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Why the Detector Makes Music

Changing the Speed from 1,000,000 to 1,000 Cycles

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IN the last issue of RADIO PROGRESS there was explained how radio frequency differs from audio and how the carrier wave, going at the high frequency, was able to carry on its back the lower speed of vibration. All this action happens in the broadcasting stations and through the air. But the next question is, when this reaches your aerial, how are the two speeds of vibration going to be separated, and why does the complicated wave send only the music to the telephones?

In the first place, as has been explained, the human ear drum cannot vibrate at anything like the high speed which the sending station puts on the air. Different broadcasters use different frequencies, or speeds of vibration, but the average is around 800,000 to 1,000,000 oscillations per second. This

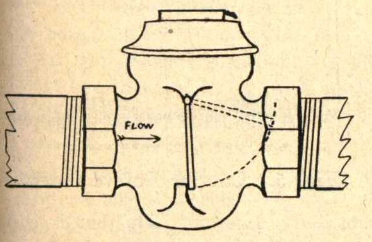

Fig. 1. Crystal Like Valve

is not only a good deal faster than the ear drum will work, but it is also a great deal speedier than the telephone diaphragm will follow. The result is that no one can possibly hear the carrier wave. To be sure, people sometimes talk about hearing it, but what they mean is that they hear the beats caused between the carrier wave and the oscillations from their own or a neighbor's set. This will be explained later.

What We Really Hear

It is the audio frequency waves which actually affect our ear drums. These vibrate back and forth at the rate of a few hundred cycles per second for the lower notes and three or four thousand for the highest notes on the piano. The whole business which the detector has to do is to skim these audio waves off the carrier wave and send them through the telephone to our ears.

Perhaps the best illustration of the action here is the team work, or lack of it, displayed in moving a heavy object. A while ago an automobile ran out of gasoline in the middle of the road. There were half a dozen passengers in it, and they all got out and tried to move it to the side of the street while they sent for some gas. Some of the fellows pushed and some pulled, and although they worked pretty hard, they did not succeed in moving the machine very far. The trouble was that the pushes and pulls came so close together that neither set of men could accomplish what they had in mind. Finally, one of the chaps said, "Instead of some of us pushing and some pulling alternately, suppose we cut out the pushes and leave only the pulls, and the machine will be moved easily."

Crystal Kills Pushes

Now, the trouble with radio frequency waves is that the pushes and the pulls, that is, the negative and positive halfs of the waves, follow each other so fast that neither side has any chance of moving the telephone diaphragm. If we can arrange some way of omitting all the pushes and leaving only the pulls, then the diaphragm will respond to the series of pulls. What we need

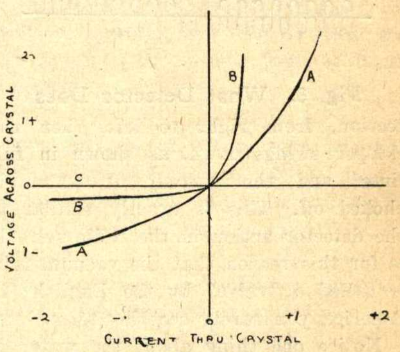

Fig. 2. Crystal Curves

evidently is some kind of a valve which will let the electricity flow in one direction and not in the other. Then by connecting it in series in the line, we will let all the pulls through to affect the diaphragm of the telephone, whereas the pushes will all be choked off and so will not interfere. We mention omitting the pushes. Of course, whether the positive half of a wave causes a push or a pull on the telephone diaphragm depends only on the polarity or direction in which it is connected. If the electricity reaching the telephone or loud speaker causes the diaphragm to move in, then by reversing the two leads, the same impulse will make an outward movement instead. So, in the above explanation, it must be understood that whether we suppress the pulls and leave only the pushes, or the other way around, makes no difference at all, since the result can be reversed by interchanging the two leads to the telephone.

Crystal or Tube Detector

In discussing the detector action, either the crystal or vacuum tube may be used for illustration. The action of these two devices is essentially the same, although the actual mechanism is quite different. In other words, both pieces of apparatus will let a current through in one direction quite easily, whereas it chokes it off pretty effectively when this direction is reversed. It is like a valve in a water pipe. This may be illustrated in Figure 1. Here we have a valve located in a water pipe. When water flows in the direction of the arrow, from left to right, the clapper swings open, as shown in dotted lines, and permits the current to flow. If pressure is exerted in the reverse direction, from right to left, then the clapper swings down, as shown in full lines, and the current of water is choked off. This is exactly similar to the detector action in the radio set. It is for this reason that the vacuum tube is called a "valve" by the English; in America you rarely see this term.

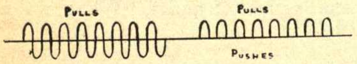

Fig. 3. What Detector Does

Notice one thing about the water in Figure 1. When the current starts to reverse against the direction of the arrow, it will take a short length of time for the clapper to swing down, and during this period water will actually flow in the reverse direction. The valve is not perfect in this respect, but for a short time allows the current to flow in either direction. The same thing holds true with the electric valve. Unfortunately, so far nothing has been discovered that completely restricts the flow of electricity in one direction, while it allows full freedom when reversed. This result is shown in Figure 2, which gives the characteristic curve of an average crystal. It will be seen that as the voltage on the crystal is made positive that the current flows through it, and that as the voltage is raised, the current increases a good deal faster than the voltage does, but when the voltage is reversed, although the current naturally reverses at the same time, still the amount of current, while not as great as before, amounts to quite an appreciable value. This is shown in curve "A." If we could get a crystal with a characteristic like curve "B" it would be very much more efficient. With such a crystal, when the voltage reversed, the amount of current passed would be negligible. So far no kind of detector, either crystal or tube, has been discovered with a curve shaped like that of "B." This means that there is still a chance of improving radio sets. The ultimate detector would be found when line "B" coincided with the zero line "C;" then no reversed current would flow at all, and all the pushes would be completely eliminated.

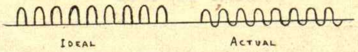

Fig. 4. How Crystal Fails

Straining Out the Pushes

Let us see how a radio wave looks before and after it goes through a detector. As just stated, this may be either a crystal or a tube set, for the action is very similar with the two. In order to make the matter a little simpler, for the rest of this article we will assume that we have a crystal set, but it must be understood that the same action occurs with a vacuum tube detector. First, we will show the radio wave before any audio frequency is impressed on it. This is called the carrier wave, and is a continuous oscillation up and down. The height of the wave, which is measured by its loudness, is governed partly by the strength of the sending station, that is, whether they are broadcasting with 100 or 1000 watts; partly by the distance through the air to the receiving station, and partly by the excellence of the receiving equipment. The spacing between peaks, which represents the time between successive impulses, is determined by the coils and condensers in the broadcasting set, and is specified by the government as 833,000 vibrations per second for a station like WDAP, Chicago, or whatever other figure the radio inspector assigns to the given station.

This continuous wave goes the same amount above and below the zero line. It is like a weight vibrating at the end of a spring. It goes just as much above the position of rest as it does below it. This is shown in the left-hand part of Figure 3. Now let us connect a detector into the set and see what happens.

The upper part, which we may call the pulls, comes through just as before, but the pushes have disappeared, that is, have been eliminated by the valve action.

Ideal Not Attained

As a matter of fact, Figure 3 shows the ideal condition corresponding to the curve "C" in Figure 2, which, unfortunately, is never attained. Figure 4 illustrates what actually happens with a detector. The perfect case would be that the pulls came through with full strength and the pushes were completely eliminated. Actually it will be seen that the pulls are reduced somewhat in strength and the pushes are not entirely suppressed, but come through in a small amount. Referring again to our crew of six men in the automobile, instead of all six pulling the machine toward the sidewalk, one of them decides he will not help, and so the pull is reduced to five. Worse than that, the sixth man turns around and pushes against the other five, and so neutralizes the effect of one of the pulls. This gives a result of only four instead of six men. As just pointed out, this is where some further improvement in radio may be looked for. The part of the curve shown below the line in this diagram

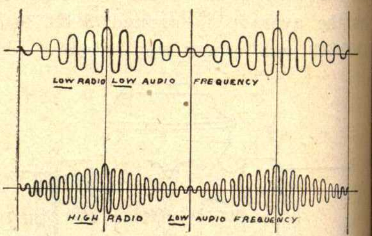

Fig. 5. Carrier Before Detector

not only does not help, but is a positive hindrance in pulling the telephone diaphragm up to the magnets.

While this imperfection of the detector is a very important point in any discussion looking toward the improvement of radio, it does not have any effect in explaining the further action of a crystal, and so to simplify the diagrams we are going to omit this small reversed part of the wave in the rest of this explanation.

Now suppose we take an actual radio wave, that is, an audio on top of a radio wave, as seen in Figure 5.

WEAF vs. KDKA

Here we have two different sending stations, the upper one at a low frequency or high wave length, like WEAF in New York, which runs at 492 meters, or 610 KC. The lower wave corresponds to a much higher frequency or lower wave station, like KDKA, East Pittsburgh, on 326 meters, or 920 KC.

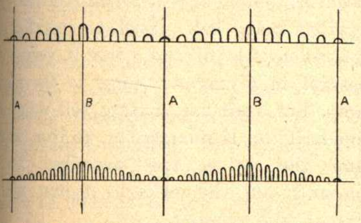

Fig. 6. **Carrier After Detector**

Both stations are singing the same note, as shown by the fact that the carrier wave rises and falls in intensity at the same speed. What happens when these two waves are run through the detector? Just as explained above, the lower part of the pushes will all be rubbed out and the pulls left just as before. Figure 6 shows how this looks.

Pushes Are Suppressed

When such a series of impulses is fed to the telephone, since only pulls are left and no pushes, all the little jerks being in the same direction, will succeed in moving the diaphragm. As mentioned above, it is too heavy to respond to each individual little jerk, but the effect of the sum total is that the diaphragm is made to vibrate. To be sure, all the impulses cause a pull, but when these impulses let up the natural spring of the metallic disk causes it to jump back again in the reversed direction. So we have a series of pulls and then letting go, then another series of pulls, and so on.

Receiver is Nervous

It is like our automobile men again. Assume that they are all nervous fellows and don't give a steady motion with their arms, but give a jerky action to the machine. As long as the jerks are all in the same direction, that is, towards the sidewalk, they will add up and get the machine in motion. When they all pause for breath it stops again, and this is the action described here. At "A" in Figure 6 the diaphragm springs back. At "B" it is sucked in. At "A" it jumps back again, etc. This action is repeated one for each *audio* wave. That is, the radio frequency has nothing at all to do with it. It will be seen that the upper curve in Figure 6 shows two audio vibrations, and the lower curve, although the radio frequency is much higher, still shows the same two vibrations. This is the same as saying that the pitch or tone of the singers is identical, no matter which station is broadcasting. If one should raise his voice and sing an octave higher, then, instead of two audio waves in the spaces represented by Figure 6, we should get twice as many, or four, since each octave doubles the audio frequency of the one below it.

This completes the action of the detector itself. Such a series of impulses as Figure 6 displays will operate a telephone pretty well. A further improvement would be to smooth out the jerky motion, and the way this is done will be explained in the next issue of RADIO PROGRESS.

IMPROVING THE LOUD SPEAKER

Not the least of many improvements that have been made in the last year in the radio art is the development by The Miller Rubber Company of an amplifying horn for use with any type of loud speaker unit, which can be manufactured in many forms to suit the requirements of loud speakers.

This horn is made from a plastic material having extreme lightness and stiffness, and is water proof so it will withstand moist atmosphere and all ordinary weather conditions. These properties are due to the composition, which is the result of long research conducted by some of the foremost chemists in the rubber industry. But the good features of this type of horn don't depend as much upon the composition as upon the structure which is given it by the process used in its manufacture.

This horn, while having a perfectly molded, solid surface adapted to reflect sound, is composed internally of a myriad small air-tight chambers. Such material cannot vibrate at any audio frequency within the range of voice or music. The delicate cellular structure just described supports the thin hard surface layer in such a way as effectively to damp any vibration which might come from the horn surface.

This invention is the result of an extensive research in which almost every known material and construction was thoroughly tested. This horn has now been adopted by some of the largest manufacturers of radio loud speakers and phonograph manufacturers in the country.

For accuracy in meeting manufacturers' specifications, this process cannot be surpassed.