Technique of D. X. Reception

By Carl Dreher

Herein are given helpful hints and remedies for eliminating extraneous noises that interfere with d.x. work. Suggestions are also given whereby the careful operator may secure greater distance than the careless one. The conclusion is that it is the operator rather than the instrument that determines the range of a receiving set.

IT is not the object of this article to describe any particular set suitable for long range reception, nor to recommend any of the various types of sets, such as regenerative receivers with audio frequency amplification, or radio frequency amplifiers, or the superheterodyne, which are found in use. Every type of receiving set, in the hands of some experimenters, seems to give extraordinary results, while other individuals, using identical apparatus, get only mediocre effects. The difference, apparently, is in the handling of the set, and sometimes in external factors such as locality. Obviously if one is going in for the delicate business of distance reception the first requisite is a decently designed set, but the discussion here will be confined to the factor of skill in operation, together with certain less controllable factors which the DX man is forced to take into account.

Freedom from Interference

Nothing is more conducive to unusual records in reception than a quiet receiving field, to use a term adapted from optics. Just as when one wants to inspect a small object under the microscope it is necessary to place it on a perfectly clean glass slide, so, in radio, when one goes after a very weak signal, the first step to success is to bar all other sounds as far as possible. This seems obvious, but how many really quiet receivers does one encounter? One of the most common faults is bulb hiss. Often superior results may be secured by changing around the tubes when several are used. The amplification may not be increased, but if some of the hiss and underlying rustle is eliminated, that much is gained. Or, there may be a gassy tube in the amplifier. Tubes now run fairly uniform, as compared to the days when a new bulb might pick up anything from Cape Race to Demerara, or stop short at Seagate. Still, now and then one is apt to hit on a noisy one, and the best thing to do, if the effect is at all pronounced, is to take it out and leave it out. Varying grid bias, lowering the grid leak resistance, or changing the plate voltage, often is of service. It is surprising how few amateurs pay attention to this important detail, which is under each individual's control, unlike external forms of interference such as static and code signals.

Induction from nearby motors or a.c. feed lines may be an important factor in curtailing the range of a receiver. The usual remedy, in the case of a.c. hum, is to swing the antenna at right angles to the line, whenever possible, thus doing away with the magnetic linking of the line and the antenna. However, in many cases the trouble is caused by electrostatic coupling between the room wiring and the plate circuit of the last tube, via the listener's body and the telephones. In such instances a considerable degree of relief is obtained by grounding the listener's body, or the metal framework of the telephones, or both, thus changing these surfaces from an intermediate condenser plate between the set and the house wiring, into a grounded shield between these points.

In one case I found that the exposed transformer coils of an a.f. amplifier were picking up induction directly from the house wiring. The coupling was magnetic in this instance and the difficulty was removed very simply by turning the receiver into a position where the exposed coil was at right angles to the field. In another case lighting a desk lamp with a long length of cord brought in the hum. The thing to do in all such instances is to experiment until the source of the disturbing field is located and the remedy is then usually obvious.

Motors with sparking brushes are a frequent cause of rattling and whirring noises in sensitive receivers. When the trouble can be localized and the motor is accessible, relief may often be secured by the use of 4-6 mfd. capacity across the terminals—and of course trimming the brushes is also very much in order and sometimes does away with the racket without further measures. But here the experimenter is apt to run up against the same kind of individual as the lightning-shy landlord. I call to mind the operator of an ash conveyer who refused to touch his motor because he said that all motors spark at the brushes when they run, and would have nothing to do with condensers because he was sure that they would draw extra current from the line.

Among other sources of interference with DX reception we may mention static. No effective and simple remedy is known at the present time. When in the form of isolated crashes with clear intervals, it does not interfere so much with the DX fiends, who are satisfied if they get the distant station's call.

When it comes to serious interference from telegraph stations, the only remedy, in some instances, is to wait until spark transmitters are barred by law or the pressure of public opinion. It is impossible to tune out a spark coil transmitter next door, and it is very hard, to say the least, to hear distant broadcasting stations if one happens to be located in the shadow of a powerful commercial spark station, even though the latter is sharply tuned and complying with the law in every respect. If this is the case, however, a wave trap may often be used to good effect. This is simply a tuned circuit coupled to the antenna through a step-down radio frequency transformer. A design employing spiderweb coils is shown in Fig. 1. By tuning the condenser and varying the trap coupling 200 meter spark stations may be eliminated with no effect on the 360 meter broadcasters.

In getting through the local broadcasters a small, low antenna is of great advantage. For some months a futile controversy raged on this point in one of the radio newspaper supplements, some listeners maintaining that it was possible to receive DX through the local stations, and others refuting them from experience. It was simply a case of receivers 6-10 miles from the locals, and using antennas with low effective height, in the first case; and in the other instance people either very near the locals, or using comparatively high aerials, or both. If one is very close, say within two miles, the problem is of course more difficult, but in any case the low antenna is advantageous. The theory on this point was first published

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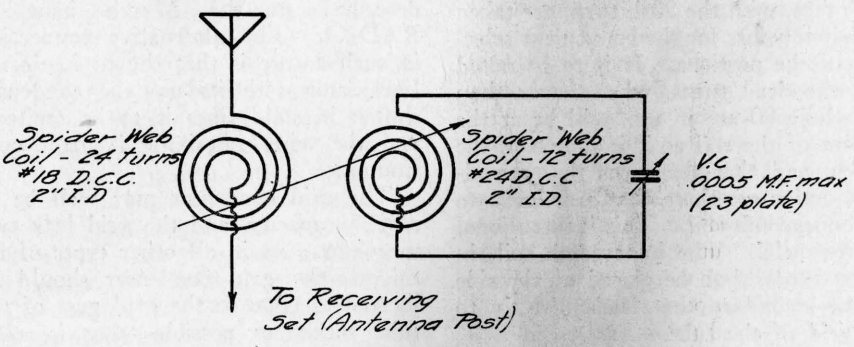

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by Mr. Frank Conrad, Assistant Chief Engineer of the Westinghouse Company in the Proceedings of the Institute of Radio Engineers, *X*, 6, Dec. 1922. Although the low antenna picks up less signal energy regeneration may be used to compensate for this in considerable part, and the results on the whole are much better than with a high antenna. This also holds for 200 meter reception. On Long Island I have picked up strong signals from Fourth District stations on a wire six feet above ground, with negligible QRM from the Second District stations about 100 miles away.

Regeneration

Regeneration consists in repeating back the signals from the plate of a tube to reinforce the oscillations in the grid circuit. When carried too far the receiving set acts as a small but often very disturbing C. W. transmitter. There has been a great deal of agitation on the proper use of regeneration and its advantages and drawbacks. Much of the discussion has been more in the way of heat than illumination.

The unfortunate fact seems to be that everybody seems to consider it legitimate to let his own receiver oscillate vigorously at times, but objects to the other fellows doing it. If we discuss regeneration, however, not as a matter of radio morals, but simply as to what is most expedient at the present stage, experience shows two things: (1) That it is helpful to use oscillation in picking up distant broadcasting stations by beating with the carrier wave; and (2) That after the station is located maximum intelligibility is secured by cutting down on the regeneration to a point where the beat note goes out, speech is not distorted, and the receiver is not a source of interference to other people on the air.

On this basis one may use regeneration to the point of oscillation in sweeping through the wavelength range of the receiver. To advise people never to let their receivers oscillate is a counsel of perfection; it may be highly commendable, but few people pay any attention to it in practical reception. It may be considered fair, under present conditions, to use a limited amount of regenerative oscillation for "heterodyne searching" as above, but to refrain from the continuous use of this mode of reception, both from motives of decency, and because it is of no earthly use. The first impulse, when one hears a distant broadcasting station, is to get it in as loud as possible. This is accomplished by local oscillation and zero-beating with the distant transmitter. Sometimes one gets fairly good music by this means, since the sounds of most instru-

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ments are considerably less complex than the human voice, but when the crucial moment comes and the announcer gives the call letters and location of the distant station, it is only luck if one succeeds in deciphering the resulting hash of words. By far the better course is to tune accurately to the station, get maximum regeneration consistent with clarity, and no more, and then, if the signal is still too weak to read, wait for it to build up outside. If he is in a fading spell just at the time of signing, you are out of luck, but you have done your best and at the same time not made an unmitigated nuisance of yourself in the ether.

Incidentally the popular notion that coupled receivers, as distinguished from single-circuits, do not oscillate into the antenna, is erroneous. They can and they do. The proposal to bar single-circuit receivers is therefore no solution at all.

Psychological and Physiological Factors

The art of deciphering faint telegraph signals or speech is partly a matter of ear-training. Loud signals have a temporarily injurious effect by making the ear insensitive to succeeding weak sounds. Anything which fatigues the ear is to be avoided. Thus any noise such as a continuous hum or machine rattle is a handicap not only because it may drown out distant stations, but because unconsciously the listener is annoyed by it and the edge is taken off his ability to make the considerable nervous effort usually necessary in getting the sign of a very distant station. Good hearing and a suitable temperament for this sort of work are of course inherent advantages which some people have.

By the same reasoning, ease in operation is of great importance, although often neglected. The energy expended in tinkering with the receiver is at least partly subtracted from the energy available for effective listening. Receiver shielding is desirable because it makes adjustment easier by eliminating the effects of body capacity, and the use of vernier attachments is almost imperative. Trying to set a 43-plate (0.001 mfd.) variable condenser to optimum position for a 360 meter station, with a small antenna, is as bad as adjusting a surveyor's transit on a below-zero day.

Among physiological factors is the matter of breathing. At the instant of trying to hear an almost inaudible call one should hold one's breath, not only to obviate the slight noise in the respiratory passages, but because an appreciable gain in ear sensitivity may be secured in this way. Details like this spell the difference between success and failure in DX work. A comfortable posture at the receiving set is also helpful.

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The Transmitting End

The fundamental item which determines the reliable sending radius of any radio station is the meter-amperes product, the effective height of the antenna, that is, multiplied by the current put into the antenna by the set. Secondary factors, such as complete modulation, but not over-modulation, and careful avoidance of distortion in the microphones and other parts of the set, rank next in importance. Thus powerful broadcasting stations like WGY, WJZ, and KDKA are most apt to make transmitting records.

There is one practice which some broadcasting stations make part of their routine that is rather unfair to some of the listeners competing for long distance honors. That is the use of the oscillator as a telegraph transmitter in signing off. By this means the range of the station is greatly extended, for the telegraph carries much farther than speech or music. Occasionally listeners whose receivers were oscillating at the time, but who were hearing the broadcasted material only as an indecipherable murmur, or not getting it at all, pick up the concluding telegraph sign and on that basis make a claim of having heard the station. This is stealing a march on the listeners who make their identification by received speech, and is unfair in that it is not telephone reception at all. The one good feature is that it puts a premium on knowing the code, at least for very low speeds; but in any case the great majority of broadcast listeners will never learn the code, for the same reason that the bulk of the people who use cameras never think of doing their own printing or developing.

Amateur telegraph radio is another matter and here a reform in the opposite direction might be recommended. Many operators make a practice of sending a few score "CQ's" and then signing once or twice. It would be better to curtail the "CQ" part and add a few more signatures. Also, at the end of a message, it is good practice to send one's call once or twice, so that a chance listener may be able to log it. To end up simply with a "K," as so many operators do, is to neglect the opportunity to be acknowledged by some listener at perhaps a phenomenal distance.

Meaning of "Range"

The meaning of the term "range" is so badly defined, as yet, in broadcasting practice, that the following suggestions may clarify the situation a trifle. For a given form of receiver the range of a transmitting station might be considered in say four gradations, as follows: (a) Consistent reception under practically all conditions and over practically 24 hours of the day. This would be the case of the powerful transoceanic tele-

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graph stations operating commercial radio circuits over which continuous communication is imperative. (b) Limited reliable service during only a portion of each day, and barring very unfavorable natural conditions. As an example we might cite the radio-telegraph circuit now being inaugurated between Holland and the Dutch East Indies. This is such a long throw—some 9000 miles—and the static conditions at the southern end are normally so bad, that it is not expected to communicate more than about three hours a day, when the entire intervening area is under cover of night, and when the tropical static is not too violent. This arrangement covers the traffic requirements in this instance. (c) Frequent freaking—meaning unreliable but nevertheless not uncommon reception. At the present stage, with existing broadcasting energy and interference conditions, most telephone reception, other than local stations or those within a few hundred miles, would come under this head. If one cannot be sure of hearing a given station at any time that he is going, this would be the proper classification, no matter how often the station was heard. (d) Phenomenal freaking — the condition of hearing a station once in a blue moon, when all the elements conspire for success. The bulk of broadcast reception over 1000 miles is in this class.

Similarly a receiving station could define its range with respect to given transmitting stations along the lines of such a scheme of classification. A broadcast fan might then remark, "My new r.f. set has a Class C range for WOC," or, "I get WGY consistently after dark, but never in the day time—that's a good B-range, don't you think so?" and so on. This would constitute a first step toward a more scientific conception of ranges and claims made for given sets and stations.

Of course the determining factor in the last two gradations defined above is the phenomenon known as fading. There is reason to believe that at a distance of some hundreds of miles above the earth there is a conducting layer, named the Heaviside layer after the great British mathematical physicist, which forms, with the earth, a sort of whispering gallery for radio signals. The wave travels on its way, bouncing off the walls of the gallery with many echoes, unpredictable interferences, and chance reinforcings; and for that or for similar reasons the familiar variation of signal strength at a distance is observed, especially at night, when natural conditions are most unsettled. Thus we have the fading and building up of signals.

In the present popular sense of the word the range is taken as the maximum reception record of the set in question,

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in most cases. This recalls the complaint of a golf professional, who remarked that when a club member once went around in eighty, say, after that he always protested that he was off form whenever he exceeded that figure—even if he never got down to it again. In reality the player's average—his reliable figure—might be around one hundred, and from the professional's viewpoint he had no right to offer the standard excuse unless he went over the latter value. Similarly in radio a phenomenal record in reception is properly speaking, nothing more than something to shoot at thereafter.

Uncontrollable Factors

Fading, static interference, QRM from spark sets, and other items which have been discussed may thus be classified, at any given time and for any given problem of reception, as uncontrollable. Of course a deferred control is possible, and on this the progress of the art depends: Static interference may be effectively conquered by greater radiation and technical improvements at the transmitter; legislation is doing away with some evils, such as the sardine-packing of the broadcasters in the narrow 360-400 meter band. But at any set time, it is obvious, luck plays a great part in DX work—and that is part of its fascination. As one sweeps up over the wavelength range of the receiver, one may be missing a transmitter down below who happens to be audible at that minute, and perhaps will never come in again at that place; or one may be running into a lucky encounter with a station at the other end of the country. One must gamble, but in the long run rational methods and a good technique win out over hit-and-miss procedures.

Semi-controllable Factors

Of elements theoretically controllable but which in practice are usually fixed by other considerations, the most important is locality. Occasionally, as in the case of camp receiving sets, the site may be picked. It is well to bear in mind, then, the superior reception conditions near bodies of water. Early in the history of the art it was found that in reception of signals on moving vehicles, such as trains, the signal strength increased near lakes and rivers; it was, as Dr. DeForest has said, as if the waves hung over the water like a mist. Obstructions, such as hills and forests, particularly when the trees are in foliage, have a weakening effect. This is very pronounced in the case of structures of conducting material. From these considerations it follows that the seashore is a better receiving location than inland mountainous territory, and rural locations are in general better than

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urban. The ideal place is a ship. For a land station, according to Mr. Paul Godley, the beach gives better results on signals coming over the water than points even a short distance inland. And of course geographical locality is important; if one had to receive an English broadcasting station in the United States at some given time, for example, the logical locality would be Maine rather than New York, for Maine is some 400 miles nearer Europe, giving a considerably better signal, and at the same time static is markedly weaker than in more southerly latitudes.

Urban experiments with portable receivers have demonstrated that at some points along the same street signals are consistently weaker than at others. At street intersections the intensity tends to rise, owing to the approximation to an open space. Overheard wires, as one would expect, absorb energy and cut down the range. Some spots in the larger cities are comparatively dead because of the effect of obstructions. As yet no instances have become public, but it would not be surprising if some day a prospective tenant, before signing the lease, should demand a guarantee that the house is not in a dead spot for radio signals!

SELECTIVE CRYSTAL OUTFIT

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¾ in. deep and it is wound with thirty turns and screwed to the remaining swinging arm. One lead is carried to the ground binding post and the other connected to the free lead from the center coil. It can be seen that these two coils being connected in series will act as a variometer in the aerial-ground circuit and tuning can be accomplished by altering their proximity to each other. It is most important that the turns on each of these variometer coils run in opposite directions. This can best be checked up by carefully tracing the course of the winding and if found circling in the same direction on both, reversing the connections of one coil.

The number of turns specified was found to be best for a 50-ft. aerial. A longer one will require less inductance in the variometer, that is more wire on the thirty-turn or less on the sixty-turn coil.

To operate, connect ground, aerial and phones to their binding posts, place both movable coils close to the center stationary one and adjust the catwhisker of the detector on the crystal till signals are heard, then move the swinging coil of the variometer until they become loudest. If interference is found between stations move the secondary coil an inch or two away and it will be found possible to tune in either station (provided they are not on exactly the same wavelength) by adjusting the movable variometer coil.

As mentioned before, the beauty of this little set is its selectivity. The writer, living about ten miles from each of two class B stations, broadcasting on much the same schedules, has no difficulty in bringing in either one loud and clear without the slightest interference, and recommends the circuit to anyone desiring an efficient yet cheap and easily constructed crystal outfit.