The Circular Band Theorem

Operational Advantages of Concentric Frequency Allocations

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• Here is a proposal of such importance that it will be very easy to predict its effect on the future of amateur frequency assignments. It is "must" reading for any operator familiar with prewar conditions in our bands, and it holds out some kind of hope for beginners troubled with finding new frequency assignments.

THE ENTIRE history of amateur radio has been the story of steady advances in a field which was at first a technical art and has now become an accepted science.[1] In the design, construction and operation of every type of equipment — transmitters, receivers, antennas, vacuum tubes — amateur radio can point with pride to its many contributions. In recent years some of the larger radio companies have established laboratories of their own and to some extent have become serious competition for amateurs in this field which they once monopolized. Undaunted, amateurs have turned to a territory which is exclusively theirs and have developed it to a fine art. This unique field, which no commercial interest would dare invade, is the peculiar world of "amateur-band operating."

Amateur-band operating, or "ABO" for short, is a distinct art which is responsible for such ingenious devices as the stabilized transmitter, the single-signal superheterodyne, rotatable antenna arrays, "resonant" filters, wide-range key clicks, dynamic prognostication,[2] and the v.f.o. These brilliant contributions can be traced directly to the crowded bands and intense competition encountered in ABO, and amateur radio can be proud of the way in which it recognized the problems and accepted the challenge.

Band Edge Technique

Starting around the year 1925 or 1935, a new type of operating slowly came into being and subsequent popularity. Realizing that after operators called "CQ" they had to start listening somewhere and that this somewhere was usually the edge of the band, a few hardy pioneers established themselves on frequencies close to the limits of the amateur portions of the radio spectrum. Their original thinking was rewarded by a high percentage of successful calls, and other stations followed suit. This practice became known as the "band-edge technique," and reached a minor peak during the 1937 DX Contest, when for 23 consecutive minutes 32 per cent of the active amateurs in the world were operating on six band edges ±2.5 kc.! It was subsequently discovered that many operators started listening on their own frequencies for replies to CQs, and this led to the custom of calling a station on its own frequency if you were at all serious about a contact and not just engaging in code practice. This type of operating reached a peak in the 1939 DX Contest, when 32.1 per cent of the active amateurs in the world simultaneously called two stations *exactly* on their own frequencies, with the result that "dead spots" were burned in at these two wavelengths and they have been useless for communication ever since. Fortunately, both frequencies happened to be just outside the high-frequency edge of the 20-meter band, so the loss to Ws isn't too great.

This brings up the point that a suitable dial has yet to be devised for v.f.o.s. used for band-edge operation. All available dials seem to have considerable inertia which may carry them *past* a band-edge station's frequency and out into never-never land, particularly when one tunes on to the station in a hurry.

It is possible that continued band-edge operation may lead to the burning of more dead spots, even within our bands, and in the interests of frequency conservation the author took it upon himself to find a solution. The addition of two more band edges in the 14-Mc. band, where the c.w. and 'phone assignments meet, was a partial answer but not entirely adequate. Seven years of research have resulted in what appears to be the only possible reply to the situation in which amateur radio finds itself.

The Circular Band Theorem

A careful study of the method of allocating amateur frequencies showed that, without exception, our wavelengths are assigned in "bands" or finite linear sections of the spectrum. For example, the 40-meter band extends from 7.0 to 7.3 Mc.! Obviously this has two band edges, and thus is a vulnerable target for the highly-developed "band-edge technique" and the consequent dan-

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[1] Webster's Collegiate Dictionary says "art is knowledge made efficient by skill, science is systematized knowledge." This is undoubtedly what Mr. Rapp had in mind. — ED.

[2] Rapp, "Putting Dynamic Prognostication to Work," *QST*, April, 1941.

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the input coupling will be necessary if a tuned antenna is used, but this might be only a tuned circuit with a link line running to the converter input.

The image ratio, which might be thought to be low with broad circuits like this, is saved by the use of the high output frequency. It measured 1000 to 1, which compares with an image ratio of about 350 to 1 at 14 Mc. in the best available communications receiver using two stages of preselection. The comparison is made at 14 Mc. because any images in the converter will be in this vicinity.

As nearly as could be measured without a screen room to eliminate all stray pick-up, the noise figure is about 6 db. better than a good pre-war communications receiver.

Circular Theorem

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ger of out-of-band operation. Suppose, however, that we were assigned 300 kc. at 40 meters with *no* band edges! This would mean that an operator would tune from 7.299 through 7.300 to 7.001 Mc., and tuning in the opposite direction he would go from 7.001 through 7.000 to 7.299 Mc. Note that at no time would he be out of the band, and hurried or careless setting of his v.f.o. would never result in a pink ticket. With no band edges to crowd, we would get a more even distribution of stations in the bands, to our eternal credit. Some of the old die-hards may object to this and spend the first hundred years — the hard ones — searching in vain for the good old band edge, but the true merit of the system will be immediately apparent to the large majority and they will settle down to make the most of it. Another way of looking at it is that, no matter what his separation is in kc. from another station — a maximum of 150 kc. in the 7-Mc. band — everyone can consider himself to be on the band edge, and so is the other fellow 150 kc. away. The advantage, of course, is that one does not have to set his frequency accurately, since no matter where he lands he is on a band edge. If this is a little hard to visualize, and we must confess it is at first, draw a

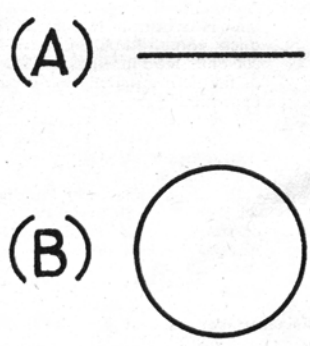

Fig. 1 — Graphical representation of the conventional FCC bands (A) and the proposed circular bands (B).

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straight line and a circle, as in Fig. 1. Follow along the straight line with a pencil point, and you will note that there are two ends, or "band edges." Now transfer the pencil point to the circle and note that by following the line you can't tell where the circle was joined together — the old-fashioned band edges — and neither can any of your friends. Thus, after running around in circles for several days you will settle down at some arbitrary point and say, "This is the band edge," and will be quite content. However, your friends are likely to end up at some other points where they will be equally satisfied.

Since the need for precision frequency-measuring equipment is eliminated, the money saved can go into additional transmitter power. An estimate after an informal survey of the W6 district indicates that the additional power resulting from this move would raise the average power in that district 0.032 db! With out-of-band worries eliminated, the FCC could reduce the monitoring of amateur bands and both parties concerned could live freer and happier lives.

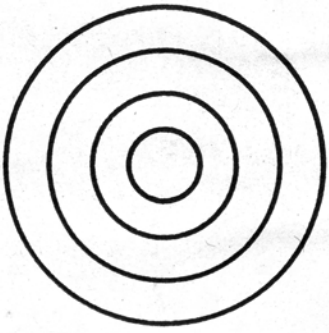

Fig. 2 — With circular amateur bands a reality, the beginners would be started in the "inner circle," to avoid any feeling of inferiority they might otherwise develop.

The bands should be assigned in *concentric* circles, as in Fig. 2, and the beginners should be encouraged to start in the smallest circle. Thus, even if one managed to get out of the band — we don't see how he could, but someone would find a way! — he would still be inside the next circle and amateur radio would have no black mark against it for out-of-band operation. Further, the fact that a beginner was encouraged to start in the *inner circle* would make him feel like he was one of the boys right off, being allowed into the inner circle!

With our thesis fully developed — the assignment of amateur frequencies in concentric circles instead of bands and the consequent elimination of out-of-band operation and band-edge crowding — we have no hesitation in encouraging experimenters in developing our technique to the point where it will be possible to work someone 40 or 50 kc. removed from one's frequency, as old-timers claim they used to do back before 1925 or 1935. All we have to do is write to our directors and congressmen and *insist* that the FCC assign us circular instead of linear bands!