The Double-Spectrum Theorem

A Compatible System for 'Phone and C.W.

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> **• It has long been recognized that the best possible solution to the QRM problem is to open all of our bands to both 'phone and c.w. This has not been too popular in the past, however, because of the mutual interference. This article offers an ingenious solution, based on contemporary thinking, that merits your careful study. Who will be the first on the air with it in your neighborhood?**

New frontiers are not easy to find in amateur radio. Thanks to the untiring efforts of our cellar scientists, practically no communications problem remains unsolved — save one. It was first presented by the late K. B. Warner in a *QST* editorial[1] and received great acclaim as a problem, but no solution was offered at the time. The author had anticipated this problem and offered a straightforward and ingenious solution[2] that, unfortunately, was never put into practice. It is a sound and workable answer but has the minor drawback of requiring complete coöperation between all of the amateurs in the world.

In all fairness, and for the complete documentation of this paper, it must be said that another solution has already been proposed, involving pulse modulation.[3] This proposal met with little general acceptance, probably because it involved unfamiliar equipment. It was also suggested at the time that, being a wide-band technique, it would not be acceptable to high-selectivity addicts and manufacturers of sharp receivers, not to mention the fact that it is inferior to ordinary c.w. for DX work. Perhaps its greatest drawback, however, was that it was not an amateur development, but merely a utilization of principles grown out of commercial work. For amateurs, this would never do.

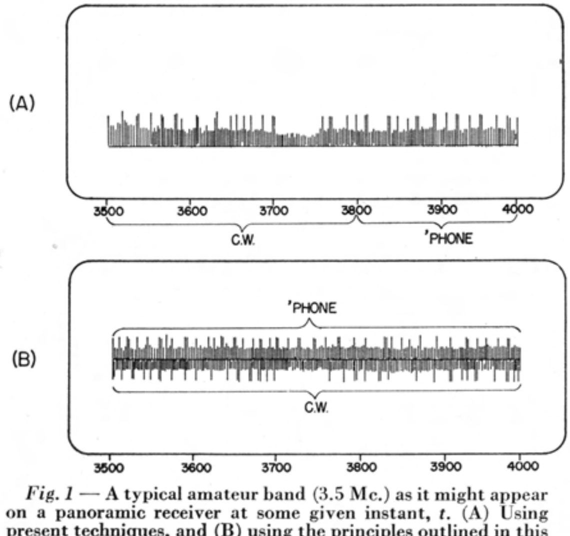

Fig. 1 — **A typical amateur band (3.5 Mc.) as it might appear on a panoramic receiver at some given instant, *t*. (A) Using present techniques, and (B) using the principles outlined in this article. The double-spectrum theorem provides for operation of both 'phone and c.w. signals on the same frequency without mutual interference.**

Needless to say, the author had not lost sight of this problem, and a certain portion of each working month has been allocated to it since 1946. We are pleased to present a solution that should be acceptable to everyone, since it has none of the objections of the previous proposals.

Fundamental Theory

A recountal of the many blind alleys that were followed would be of little interest to anyone except those who would care to repeat these many unsuccessful experiments, and thus it will be omitted. The first glimmer of hope came in 1948, when several references were made in the literature to "positive" or "upward" modulation. Heretofore most normal 'phone men had considered modulation to be something that required both upward and downward swings, but this was merely a convenient concept. However, with this coruscation about "positive" modulation, it was not too difficult to postulate a spectrum with "positive" modulation for 'phone signals and "negative" modulation for c.w. signals. Although the author is considered to be a fairly unemotional type, it must be confessed that the first realization of the importance of this invention reduced him to a nervous condition popularly described by the expression "as jittery as a June bride."

This, then, was an approach worth investigating. With positive modulation for 'phone, and negative modulation for code, all that was required was a receiver that would respond only to positive or negative modulation, but not to both. Negative modulation, for obtaining the code signals, presents no problem at all, obviously.

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[1] K. B. W., "Wanted: A Second Spectrum," *QST*, Dec., 1947.
[2] Rapp, "The Staggering Band Theorem," *QST*, April, 1947.
[3] Griffin, "Narrow-Band Pulse Transmission," *QST*, July, 1949.

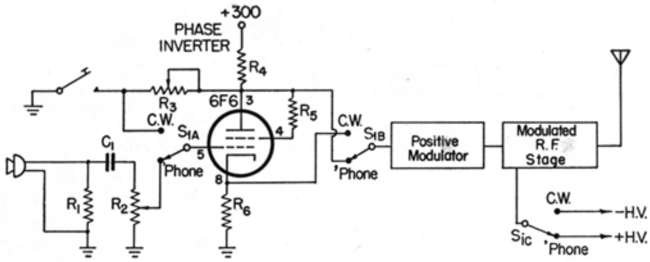

Fig. 2 — **The basic transmitter circuit.** S_1 **switches the transmitter for 'phone or c.w. operation.**

C_1 — 0.01-μfd. 400-volt paper.
R_1 — 1.0 megohm, ½ watt.
R_2, R_3 — 1-megohm volume control, linear taper.
R_4, R_6 — 10,000 ohms, 2 watts, matched within 5 per cent.
R_5 — 470 ohms, 1 watt.
S_1 — Three-pole 2-position rotary switch (ceramic insulation).

Using the pedicular circuits that 'phone men use for positive modulation, a phase inverter and a d.c. amplifier (for the keyed characters) represent all of the additional equipment necessary. Since the d.c. amplifier will also pass audio frequencies, the same modulator can be used for both 'phone and code work, and it requires only switching of the input from microphone to key and the selection of the properly-poled output from the phase inverter. The basic circuit is shown in Fig. 2. Any of the common circuits for positive modulation can be used — some variations of clamp-tube modulation are very popular in this application — and your favorite circuit is the right one for you to use. A 6F6 is shown in the phase-inverter circuit, but one section of a 6SN7 can be used if desired. The audio quality is about the same in either case. The control, R_3, is set to the position that gives chirpless and clickless keying, and in some instances a small 100-μμfd. mica condenser may be required across the key contacts. As shown, the circuit cannot be used for break-in operation with either c.w. or 'phone, unless some type of voice-control and oscillator hold-in circuit is used. The hold-in circuit is coupled at the switch arm of S_{1A}.

Receiving the Double Spectrum

Fortunately, the receiving system represents no new or unfamiliar techniques, and many receivers are already in a suitable condition for receiving 'phone (or c.w., but not both) signals of this new type. There are many limiters in receivers that work on the positive (or negative) peaks, and all that is required is a *combination* limiter that will work on one *or* the other. The circuit in Fig. 3 shows one way that it can be done — no doubt many other possibilities will occur to discerning readers. This circuit can be built as a separate unit and coupled to any receiver between the detector and the first audio stage, or it can be built into the receiver.

The operation of the receiver circuit is easy to follow. Depending upon the position of S_1, all positive or negative modulation will be short-circuited by the crystal diode, and only the modulation of opposite polarity will reach the grid of the amplifier. Note that this requires d.c. coupling from the diode load resistor, R_1, and the absence of a coupling condenser is deliberate. There is some difference in performance among the crystal diodes, and the new rhythmic 1N2N proved to be the best in this particular application.

When you want to receive 'phone signals, switch S_1 (Fig. 3) to "PH.," and only signals with positive modulation will come through. If code is your pleasure, switch S_1 (Fig. 3) to "C.W." and tune in your favorite "CQ DX." One of the first things you will notice, after you have grown accustomed to the use of this adapter, is that you will occasionally hear 'phone signals when S_1 (Fig. 3) is in the "C.W." position, or c.w. signals when S_1 is turned to "PH." This indicates that the 'phone (or c.w.) signal is not using pure positive or pure negative modulation, and the operator will doubtless welcome a call that tells him his equipment is slightly out of adjustment.

A few astute readers may have noticed that like the previous proposal,[2] this solution requires the coöperation of all amateurs in switching over to these new methods of modulation, for complete success. However, since many 'phone men are already embracing positive modulation techniques, we feel certain that this proposal will meet with instant acceptance. You can change your transmitter over now and modify the receiver later (accepting some QRM in the meantime), or you can go whole-hog and immediately enjoy the fruits of a double spectrum.

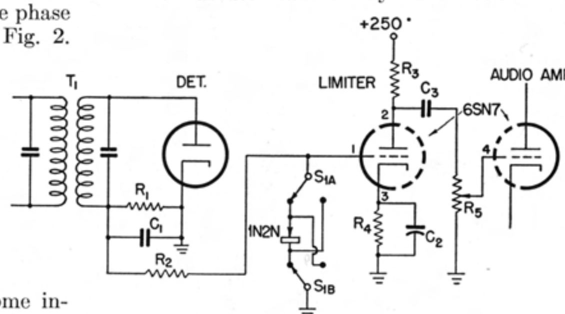

Fig. 3 — **The receiver adapter circuit.**

C_1 — 470-μμfd. mica or ceramic.
C_2 — 10-μfd. 25-volt electrolytic.
C_3 — 0.02-μfd. 400-volt paper.
R_1, R_2 — 1.0 megohm, ½ watt.
R_3 — 47,000 ohms, 1 watt.
R_4 — 1000 ohms, ½ watt.
R_5 — 1.0-megohm volume control, linear taper.
S_1 — D.p.d.t. rotary switch, low-loss.
T_1 — I.f. transformer.

[*It is recommended that readers who do not fully appreciate the significance of the present disclosures wait for a subsequent article on complete alignment and tune-up procedures before building the equipment.* —Ed.]