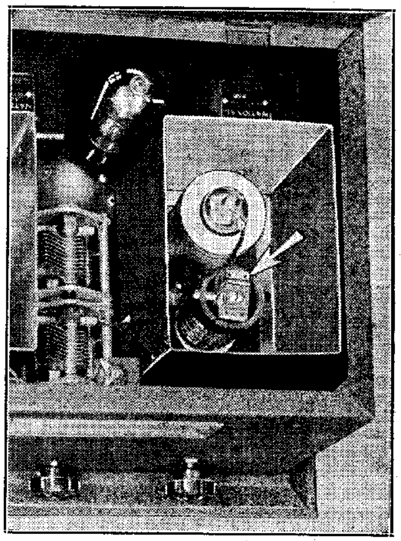

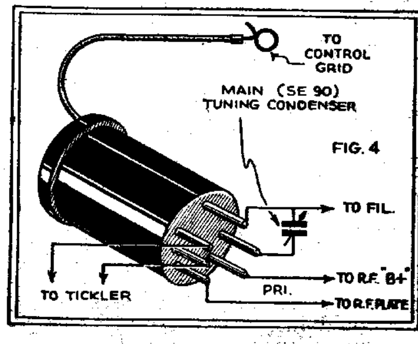

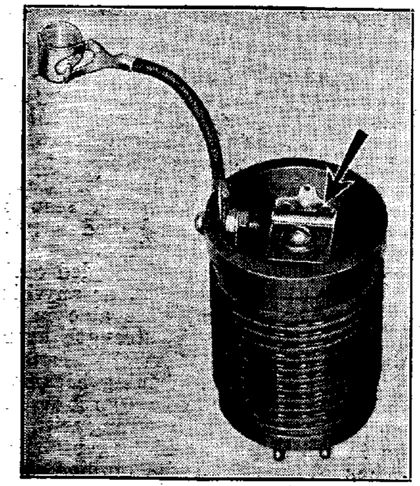

Fig. 4 (above)—Coil connections in a commercial band-spread unit, designed for use in the National SW-58 short-wave receiver. Fig. 5 (right)—A commercial form of band-spread plug-in unit, which may be instantly replaced by standard coils for band extension. Fig. 6 (left)—The National SW-58 with band-spread coils.

BAND SPREADING

By JAMES MILLEN, M.E.*

The "broadcast" fan who has just become acquainted with the wonders of short-wave reception will be particularly interested in this article by Mr. Millen, a leading short-wave expert, who here describes the theory and practice of how to spread the signals over the dial and thus render short-wave tuning easier.

● CONDITIONS concomitant with short-wave reception are such as to necessitate an unusual degree of finesse and technique on the part of the operator, when tuning systems, closely comparable to those used in broadcast receivers, are employed. This delicacy of control is immediately appreciated when it is considered, for instance, that the average short-wave receiver design for 20-meter reception covers a band of about 8 megacycles in one complete sweep of the dial, which is more than eight times the frequency range encompassed by broadcast transmission between 200 and 550 meters! On a broadcast receiver designed for simplified tuning and logging, the 400 kc. band between 300 and 500 meters occupies about three-quarters of the dial. In contrast, the same number of kilocycles, representing the amateur 20-meter allocation, occupies only one-thirtieth of the entire dial range! Such concentration inevitably results in hair breadth tuning and micrometer logging which is unsatisfactory and inaccurate.

To start with, it must be understood that the problem has nothing to do with the *electrical* separation of stations—the actual selectivity. Whatever means are adopted to facilitate the mechanical location of the station will not reduce interference from adjacent channels, except to the extent that simplified tuning may facilitate sideband choice with a slightly superior rejection characteristic. If we so design the tuning ensemble that 400 kc. is spread over 100 dial divisions, instead of 9, the selectivity characteristics of a signal receiving interference from two stations 5 kc. on each side of the desired frequency will not be improved in the least. The 5-kilocycle beat notes will be as intrusive as ever—but it will be much easier to center and log the desired signal. And if the interference is caused only by a solitary station, simplified tuning will make possible the rapid reduction of this interference by selecting sidebands (in the case of a modulated signal) or by employing a local beat frequency (in C.W. reception) on the side away from the interference.

A High Ratio Dial

The most obvious solution to the problem is the simple mechanical expedient of employing a high ratio dial—such as the 250-to-1 device used in the crystal controlled Stenode. This, of course, does not effect band-spreading, as far as the dial reading is concerned, but it does eliminate the necessity for over-exacting delicacy in control. The objections to the high ratio dial are that it does not solve the logging problem and, unless the mechanism is cleverly designed and carefully made, the back lash is likely to be annoyingly excessive.

Special Condenser Plates

Attacking the subject from an electrical point of view, the possibility of specially curved condenser plates is an immediate consideration. It is not at all difficult to design a condenser plate so

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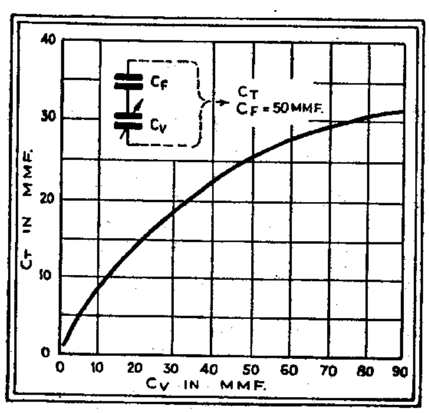
* The National Company, Malden, Mass.



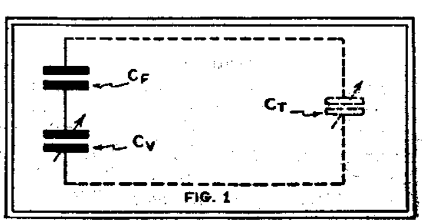
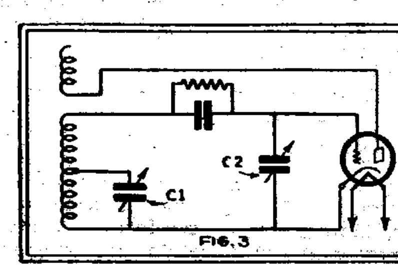


Fig. 1—A simple series condenser arrangement for reducing the variation in tuning capacity, Ct, with changes in the variable or control capacity, Cv. Fig. 2—Indicating how the rate change in tuning capacity, Ct, varies as the relationship of variable to fixed capacities is changed. Fig. 3—A circuit arrangement which approximates Figure 1, and which permits the inclusion of band spread components in the coil unit.



Band Spreading

(*Continued from page* 332)

that the capacity variation over a desired portion of the tuning curve is exceedingly small. If desired, the entire tuning range may be stretched over a frequency variation of a minute order. This is a highly efficient system of band-spreading, and solves both the tuning and the logging problems. The only objection to the system is that it definitely limits the receiver to a very small portion of the short-wave spectrum unless an inordinately large collection of coils is available—a severe limitation to practicability.

Use of Fixed and Variable Capacitors

A similarly desirable ratio between control adjustment and tuning capacity variation can be achieved by shunting the tuning inductor with a series of a fixed capacitor and a variable capacitor, as shown in Fig. 1. Condenser Cf is the fixed capacitor and Cv the control or variable condenser. The combined capacities of these condensers, or the tuning capacity Ct (neglecting circuit and distributed capacities) is equal to

$$C_{t1} = \frac{1}{\frac{1}{C_F} + \frac{1}{C_V}}$$

If we increase the capacity of the variable condenser by the amount AC, the capacity of Ct now is

$$C_{t2} = \frac{1}{\frac{1}{C_F} + \frac{1}{C_V + AC}}$$

where Cf and Cv are the same as in equation (1).

The difference between Ct2 and Ct1, the change in the actual tuning capacity Ct, is obviously equal to

$$AC_t = C_{t2} - C_{t1} = \frac{1}{\frac{1}{C_F} + \frac{1}{C_V + AC}} - \frac{1}{\frac{1}{C_F} + \frac{1}{C_V}}$$

Simplifying,

$$AC_t = AC \times \left[\frac{C_F^2}{C_V^2 + 2C_V C_F + C_F^2 + C_V AC + C_F AC}\right]$$

As the portion of equation (4) in brackets is always a fraction, it is obvious that ACt is always less than AC. Inspection of the equation (or complete differentiation) will also suggest that the rate change of ACt will depend upon the ratio of fixed to variable capacities. The curve, Fig. 2, illustrates this relationship. It is evident that, by choosing a large variable condenser and a small fixed condenser, we can make the variation of Ct as small as we desire, over the entire dial range! The change in Ct will always necessarily be less than the capacity of the fixed condenser.

An objection will immediately be raised against this system on the grounds that it suffers from the same limitations as the special plate arrangement, and that for a similar degree of band-spreading the same number of coils will be required to cover the short-wave spectrum. This would be so were it not for the fact that band-spreading is necessary only over certain portions of the dial (broadcast or amateur, according to taste) and that this particular series-parallel arrangement can be approximated by incorporating the fixed condenser in the plug-in coil unit, two or three such units sufficing for band-spread requirements, while still permitting the use of standard coils for complete spectrum coverage.

A Commercial Band-Spread System

The circuit of such an arrangement is shown in Fig. 3, while Fig. 4 shows the actual connections made in the National plug-in coils. The tuning condenser, capacity C1, is shunted about only the lower portion of the coil. The distributed capacity of the upper portion of the coil functions as the fixed capacity in Fig. 1. We thus have a fairly large variable capacity working against a very low fixed capacity—the requirement for a low rate change in actual tuning capacity Ct. The trimming condenser, C2, is used merely to set the band-spread at the desired portion of the tuning curve. Grid condenser and grid leak are also incorporated in the coil unit shown in Fig. 5.

This arrangement, in conjunction with a 270-degree condenser and a scientifically designed dial, results in an ideal amateur receiver, both 20-meter and 40-meter bands being spread over fifty dial divisions about the center of the dial.

In designing such a unit, constants must be chosen so that the natural periods of any portion of the coil do not approach the tuned signal frequency, such a condition resulting in a great increase in the resistance of the coil. The L/C ratio of the National unit is particularly conducive to a high degree of sensitivity which is effectively conserved by the use of R-39 insulation.

Figure 6 shows the band-spread coil plugged into a standard short-wave receiver. Substitution of an ordinary coil automatically readjusts the receiver for the usual extension of frequency bands.

Transmitter From Neutrodyne

(*Continued from page* 335)

has an appreciable length compared with that of the antenna, the antenna should be shortened just the length of the ground lead. If a counterpoise is used in place of an antenna, it should be the same length as given above for the antenna and may extend in any direction, but the opposite direction is preferable. The radiating system is tuned to the transmitter frequency by means of the antenna series tuning condenser. There will be a sharp increase of plate current to the power amplifier as the radiating system is tuned through resonance. If the plate current is high at all settings of the antenna series condenser the coupling is probably too close. This means that the number of turns in use in the antenna pick-up coil should be reduced. If connecting the radiating system and tuning it has no noticeable effect on the plate current to the power amplifier, the system is probably too long or too short.

No antenna current indicator is necessary. If one is desired the filament of a deactivated 199 tube in series with the antenna will serve. It will glow at just about normal brilliancy with the antenna current that this transmitter can supply. The silvery coating within the tube may be evaporated by holding the end of the bulb over a hot flame for a time and so making a "window" through which the filament may be more readily observed.

Does the set really work? Well, on the very first test a station thirty miles away was "worked," who gave a very fine report. Next a station fifty miles away was "worked" and a similar report received, and this was followed by a report from a station nearly a hundred miles away. Not bad for daylight work and the very first time on the air! The night range is much greater of course. A pleasant surprise was that duplex telephony was possible with this transmitter. On account of the low power it is possible to transmit and listen-in at the same time and in the same band.

Tube Data Chart

Tube No. in fig. 1	*Type of Tube*	*Tube Use*	*Grid Bias*	*Plate Voltage*	*Plate Curr. mills*
1	201A	M. Osc.	25,000 ohm g. l.	90	12
2	112A	P. Amp.	—27	90	14
3	201A	1st A. Amp.	(—1)	22½	0.5
4	201A	2d A. Amp.	—4½	90	2.5
M	171A	Mod.	—27	135	17

With a completely battery operated set, all the above values except plate currents are predetermined. The plate currents to the master oscillator and the power amplifier are determined by adjustments and load. Antenna coupling, etc., should be varied until the above values are approximated. The above values are also helpful when a "B" eliminator is used and no voltmeter is available.