But who put the microphone on the piano? We will wager that none of the operators were around when that photograph was posed.



REAR VIEW, STUDIO CONTROL PANELS—WBAL, BALTIMORE

WBAL

YOU are next invited to gaze on the studio control panels (rear view) of WBAL, Baltimore, Maryland. Apparently not all the equipment was in when this photograph was taken. There is enough, however, to enable you to understand why a broadcasting station gets out of order once in a while.

WEAF

ONE of the best known regular features on the air is the Sunday night Capitol Theatre broadcast through WEAF, New York and its chain. The smooth and perfectly controlled job invariably turned

A NEW STUDIO OF WENR, CHICAGO WHICH HAS A NOVEL WALL TREATMENT

"HE WAS A GENIUS—HE FREQUENTLY SAID SO HIMSELF"

out is no accident. One of the reasons, we are told, is that two of the control engineers assigned to cover the evening program listen to the Sunday afternoon performance in company with the assistant conductor of the theatre, taking notes which later guide them in producing a first-class piece of work in transmission.

It may also be of interest to consider the amount of equipment tied up whenever the big duck, WEAF, and all the little ducklings, to the number of about fifteen, are connected together by wire lines. According to Mr. George F. McClelland, Manager of Broadcasting for WEAF, 9300 miles of wire are used to carry an important program from the Atlantic coast to stations east of the Missouri River, from Minneapolis on the north to St. Louis on the south. The currents travel through underground circuits and over 124,000 telephone poles. The telephone lines, as originally designed and installed, were intended only for transmission of the essential frequencies of speech. The lines used for broadcast transmission must be equalized over a far greater range, in order that natural speech and music may be delivered to the various stations on the chain. About one hundred men cover the transmission, not only in the broadcasting stations themselves, but at twenty-four repeater stations along the lines, where the audio currents are boosted in order to maintain proper quality and margin over noise.

WHT

THROUGH Reeve O. Strock, the chief engineer, WHT reports the installation of a "mixing panel", a device such as was described in the April, 1926, RADIO BROADCAST, to secure greater flexibility in balancing musical ensembles. The report does not give much in the way of circuit details, but it is stated that five studio microphones and all incoming lines may be put on the air simultaneously in any volume proportion desired.

The Rôle of the Engineer in Radio

IF I were entirely ignorant of radio conditions, in a technical sense, wanted to buy a good receiving set, and had no means of getting expert counsel, I should adopt the following curious procedure. Instead of listening to salesmen, who, in my unprepared state, would probably merely befuddle me with their talk, or reading advertisements, which nearly always start with the claim that the set advertised is the eighth wonder of the world, I should try to find out what percentage of their gross income various manufacturers devote to research. When I had discovered the one with the highest ratio in that regard, I should look over a list of his sets, buy the most expensive I could afford, and let it go at that. I might not end up with the best receiver I could buy for the money, but I rather think I would. Neglecting all the other factors involved, the single consideration I have suggested would probably set one on the right path.

The fact is that in radio, as in every other field, one is not apt to get something for nothing. And progress must be bought like everything else. One manufacturer turns out a better product than another, as a rule, because he spends more in finding out how to make his machines superior. It is really astonishing how many radio manufacturers have gone into production on a formidable scale, advertised extensively, sent out an army of salesmen, and invested a gold-mine in the whole structure, when they really had nothing to sell. The product itself was the last thing they thought about. A radio receiver, to them, was a radio receiver. An engineer was anybody who said he was an engineer and could get a few other people, who also said they were engineers, to say that he was an engineer. If he was given the title of Chief Engineer, then all doubt was dispelled. The man was a genius—he frequently said so himself—and that his words dripped with wisdom was proved by the fact that he always spoke in such intricate and technical terms that the promotors of the enterprise could not make head or tail of what he said. All that remained was to put his masterpiece into a fancy box and wait for the money to roll in. . . . Sometimes the creditors have received as much as twenty cents on the dollar.

In this day of high pressure salesmen, well nourished advertising agencies, fifty-thousand-a-year executives, scientific management, expert industrial prophets, and all modern improvements, it is well to remember that our little radio world rests on the shoulders of only one Atlas, the engineer. Or, if you prefer Biblical to mythological figures, do you remember the injunction to build your house upon a rock? If so, you have a better memory than many of the radio set manufacturers whose stock issues dropped from the twenty dollar to the fifty cent class during 1925. Look into the cause of these sad declines, and you will find them many and various, but there is one factor which turns up in seventy-five per cent. of all wrecks, and that is poor or mediocre engineering. The thing started wrong, and it would be a miracle if it had ended right. And miracles occur in hagiology, seldom in radio.

What, then, is this engineer, whose horn I blow so loudly? It has been said that an engineer is a man who can do with one horsepower what any fool can do with two; and that is not a bad definition. Going back a step, we find that this efficiency arises from superior quantitative knowledge. The engineer knows definitely where he "is at" and where he wants to go. But so does a shop-foreman. Going back another step, it appears that the engineer's proficiency rests on the organized body of technical knowledge handed down to him through the various sciences from which his art is derived. He knows his underlying physical theory, is able to express it mathematically, that is, succinctly, exactly, and generally, to confirm it by measurement, and finally to apply it practically to his machine. The engineer is to the cut-and-try set constructor what Oscar of the Waldorf is to a chef in a hash-house.

The necessity for design and production engineers is obvious, since they must be depended on to get out the product. The department which is more likely to be neglected is that of research and development. Instead of parting with the necessary cash for a development division, some short sighted executives think they can get away with it by imitating their competitors. This has two disadvantages. One is that the competitors may not be worth imitating. The other is that the copying firm is always a year or so behind the copied. The proper procedure is to originate when

one can and to adapt good ideas derived from competing sets, when expedient, and as far as business ethics will allow. All manufacturers keep an eye on competing sets, and know their good and bad points quite as well as they know the strength and weakness of their own equipment. That is, all manufacturers who are not asleep, and in industry, as when one is freezing, sleep is death. If you walk into the laboratory of a manufacturer of loud speakers, you will find every model of loud speaker on the market, some intact and some taken apart. Furthermore, there will be characteristic curves of all these instruments, showing how some of them lose the low frequencies, some the high, and some both, and depicting the various humps and troughs which make them what they are. But the enterprising manufacturer and his engineers do not spend much time chuckling over the faults of competing makes; they try, rather, to evolve something superior to anything hitherto known, and to surpass themselves as well as their rivals. And this holds for all the numerous parts and complete sets on the market; in every case the firms interested fall into two main classes: those who strive for improvement and those who are satisfied to copy the leaders. The former class is also found to be soundly financed, while the camp-followers generally skate on thin ice. Good research is one of the elements of sound financing; it is insurance against dropping behind in the race for technical supremacy, which, in the last analysis, determines profits.

Sound engineering is as important in development and operation of broadcasting stations as in the manufacture of receiving equipment. The two fields are analogous, development having its place in each, followed by production in one case and operation in the other. There has never been a first class broadcasting station without a first class development division behind it. If you see a station that remains unchanged from year to year, all you may safely conclude is that it may have been a good station once. It is not only a matter of apparatus, but also of sound methods in operation. Tests and procedures must be carefully planned or a smooth performance on the air need not even be hoped for.

If the engineering is unsound, no amount of brilliant program work will make up for that weakness. An instance: a very important dinner was to be broadcast. In addition to the speakers at the banquet, it was necessary to furnish public address service in the banquet hall on the entire output of the broadcasting station. That is, programs from other cities were to be broadcast and simultaneously made available through the public address system to the diners. The best method of handling this was to feed the public address system continuously from the control room amplifiers of the station.

As a new amplifier system was being installed at the hotel, it was impossible to test the lay-out until a few hours before the dinner was to start. Then, to the consternation of everyone, the combination of public address and broadcasting station audio amplifiers howled lamentably as soon as the connections were made. The diagnosis was simple—coupling between the pick-up microphones and the loud speakers in the banquet hall. The tables were all set up, the speakers' platform had been placed, nothing remained but to bring on the food. But without the public address and radio service the banquet would have been, as the boys in the shipping room say, a flop. What was to be done? It was a problem that had to be solved in a hurry. One of the engineers looked around in the annoying, ruminative way these bipeds have in such situations. He observed a small balcony, which he inspected thoughtfully. He went under it and clapped his hands. He went back into the middle of the room and clapped them some more. He directed an assistant to stand under the balcony and slap his palms together enthusiastically, while the first engineer stood at the far end of the hall and listened. He then had a microphone placed under the balcony. The assistant spoke to it. The system reproduced without howling. "If the speakers' table is placed in the lee of that balcony," remarked the engineer, "you will get public address service. Otherwise not." And immediately all the king's horses and all the king's men were set to moving the speakers' table under the balcony, and the banquet was run off successfully. The incident was not an unusual one. In the last analysis, if the engineer's part of the show is sick, the whole show is sick. If he crashes, all is lost. He is the foundation and the framework. Let the elegant gentlemen in the superstructure remember that.

"Please Send Up a Wire"

SOME time ago, in this dizzy department of an otherwise respectable publication, I wrote a skit entitled, "The Laying of the Lines." This opus was my burlesque conception of a young woman radio critic's idea of remote control, derived from a paragraph written by the fair one (since departed from the radio ranks), in which she gave it as her opinion that the lines between New York and Schenectady must have been "carelessly laid" on one occasion when they became noisy during a concert. Pouncing on this phrase, I wrote a piece in which I pictured myself as "laying the lines" by rushing up the east bank of the Hudson with a roll of twisted pair under my arm. One must write about something.

Extravagant? Absurd? Even so. And yet it was brought home to me, the other day, that whatever nonsense one writes, it will be only a little more foolish than the sober thoughts in some people's heads. Attend, then, to a true story.

A movie actor, nationally famous and fabulously rich, had finished a new picture. For the sake of the publicity, the producer arranged to broadcast some scenes from the photoplay, with a musical accompaniment, and to add to the interest, the star was to speak from the studio to the radio audience.

The arrangements having been made in the usual manner, and the event scheduled for a certain evening, a telephone call was received at the broadcasting station on the afternoon of that day from a third assistant secretary of the cinema celebrity. The substance of it was that Mr. X desired to attend a prize-fight in Two Hundred and Twelfth Street (about nine miles from the studio) that evening, and would it not be possible to rush a wire

"WOULDN'T IT BE POSSIBLE TO RUSH A WIRE UP THERE?"

up there, so that Mr. X could broadcast without missing his diversion?

Yes, truth will beat fiction any day. The name of the miracle-seeking star will be given on application to any United States Senator.

Memoirs of a Radio Engineer. XII

"MY MAGAZINES SERVED SOMEWHAT LIKE A LOVER'S PICTURE OF HIS SWEETHEART"

MY ACCOUNT so far has been of urban amateur radio. I did, indeed, take radio with me on my vacations, but only in the form of magazines on the subject, manufacturers' catalogues, and the like. As I was going to school, I enjoyed a vacation period of some two months each summer, which was spent in the Catskills, as a rule. The radio reading matter which I took away with me served somewhat like a lover's picture of his sweetheart, and had the same limitations. After a month's absence from my receiving set, I usually felt a great longing to hear actual signals again, and there were several years when I returned to the city a week or so sooner than was necessary, because my craving for dots and dashes could no longer be restrained. A curious mania, and one which I scarcely comprehend to-day, although I remember it clearly enough. Presumably what killed it was an overdose of dots and dashes when I went into radio professionally.

In 1913, however, my family occupied a cottage in Bushnellsville, Greene County, New York, and my receiving equipment went up there with me. It consisted of a loose-coupler covering a range of from 300 to 3000 meters, approximately, galena detector, and 2000-ohm telephones, with the usual accessories. The water supply in the house came from a spring about 2000 feet distant, through galvanized iron pipe, partly on the surface and partly buried; this gave me a good ground. I strung a single-wire antenna to a tree about 250 feet from the house, and higher up the hill. I climbed the tree and my sister helped me on the ground. The height of the free end of the wire must have been around 40 feet, and it was practically parallel to the side of the hill on which the cottage stood, so that it had a slope of thirty degrees or so, reckoning from the horizontal, and fell into the class of sloping, or, as they were then sometimes called, "compromise" antennas. The lower end of the wire was supported by a tree about thirty feet high, and thence the lead-in dropped vertically to my window.

Bushnellsville is practically in the center of the Catskill range, about 120 miles northwest of New York City, with mountains for thirty miles and more in every direction. The elevation is 1600 feet above sea level, and the tops of the mountains rise 1400 feet higher. Under such unfavorable receiving conditions I had little hope of picking up daylight signals, and I never did. I listened often, but heard only static crashes, and plenty of them, because scarcely a day passed in this valley without a lightning storm of greater or lesser severity. But what I expected to get was the nightly press report of WSL, the Atlantic Communication Company's large station at Sayville, Long Island. This transmitter was a Telefunken spark set rated at 35 kilowatts. I don't know what the actual antenna power or "Turm Kraft," as the German engineers called it, amounted to—possibly something in the neighborhood of 10 kilowatts. Anyway, it was the powerful set of its time, and did a great business communicating with vessels crossing the Atlantic, which it sometimes worked as far east as Gibraltar. The wavelength was somewhere up in the two thousands, about 2800, if I recollect, and each night it sent several thousand words of press, starting around 8 P. M., at about 12 words a minute, including news items, baseball scores, and other items of interest. I was able to get a very readable signal from WSL, and copied him every night. In this way I had the baseball scores every night at about ten o'clock, when nobody else in Bushnellsville knew them until noon the following day. Then the mail, including newspapers, arrived by stage coach, the village being four miles from the nearest railroad station. Most of the natives knew nothing about radio, and believed that I secured the ball scores by some sort of necromancy.

Sayville was the only station I could get reliably. Time signals from NAA, Arlington, were weak, although generally audible at the 10 P. M. transmission. On 600 meters I heard a few ships, and WSC, the Marconi station at Siasconsett, Massachusetts. None of the New York city stations ever let out a peep as far as Bushnellsville was concerned. Mountain reception on a crystal was a different proposition from my city experiences, relatively close to WNT, NAH, and WCG. But, even as conditions were more difficult, the thrill of being in touch with the outside world was greater. There was a peculiar incongruity between the green clad hills and my antenna, and the mastery of space which radio communication gives to man seemed more remarkable in the hills than in the city, where mechanical appliances and triumphs are the regular thing.

In walking and driving about the Catskills in those years (1912-1914) I never saw another antenna. I have sometimes wondered whether I was the first to introduce radio into the haunts of Rip Van Winkle, in the summer of 1913. If there are any other claimants to the honor, let them speak now, or forever hold their peace.

¶ *A regular portion of Mr. Dreher's department, "As the Broadcaster Sees It" is devoted to technical procedure in broadcasting stations. That section of his department is of especial interest and help to the many engineers and others engaged in the daily solving of problems of broadcasting. Mr. Dreher invites contributions from other broadcasting engineers, telling of kinks of operation, or any kind of short report on their daily technical experiences which will be helpful to those similarly engaged. All contributions accepted will be paid for at our regular space rates. We believe, also, that the technical side of the operation of a broadcasting station is of deep interest to the great body of radio experimenters as well as to those who make their living supplying broadcast service to the listener. The material appearing in this department is so written that it is sufficiently technical to be of help to the engineer, but yet not too involved for the average experimenter to comprehend.*