What About Single Sideband?

What It Offers in Amateur 'Phone Communication

BY DONALD E. NORGAARD,* W2KUJ

• If you operate a 'phone transmitter you can't afford to pass up this article. It tells exactly why and how single sideband steps up the effectiveness of your transmitter — equivalent to at least an 8 times power increase — and at the same time increases the effective width of the 'phone bands by several times.

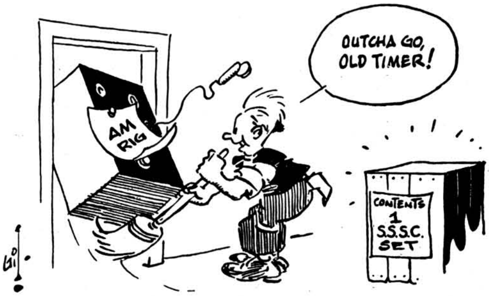
This is the first of a series of three articles. The second and third will cover a new, simplified method of generating and receiving s.s.s.c. signals.

Recent articles in *QST*[1,2,3,4] have indicated that the time is ripe for single-sideband amateur telephony. Actually, in one sense, it always has been the time for single-sideband operation because of the congestion of our amateur bands, but single-sideband techniques of the past have not been very well suited to amateur use. This article, the first of a series of three, is presented in the hope that the concepts of single sideband can be explained in as easily-assimilated form as possible, and to incite enough interest among QRM-weary hams so that our 'phone bands finally become useful property. These bands can become so *only if we all get together and clean house.*

Fortunately, "house cleaning" on the 'phone bands is going to be easier than many of us secretly think. New techniques of generating and receiving single-sideband signals have been developed, and these techniques are of such a nature that the change to single-sideband operation will become a real pleasure. Remember this: twenty years ago we did clean house in the case of c.w., and everybody shared the benefits when T9x signals became the order of the day. At least, nobody was hurt except the guy who wouldn't or didn't follow the trend.

Goodman[1] and Grammer[4] along with others have indicated that there are selfish motives to be served in changing over to single-sideband 'phone. Good sportsmanship also demands that we do so, now that it is going to be relatively painless. Even this point of view serves our selfish motives, too, since QRM is the wrecker of most 'phone contacts, and it is definitely true that single-sideband 'phone is capable of resisting QRM better than any other known system, as well as being least offensive in creating QRM. What are we waiting for?

Let's get down to facts and details. How and why can single sideband "buy" us better communications? First of all, a single-sideband signal uses up *less than half the space in the band* than that occupied by *properly-operated* a.m. or n.f.m. transmitters, regardless of power. Next, it doesn't "waste any steam blowing the whistle"! By that is meant the relatively tremendous amount of power devoted to transmission of the carrier com-



pared to intelligence-bearing sidebands. There just isn't any V-J day "whistle blowing" to blot out the other fellow and rob yourself of "steam." These things are mentioned first because they should be obvious and we want to start out agreeing with one another in this discussion.

Carrier and Sideband Relationships in A.M.

Some of the best heads in the country have been scratched bald by their owners in trying to figure out the best way to predict on a theoretical basis how single sideband stacks up alongside our old acquaintance, amplitude modulation. The head scratching is over now, and the following analysis, which is backed up by thorough laboratory investigations aimed at finding the facts, should give us an idea of what to expect.

To keep things on a simple basis at first, assume that an ideal a.m. transmitter has a carrier *output* of 100 watts. We know that when this carrier is

* Research Laboratory, General Electric Co., Schenectady, N. Y.

[1] Byron Goodman, "What Is Single-Sideband Telephony?" *QST*, January, 1948.

[2] O. G. Villard, jr., "Single-Sideband Operating Tests," *QST*, January, 1948.

[3] Arthur H. Nichols, "A Single-Sideband Transmitter for Amateur Operation," *QST*, January, 1948.

[4] George Grammer, "Single-Sideband Power Gain" (Technical Topics), *QST*, March, 1948.

modulated, sidebands are generated in proportion to the strength of the modulating signal (until we reach 100% modulation), and that the carrier strength itself is not affected *at all* by modulation. A plot of the frequency spectrum (voltage *versus* frequency) of the simple case of steady 100% modulation of the carrier by a single tone (sine wave) of 1000 cycles would look like Fig. 1. The envelope (a plot of voltage *versus* time) would, of course, have the appearance of Fig. 2. All right, so far? Our *Handbook* tells us [5] that in a resistive circuit where the resistance stays constant the power is proportional to the square of the voltage applied. In the case we are talking about, three voltages are applied; one is the carrier, and the other two are the upper and lower sidebands, respectively, in accordance with Fig. 1.

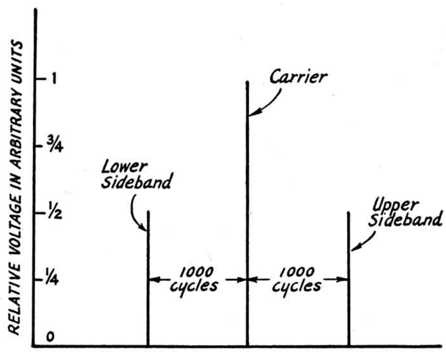


Fig. 1 — **Example of 100% modulation of a carrier by a single tone of 1000 cycles per second.**

The voltage of each of the sidebands is half that of the carrier. Therefore, the power in each sideband is $(\frac{1}{2})^2$ times that of the carrier. Since it was assumed that the carrier output was 100 watts, the power in each sideband is 25 watts, and the *total* sideband power is 50 watts. This, incidentally, is the maximum single-tone sideband power that can be generated by amplitude modulation of a carrier of 100 watts. No one has ever been able to do better, because it just isn't possible to do so. (It doesn't help to overmodulate! This *cuts down* the desired sideband power and generates spurious sidebands called splatter. Hint: check your own sideband splatter.)

We can represent the information in Figs. 1 and 2 by means of a vector diagram and make some more calculations. In Fig. 3 the carrier voltage is given one unit length. Therefore, the upper and lower sideband voltages have one-half unit length, and are so indicated. Now, watch out for this one: In Fig. 3 the carrier vector is assumed to be standing still, though actually it makes one revolution per cycle of carrier frequency. Imagine you are standing at the origin of the carrier vector and are spinning around with it at carrier frequency. What you would see are the upper- and lower-sideband vectors rotating in *opposite* directions at the modulation frequency in such a way that the terminus of the last vector in the chain of three lies along the line of the carrier, bobbing up and down at 1000 cycles per second. As far as you could tell, the carrier vector does not move or change at all, and that is the impression Fig. 3 is intended to convey. At the instant of time (T_0, Fig. 2) chosen for Fig. 3 the three vectors are all in line and add up to two voltage units. One two-thousandth of a second later the sideband vectors have rotated one-half turn each, and the three vectors add to zero, since $1 - \frac{1}{2} - \frac{1}{2} = 0$. This should make it easier to understand the relationship between Figs. 1 and 2 without too much trouble.

Now, here is the point of all this: The carrier vector is one voltage unit long — corresponding to a power of 100 watts. At the instant of time shown in Fig. 3, the total voltage is two units — corresponding to $(2)^2$ times 100, or 400 watts. One two-thousandth of a second later, the answer is easy — the voltage and power are zero. Therefore, the transmitter *must* be capable of delivering 400 watts on peaks to have a carrier rating of 100 watts. Stated differently, the excitation, plate voltage, and plate current must be such that the output stage can deliver this peak power. What about this? We are already up to 400 watts on a 100-watt transmitter! Yes, we are, and if the transmitter won't deliver that power we are certain to develop sideband splatter and distortion.

Under the very best conditions that can be imagined we need a transmitter which can deliver 400 watts of power on peaks to transmit a carrier power of 100 watts and a total maximum sideband power of 50 watts. What does this 100-watt carrier do *for* the transmission? The answer is it does nothing — for the simple reason that it does not change at all when modulation is applied. The carrier is just like a hatrack — something to hang sidebands on. It seems silly to carry a hatrack around with us just so that we can say that we have brought two hats along. Yet, that is just exactly what we do when we hang two sidebands just so on a carrier and go out with the whole thing into our crowded 'phone bands to be jostled about. Far better to put on a hat and leave the hatrack home where it belongs! One hat? Certainly. It is ridiculous to go around trying to wear two dinky hats at the same time — especially in the rain!

Leaving the Carrier at Home

Sure, take a look at Figs. 1 and 3. Suppose we leave the carrier home and double the amplitude of each of our sidebands. This will still run our transmitter at its peak output capacity of 400 watts, all it can do. Well the sideband power

[5] ***ARRL Handbook,*** **25th Edition (1948), p. 25.**

goes up all right. The sideband voltages are doubled, so our sideband power is four times what it used to be. That means each sideband is 100 watts, and our transmitter is not overloaded on peaks. The total sideband power is, of course, 200 watts. But this sideband power doesn't do much for us if it can't all be put to wórk. That is the situation with two sidebands and no carrier; nobody can take advantage of this sideband power, for it is in such a form that it doesn't lend itself to readability, no matter how you try to use it. Yet, the power is there and it can be read on a meter, but that's about all.

What if we leave one of the sidebands home, too? If we do, we can increase the voltage on the remaining one to two units and run our transmitter at its maximum peak power output of 400 watts. This time it is *all* sideband power. It so happens that sideband energy in this form is usable. Yes sir, all of it can be used, for it is just like c.w.! It is indeed, and we receive it in just the same way. All that is necessary is to set the b.f.o. in our receiver so that it is at the same frequency as the carrier we left home. Good. We don't have to carry our own hatrack around, and we don't have to go out with two little pint-size hats on either. Your host will let you hang your hat on his hatrack, and your hat won't know the difference, either, because the hatracks we are talking about are *identical*. What a fine thing that is. We put out 400 usable watts with a transmitter that could put out only 50 usable watts in the form of amplitude modulation.

Expressed in decibels, the ratio of 400 watts to 50 watts (8:1) is 9 db. How big an antenna would it take to get 9 db. gain on the 75-meter 'phone band? Even on 10 meters this is *quite* an antenna! Make no mistake about it, 9 db. antenna gain is valuable, but the same gain attained without

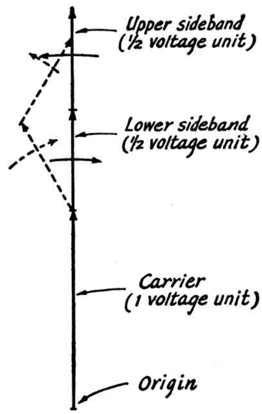


Fig. 3 — Vector diagram of 100% modulation of an a.m. carrier at the instant (corresponding to T_o in Fig. 2) when peak conditions exist. The broken vectors show the relationships at an instant when the modulating signal is somewhat below its peak.

even touching the antenna has the same value. Any antenna gain is additional gain, of course. But this isn't the complete story. The transmission covers only half the spectrum of the a.m. transmission and isn't blowing a loud whistle in the middle of it all. This kind of 9-db. gain doesn't bother the other fellow as much as if it were obtained with antenna gain on a.m. transmission. But why should we worry about the other fellow? We should, because far too frequently, "the other fellow" is yourself, and that hurts!

Before climbing down from the ivory tower of theory we ought to see what hanging our hat on our host's hatrack really means. First of all, his hatrack has not been dragged through the mud and rain of propagation. It has our wet hat hanging on it and the hat won't fall off unless the hatrack is unsteady — it won't provided we are not careless about how the hat is put there. The point is this: The sideband must be based on a good clean carrier of immaculate frequency stability, and our host's carrier must be stable, too. There is nothing difficult about either of these things any more. A good crystal-controlled oscillator or a really stable VFO is a necessary part of a present-day transmitter, anyway, so there is no worry on this point. Receiver stability has become increasingly important through the years and it is quite likely that our host is today in possession of a fairly good receiver. At least, to hear him tell about it over the air or at the club, there never was a better one! But even if he doesn't have the very best that can be constructed, he might be willing to steady it a little bit by hand or to do some tinkering with it in the free time between rag-chews and schedules (or CQs) so that he doesn't have to coax it along constantly. There is no denying that it can be done.

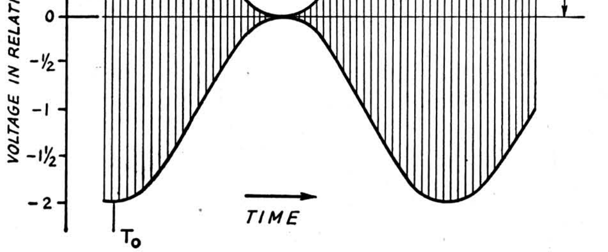


Fig. 2 — Envelope of carrier 100% modulated by a 1000-cycle sine wave.

Transmitter Ratings

Back to earth again, we might worry about the little 100-watt transmitter straining itself to put out 400 watts, for that is what we said we wanted it to do. It can do it for a short percentage of the time, but it probably would burn up if we kept that one sideband generated by the 1000-cycle tone pumping through it steadily. Fortunately, speech is used for 'phone modulation (well, most of the time, anyway) and speech waveforms have a high ratio of peak to average power. It is average dissipated power that burns up tubes, so there is nothing to worry about on this score until we learn how to talk with waveforms having a

much lower ratio of peak to average power. Actually, the steady 100-watt carrier of an a.m. signal causes most of the dissipation in the 100-watt transmitter, but it was built to stand up under that kind of treatment. If dissipation sets the rating of the 100-watt a.m. transmitter, it is quite reasonable to expect that we may be able to get over 600 watts peak power out of the same final amplifier when it handles a single sideband of speech input. Dissipation usually does determine the carrier power that a final amplifier can deliver in the case of a.m.

While shrouded in theory, we were talking about *output* power, and managed to show that we could get 400 watts of sideband power output with single sideband at the same peak power that gave only 50 watts of sideband power in the case of a.m. That's fine for comparison purposes on a theoretical basis, but there is the practical matter of efficiency to consider. Let's lean over backward and say that a *good* Class C plate-modulated amplifier such as the one in our ideal 100-watt a.m. transmitter runs with an efficiency of 80%. Neglecting the fact that the total input under modulation with speech is somewhat higher than the carrier input (which is 100/0.80 = 125 watts), the dissipation in the output stage is 25 watts. Let us say, however, that the modulation still drives the transmitter to its peak output power of 400 watts, but has very low average power. Therefore, the peak sideband power output is 50 watts, with very low average power. Here is a strange way of rating things, but it means something: The peak *useful* sideband power is 50 watts obtained with a final-stage dissipation of slightly over 25 watts in the a.m. transmitter. The peak input power is, of course, 400/0.80 = 500 watts, since the efficiency of 80% is pretty nearly constant with this type of operation. You have already guessed what the next thing is. The peak useful efficiency is

$$\frac{\textit{peak useful power output}}{\textit{peak input}}$$

or 50/500 = 10%. Who says high efficiency? This figure is not the true efficiency of the output stage — that's the assumed 80% — but it is the "communication" efficiency. The transmitter, of course, cannot tell the difference between carrier and side-band signals it deals with in the unholy combination called a.m., so we must be satisfied with 10% "communication" efficiency as we have defined it.

Now let's look at the single-sideband situation. The output stage must be a linear amplifier. This linear amplifier will have characteristics quite similar to Class B modulators used, for instance, in the little 100-watt plate-modulated a.m. transmitter. Suppose we put into this transmitter the same speech waveform we used in the example above. This wave had a high peak-to-average power ratio, if you recall, and we were concerned only with conditions during the peak period. Things are adjusted so that the peak *output* is 400 watts in order to fall into our theoretical pattern. The theoretical maximum peak efficiency of a linear amplifier is 78.5%, but nobody ever got that much out of such an amplifier. However, with modern tubes we can get 70% peak efficiency quite comfortably, so let's use that figure in our calculations. All right, the peak power input is 400/0.70 = 572 watts, which, if sustained, would get some tubes mighty hot at 70% efficiency, if they could dissipate only 25 watts. This signal isn't sustained, however, for we assumed a speech input wave having a high peak-to-average power ratio, and it is average power that makes plates incandescent. Well, all of this 400-watt peak output is useful "communication" power, and it is obtained at 70% efficiency. Thus we can say that the communication efficiency of the final stage of this single-sideband transmitter is 70%. Did somebody say something about low efficiency in a linear amplifier?

All this does sound wonderful. What about plate dissipation in the final stage? If we neglect the average dissipation during modulation with our speech wave, then one might say that the total dissipation is close to zero. It certainly would be if we had vacuum tubes with linear I_p-*vs.*-E_g curves right down to cut-off. At the present time it seems impossible to buy tubes like that because of a critical shortage of linear vacuum curve extractors in the tube-manufacturing business. But there are plenty of tubes that make good linear amplifiers, and they do not have linear I_p-E_g curves at all. This generally means that the linear amplifier is operated in such a way that there is d.c. input even though there is no signal input. This d.c. input power, of course, heats the tubes when no signal is there, and represents most of the dissipation that the tubes are called upon to stand under conditions of speech modulation. In most cases good linearity is obtained when the no-signal input plate current is about 5% of the maximum-signal plate current. This means that the no-signal dissipation is about 5% of the maximum input power, since the d.c. input voltage is held constant. Therefore, the total dissipation would be something close to $572 \times 0.05 = 28.6$ watts.

That's within gunshot of the 25 watts which our a.m. transmitter burned up in the plates of its tubes. You have guessed it again; the output stage of the single-sideband transmitter delivering 400 watts peak communication output can use the same tubes that are necessary in the 100-watt-carrier-output a.m. transmitter which delivers 50 watts peak communication output. This is good enough to interest almost any red-blooded 'phone man.

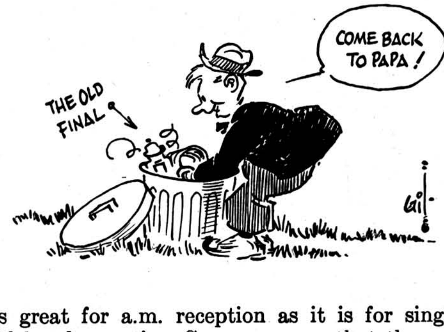
The foregoing comparison isn't absolutely accurate, since the actual waveform of speech input is unknown. But it is a fair comparison, and experience and tests support the argument. That is what really proves the point.

Signal-to-Noise Ratio

The business of receiving a single-sideband signal probably needs a little clarification yet. Let us examine the characteristics of receivers and find out what happens when a signal is received. To do this let's take a receiver to the ivory tower of theory for a few minutes.

Theory says (and experience bears this out) that noise power is proportional to the effective bandwidth employed in a system. The noise we are considering now is "thermal noise," frequently called "receiver hiss." This is not to be confused with man-made noises of the impulse type such as automobile ignition, commutation noises, or even an interfering radio transmission. No, it is just pure "theoretical" noise, which, however, is no figment of the imagination, since it can be measured, and, equally important, heard in our receivers. The single-sideband signal requires only half as much i.f. bandwidth as the a.m. signal requires to provide a given audio bandwidth. Therefore, we should not use more receiver bandwidth than the type of transmission requires us to use, since we do want to deal with pertinent facts in comparing one system with another. Reducing the effective receiver bandwidth by a factor of two cuts down the noise power output of the receiver by the same factor, when only thermal noise is considered. But this reduction in bandwidth does not affect the ability of the receiver to respond to all of the sideband power it receives from a single-sideband transmitter. At least nothing is being wasted. This begins to look as though we receive all of the single-sideband power available at the receiving location and hear only half the noise power that would be heard when receiving an equivalent a.m. transmission with the same receiver gain. This is absolutely true, so in haste we might put in another 2:1 factor of improvement in signal-to-noise ratio simply because we measure half the noise power when the bandwidth is cut in half. Apparently, this would then give the single-sideband system a 12-db. (16-to-1 power ratio) signal-to-noise ratio gain over the idealized a.m. system. In one sense this is true when considering power relationships alone, but before we reach any conclusions we should see how a detector responds to signals furnished to it by an i.f. amplifier.

We see from Figs. 1, 2 and 3 that the two sidebands in our idealized a.m. system each have 25% of the carrier power, but 50% of the carrier voltage. In an idealized a.m. receiver the detector is a linear or envelope detector, and linear detectors respond to voltage — definitely not to power as such. Therefore, the detector output corresponds to the envelope voltage, giving a demodulated signal voltage having a peak value equivalent to one voltage unit if we assume that each sideband is ½ voltage unit at the detector. The demodulated signal in this case is our modulating signal, a 1000-cycle sine wave. This may be expressed as one unit of 1000-cycle audio power at the detector output. The characteristics of thermal noise, however, are such that this same detector produces noise power output in proportion to the i.f. bandwidth, which, of course, is necessarily twice



as great for a.m. reception as it is for single-sideband reception. So we can say that the a.m. receiver detector output (or audio output) has one signal power unit and two noise power units when two sidebands totaling one-half a power unit are applied to the detector. (These units are not necessarily the same, but are in the same classification. Obviously, this depends on the relative strengths of the signal and the noise.)

In order to produce the same detector output when only one sideband is applied to the detector (along with a sufficient amount of locally-generated carrier at the correct frequency) its voltage must be the same as the combined voltage of the *two* sidebands that were applied in the case of a.m. reception. The power in this one sideband is twice the combined power of the two sidebands which produce the same voltage output from the detector. This is the same thing we saw when comparing total sideband power of two sidebands with the power of one sideband having the same voltage as the combined voltage of the two sidebands, when we discussed the transmitters. At the receiver we can say that we get one signal-power-unit audio power output from the detector with one unit of sideband power input applied to the detector, and one unit of noise power since we can slice the i.f. bandwidth in half to reduce the noise power output by half.

It doesn't take much figuring to see that if it requires twice as much single-sideband power as it does double-sideband power, to get the same signal output power from a receiver with the noise power output half as much for single-sideband operation as for double-sideband operation, nothing has been gained in *signal-to-noise ratio.* But nothing has been lost, either. Since measurements confirm the reasoning we have just been through, we should give back that 3 db. we thought at first we had earned by reducing the bandwidth by two to one. Therefore, on an idealized theoretical basis we must conclude that *single-sideband operation can give 9-db. signal-to-noise ratio improvement over amplitude modulation operating at the same peak power output.*

Back again from the ivory tower we begin to wonder what significance this 9-db. system gain has, since we arrived at this figure on an *idealized basis.* This idealized condition included consideration of only the necessary facts in order to avoid confusion. But to the amateur, confusion in the form of QRM is not avoidable except under idealized conditions, which seldom, if ever, occur in the ham bands. In fact, commonplace man-made disturbances so completely mask out thermal noise in a good receiver operated on our low- and medium-frequency bands that we should try to evaluate the performance of single sideband working under the conditions we know we do have.

Impulse noise — the clicks and pops we hear — produces detector output voltage more or less proportional to bandwidth. Immediately we can say that single-sideband reception at half bandwidth will give us almost 3 db. receiver s/n gain with this kind of noise, provided we cut down the bandwidth in the right way. That's fine, because we can get a practical gain of almost 12 db. over this type of noise when we use single-sideband transmission. That's the kind of noise we want to beat!

QRM in A.M. and S.S.S.C. Reception

Another type of QRM is the usual one — interfering radio transmissions. These fall into several classifications which deserve individual consideration. The first case is that of interference which has a signal strength definitely lower than that of the desired transmission. (Quite a rare thing, but sometimes it does happen that way.) With conventional receiver conditions (a.m. reception), all of the interfering energy that reaches the detector heterodynes with the carrier of the a.m. signal being received and produces a beat note between the two carriers, along with "monkey chatter" caused by the voice sidebands of the undesired transmission beating with the relatively strong desired carrier. A crystal filter may be used to put a notch in the i.f. passband so that the carrier heterodyne is practically eliminated, but most of the monkey chatter remains. (This depends, however, on the shape of the i.f. passband when the crystal filter is switched in.) In almost every case of this kind the heterodyne between carriers is much more bothersome than the monkey chatter, so it pays to notch out the interfering carrier. With single-sideband reception, the exposure to interference is cut down to half, but any interfering signals (carriers or sidebands) that lie within the band occupied by the desired transmission will cause heterodynes and monkey chatter in proportion to their strengths. The crystal notch may be used to eliminate one carrier heterodyne, but that is about all it can do. The advantage of single-sideband reception in this case is principally that, on the average, only half the number of heterodynes will be heard, where interference is the only disturbance to otherwise flawless reception. Well, that helps.

The case of an interfering signal of about the same strength as the desired signal is next. If nothing is done to eliminate the interfering carrier before it reaches the detector, all of the sidebands that are passed by the i.f. amplifier are demodulated against each carrier, and there is as much monkey chatter caused by the desired sidebands beating with the interfering carrier as there is from the undesired sidebands beating with the desired carrier. In addition, there are usually equal amounts of halfway-intelligible speech outputs from each transmission. Of course, the heterodyne of the carriers is by far the loudest signal heard, and it consists of a fundamental heterodyne note and a series of fairly strong harmonics throughout the audio band. Add a little QSB on both signals to this picture and not much is left of either signal — especially, it seems, to the desired one! When the carrier of the interfering signal is put in the crystal notch a lot of the curse is removed. The remaining monkey chatter is, of course, more bothersome than in the case where the interfering signal was not so strong. With single-sideband reception under the same conditions, an interfering carrier produces a single-tone heterodyne, and the interfering sidebands produce monkey chatter, but nothing intelligible. Use of the crystal-filter notch can eliminate the carrier heterodyne, leaving only monkey chatter. Here again, the exposure to QRM is cut in half, since the receiver bandwidth can be cut in half without sacrifice of audio bandwidth, so the situation is similar to the first case (interference weaker than the desired signal) but, of course, worse. When the desired transmission is besieged by more than one interfering signal of equivalent strength only one of the carriers can be put in the crystal notch, and the others have to be tolerated along with monkey chatter. The remaining heterodynes, however, are definitely less disturbing since they are not distorted in the detector. What is left is then purely a fight on the basis of strength and intelligibility. Single-sideband intelligibility is definitely of a superior nature.

When the interfering signal is stronger than the desired one, the only intelligible one is the stronger in a.m. reception, since the situation is the reverse of the first case. This is true until at least the undesired carrier is notched down so that it does not reach the detector. But all the troubles are not so easily disposed of. The low-level speech sidebands of the interfering transmission appear as monkey chatter, while the stronger ones which exceed the level of the desired carrier serve as virtual carriers against which the desired carrier and its sidebands are demodulated to produce whistles, groans, and monkey chatter of a kind that is horrible. It's all a weird mess in spite of anything that can be done with the very best conventional receiver. With single-sideband reception of the desired weaker signal, all of the undesired noises are, of course, louder than in the previous cases, but that is the only difference. Notching out the chief offender — the interfering carrier — frequently wins the battle, but it is not certain to do so. After all, there are limits, but you have a fighting chance, because somewhere there in the background is perfectly clean intelligible speech without distortion. The only trouble is that the monkey chatter may be louder, but not funnier. Of course, two strong interfering transmissions partly or wholly within the receiver passband make just that much more trouble. Here again, the fact that the receiver bandwidth can be cut in half cuts down the average probability of trouble by a factor of two to one.

It has been assumed in the discussion of the QRM problem that the receiver is not overloaded by signals, and that the interfering signals are of good quality and frequency stability. The difficulties are greatly compounded when "rotten" signals are involved. The rotten signal not only does more damage than necessary to others using the band, but is out of luck when it is the recipient of QRM from other transmissions.

When single-sideband signals are in the rôle of interfering signals, the principal effect is monkey chatter unless the sideband strength is sufficient to put the interference in the class of a signal which exceeds the carrier strength (of an a.m. signal). Single-sideband reception clears up this difficulty, but does not eliminate *all* interference. Single-sideband reception of standard a.m. and n.f.m. signals with exalted carrier is possible and feasible. Such a receiving method improves the present situation tremendously, but the full advantages cannot be exploited until single-sideband transmissions are the only ones involved. The techniques for this type of reception will be the subject of one of the articles of this series.

Laboratory tests and on-the-air experience with single-sideband transmitting and receiving equipment indicate that single-sideband signals are the most QRM-proof signals that are known, as well as the least troublesome in creating QRM. This makes it sound as though amateur telephony, when based on single-sideband operation exclusively, could be a great deal better than it is now. It can be, and will be. As Art Nichols said, "It's up to *you*." [3]

Strays

We haven't tried it yet, but an ardent practitioner of the worm warmer's art, who prefers anonymity, writes: "For a good underground transmitting antenna use Type USE-8-600-V Impervex Trenchwire, made by Crescent Wire and Cable Co."

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W6AGO was instrumental recently in handling a message from an overseas G.I. to his mother in this country, giving her power of attorney. The message was held legal, and the serviceman's desires subsequently recognized by a large banking institution, which speaks well for the esteem in which amateur traffic handling is held.

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If you're searching for strap-iron "U" brackets to brace that new antenna boom or mast, contact your local railroad signal depot and get permission to look over their scrap heap. W2VP found just what he needed on such a jaunt — discarded pipe-line hangers that fit a 2 $\times$ 4 snugly.