The Challenge

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There are still many people who remember well when radio was used solely for telegraph purposes. At that time there was no broadcasting, no transoceanic telephony and, of course, no television or radar. Nor were there any of the countless other services now rendered by radio, such as telephone communications with airplanes and with motor vehicles. Beginning back in the early days of radio with the first appreciation that each single radio service required a separate band of frequencies, additional services meant inevitably a growth toward higher and higher frequencies. This growth passed rather swiftly with the years, first from tens of kilocycles, where commercial radio first started, to megacycles, and thence to tens, hundreds and thousands, and now more recently to tens of thousands of megacycles. With our best laboratory techniques, we are now at a rather indefinite and probably temporary frontier around a hundred thousand megacycles. This briefly is the half-century path that has led to the work of this particular Professional Group.

It is interesting that, as radio progressed, warnings were sounded at various times that troubles lay immediately ahead and each trouble, in its turn, found a solution, always with the result that radio advanced on into new and even more interesting fields. The first false alarm came in the early days of radio, when it appeared that transmission to distant points became progressively poorer with increasing frequency and that beyond about 1,000 kc the medium might indeed be useless. As most engineers know, it turned out that the region of poor transmission was confined to a relatively narrow band centering at about 1,500 kc, and beyond this frequency there was another vast region that was very useful indeed. For the want of a better name, this new region has been called the short-wave band.

As this short-wave region developed, it was soon found that at some frequency around 30 mc these very short waves no longer followed the curvature of the earth but passed into interstellar space. Thus the frequency region beyond appeared to be useful only for distances out to the horizon or slightly beyond. At first, this seemed like a distinct limitation, and again it seemed that the end of the useful radio spectrum might be at hand. However, it developed that there were numerous local services for which these higher frequencies were well adapted and again plenty of use was found. This time the new region was called the ultra short-wave band.

Prompted in part by the spirit of pioneering and in part by a need for still more services, the engineer continued to push his frontier forward. Two difficulties, long envisaged, soon became critical. In one, the coils and condensers then used as tuning elements became vanishingly small. Even more disturbing, the electron which so far had seemed so fleet-footed now appeared relatively sluggish and, accordingly, failed to perform its expected functions. With the devices in use at that time, both difficulties became particularly serious at frequencies around 1,000 mc, and for the third time it appeared that radio might have reached its limits.

In about 1931 a study was begun of the practical possibilities of transmitting very short electromagnetic waves through hollow metal pipes and along dielectric wires. Out of this work came three distinct types of elements all particularly well-adapted to the higher frequencies. These solved, for a time, the problem of vanishingly small circuit elements. Closely associated with these new developments and quite as important to the problem at hand were new techniques for dealing with electrons. Together these methods have circumvented, temporarily at least, many of the difficulties of a decade earlier and again radio has moved into greener pastures.

Prompted once more by the pioneering spirit, many of you have more recently moved still further onward. Your new frontiers are poised temporarily at about 100,000 mc. As you are finding, the circuit elements—this time resonant cavities—are again becoming distressingly small, and again the improved electronic methods are in trouble. Obviously new techniques are again needed. This is one of the challenges that confronts you as members of this group.

It is apparently not sufficient that we be plagued merely by limitations of method. We are again having troubles with the radio medium. Many years ago it became apparent that at some future time when sufficiently high frequencies were reached and the wavelength became comparable with the diameter of rain drops, substantial absorption from rain would ensue. This difficulty has long since been encountered and it has proved to be quite as real as anticipated. Absorption from rain becomes appreciable at frequencies as low as 10,000 mc and becomes serious at 30,000 mc. Presumably it becomes progressively more serious at frequencies beyond. Rain attenuation is therefore unlike the narrow absorption band type of attenuation found many years ago at 1,500 kc.

Added to these attenuations come others that are truly of the narrow-band type. One which is due to water vapor (not water droplets) occurs at a frequency of about 22,300 mc. Another, due to oxygen, occurs at 60,000 mc and perhaps also at 120,000 mc. Viewed from the infra-red end of the spectrum, we know that there must lie ahead countless other absorption bands. The outlook for purely radio applications of the frequencies that lie ahead is therefore again rather unpromising.

All of the difficulties cited above add up to one of the greatest challenges ever to confront radio research. Much of it falls to the Professional Group on Microwave Theory and Techniques, of which we are a part. We get great comfort from the thought that on previous occasions similar difficulties have been encountered and although they then seemed very real, each in its turn found a solution. Perhaps our present problem will also find a solution, but the method is not evident at the moment. In the meantime we proceed in accordance with the best traditions of our profession, calmly and one step at a time, with the assurance that even if the useful radio spectrum should terminate at its present apparent frontier, our efforts will have contributed substantially toward that much larger task of unravelling the puzzles of Nature. Being good engineers we shall, of course, try to look sharply as we go along our way for useful applications. Very likely there is a place in the waveguide type of transmission line for any new frequency regions we may open. Perhaps also there is something useful in the application of these higher frequencies to molecular physics. Then, too, there may lie ahead a new and very different kind of radio than any we have thus far envisaged. Anyway, let's accept the challenge, push on, and see what happens.