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MEANS FOR TUNING ELECTRICAL OSCILLATORS

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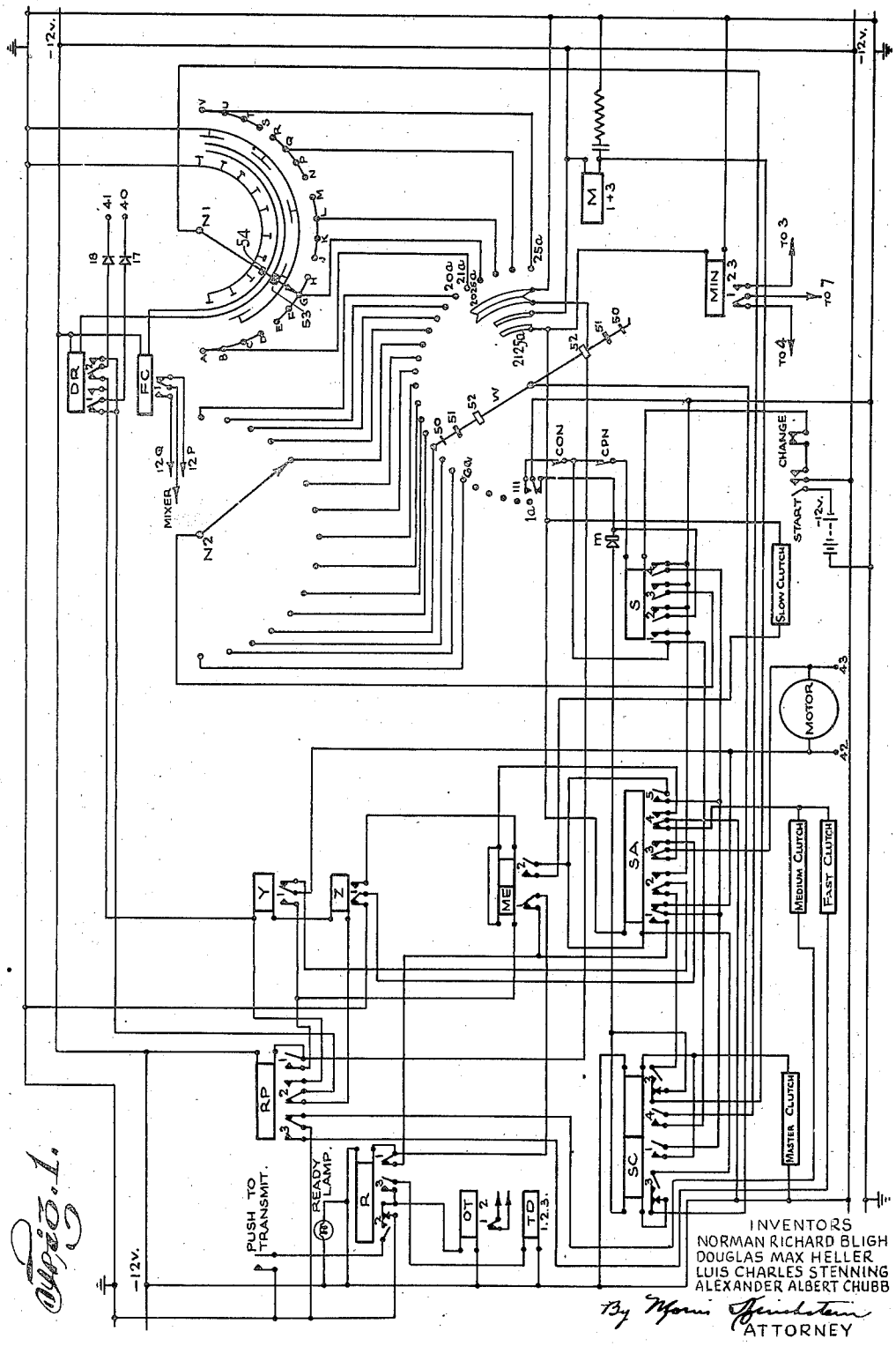


Fig. 1.

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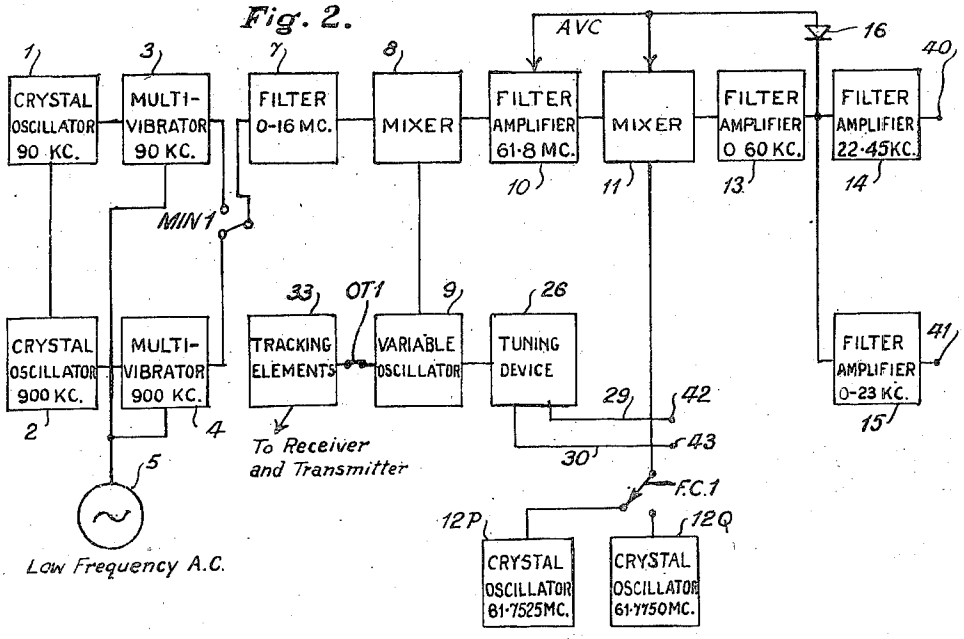
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Fig. 2.



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MEANS FOR TUNING ELECTRICAL OSCILLATORS

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In Great Britain December 14, 1942

11 Claims. (Cl. 250—36)

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This invention relates to apparatus for tuning a variable electrical oscillator and of the type comprising (*a*) an electrical generator or generators adapted to provide alternatively a set of standard frequencies spaced at minor intervals (say f_0), to one of which the variable oscillator has to be tuned, and a set of standard frequencies spaced at major intervals (say $10f_0$), (*b*) means for comparing the frequency f to which the variable oscillator is tuned with the frequency of any member of either of the said sets. As indicated by the examples, the said intervals in any one set are preferably all equal in any one set and the major interval is preferably an integral multiple of the minor interval; both sets can then be harmonics of a single master oscillator and the second set derived from the first by suppressing members of it. But, though no advantage of departing from this arrangement is known, the equality of the intervals in any one set and making the major interval an integral multiple of the minor are not essential to the invention. When the variable oscillator is said to be tuned to one of the standard frequencies of either of the said sets of standard frequencies, it is not necessarily implied that it is made to oscillate at that frequency; it is implied only that it is made to oscillate at a frequency standing in some predetermined relation to (e. g. having an assigned difference from) that standard frequency. When the said relation obtains, the frequency of the variable oscillator will be said to coincide with that standard frequency.

In the use of means of this type it is possible to proceed as follows. The variable oscillator starts tuned to a frequency lower than the lower limit of the second set, and the said means (*a*) are made to give the second set of frequencies spaced at major intervals. (Of course it would be equally possible to start beyond the upper limit.) f is increased until the said means (*b*) indicate that f coincides with a standard frequency, which must be the lowest member of the said second set. This fact is noted. f is increased further until it again coincides with a standard frequency, which must be the second of the said second set. The process is continued, the coincidences being counted, until f coincides with the member of the said second set next lower than the frequency to which the oscillator is to be tuned. (Alternatively it might be made to coincide with the next higher member.) Means (*a*) are then made to give the first set of standard frequencies spaced at minor intervals. The process is then continued and the number of coincidences with members of the first set counted, until there is coincidence with the desired member of the first set. The advantage of this procedure is, of course, that, when the member of the first set is large, fewer comparisons are necessary than if the oscillator were made to coincide in turn with each member of the first set below the desired frequency.

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This method has been proposed in the specification of copending patent application Serial No. 484,332 filed April 24, 1943; the present invention is specially adapted for use in association with the invention of that specification; its object is to enable the said procedure to be performed with ease and rapidity and, at least partly, automatically.

This object is achieved, according to one feature of the invention, by providing driving means for varying continually in the same direction (at least so long as the change-over means hereinafter mentioned do not operate) the frequency of the variable oscillator, by applying to an automatic selector switch, on the occasion of each coincidence between the frequency of the variable oscillator and a standard frequency, a pulse adapted normally to move its wiper on one step, by providing change-over means associated with the automatic selector switch for causing the second set of standard frequencies to be replaced by the first set when the wiper reaches a predetermined stud of the automatic selector switch, means for varying at the will of the operator the number of steps that the wiper must take under control of said coincidences before it reaches the predetermined stud, and by providing also stopping means, adapted to be associated with different steps of the automatic selector switch, that put the said driving means out of operation when the wiper of the automatic selector switch reaches the stud with which the stopping means are associated.

The change-over means may be capable of being associated at the will of the operator with different studs of the automatic selector switch, so that these means will cause the second set of standard frequencies to be replaced by the first set when the wiper reaches the stud with which the change-over means have been so associated. Alternatively, the change-over means may be permanently associated with a predetermined stud of the automatic selector switch, means being provided for varying at the will of the operator the number of steps that the wiper must take under control of the coincidences before it reaches the predetermined stud.

The automatic selector switch is preferably an instrument of the kind used in the art of constructing automatic telephone exchanges but it may also be any instrument equivalent to an instrument of the said kind for the purpose assigned to the automatic selector switch in this specification. Further, if the automatic selector switch is an instrument so equivalent, the terms "wiper" and "stud" mean the elements of it corresponding in function to the wiper and stud of an instrument of the said kind.

Suppose then that the standard frequency to which the variable oscillator is to be tuned is such that the oscillator has to make n_2 coincidences with the second set of standard frequencies and then n_1 coincidences with the first set in order to reach that standard frequency. Then the change-over means might be associated with the n_2 step of the automatic selector switch and the stopping means with the (n_2+n_1) step. But then the step with which the stopping means would have to be associated would depend on n_2 as well as on n_1. It is more convenient to make the position of the stopping means dependent only on n_1 as the position of the change-over means is dependent only on n_2. The modifications of the simple arrangement that are preferably made to produce this and some other subsidiary results are best explained by describing the general manner of operation of a particular example of apparatus according to the invention.

In the accompanying drawings:

Fig. 1 is a circuit diagram of the said example, and

Fig. 2 is a block diagram of part of a radio transmitter-receiver station embodying the arrangement shown in Fig. 1.

Referring now to Fig. 1, the automatic selector switch, the wiper of which is denoted by W, has twenty-five studs, of which those numbered **6***a*–**29***a* are associated with a selector switch N2 and the last five are associated with a selector switch N1. On the shaft of the wiper W are three cams **50**, **51**, **52** in duplicate, of which **51** opens a contact **2025***a* only when the wiper is on one of the studs **20***a* to **25***a* and **52** closes a contact **2125***a* only when the wiper is on one of the studs **21***a* to **25***a*; the function of the third cam **50** will be mentioned later. When the contact **2025***a* is open and the contact **2125***a* is closed, a relay causes the generator of the standard frequencies to supply the first set of frequencies which (in this example) are 90 kc./s. apart; when the contact **2025***a* is closed and the contact **2125***a* is open, the generator supplies the second set which (in this example) are 900 kc./s. apart. Accordingly the said contacts are the main part of the change-over means and the change-over is complete when the wiper reaches stud **21***a*.

When the start and change switches are operated, the wiper, starting at stud **1***a*, begins to move step by step, under the usual self-interrupting action of its driving magnet, until it reaches a stud selected by the selector switch N2. When it reaches that stud, it initiates actuation of a clutch, associated with a gear controlled by a relay, and causes a motor to drive the tuning element of the variable oscillator (not shown). At the same time the magnet ceases to be supplied with pulses from its self-interruption and is supplied instead with a pulse whenever a coincidence occurs between f, the frequency of the variable oscillator, and a standard frequency of the second set. Consequently, if there are to be n_2 coincidences with this set, there must be n_2 studs

of the automatic selector switch between (and including) the stud selected by the switch N2 and the stud **20***a*; this is secured by choosing suitably the position of the switch N2.

After the stud **21***a* has been reached, coincidences occur with members of the first set of standard frequencies. The wiper therefore still moves on unitl it reaches a stud that has been selected by the switch N1. Then the drive of the motor ceases, a signal lamp is lit; and a device is brought into operation which maintains f in coincidence with the desired member of the first set. These constitute the aforesaid stopping means. For this purpose there must be n_1 studs between (and including) stud **21***a* and the stud selected by the switch N1; this again is secured by choosing suitably the position of the switch N1.

That is the main operation; but some subsidiary operations are also important. First, it is desirable that the drive of the tuning element should be slowed down when the wiper approaches the stud **20***a* just before the change to the first set of frequencies occurs. This is conveniently achieved by providing a second clutch associated with gear of a larger reduction ratio than the gear associated with the aforesaid clutch. Second, it is important that the system should be in a suitable state before the wiper begins to move from its starting point. In particular, the tuning element must be in its normal starting position, the wiper must be on stud **1***a*, and the positions of the switches N2 and N1 must be selected.

A detailed explanation will now be given, by way of example, of how both the main and subsidiary operations may be performed automatically by the use of relays and clutches.

In order that the purpose of the relays and the like shall be understood, it is necessary to know something of the rest of the variable oscillator of which the devices shown in Fig. 1 form part. It will be supposed that this generator is of the kind illustrated in Fig. 2, which is a modification of the drawings of copending application No. 484,332. The parts represented in the drawings of the copending application by numerals **31**, **32** and **35** are irrelevant to this invention and have been omitted from the present Fig. 2. The parts represented by numerals **22**—**25**, and **27**—**30** in the drawings of the copending application have been profoundly modified; for the present invention is concerned with the substitution of automatic setting for mere counting. The terminals **40**, **41**, **42** and **43** of the present Fig. 1 are connected respectively to the terminals **40**, **41**, **42** and **43** of present Fig. 2.

Relays which are the same as the relays **19** and **20** of said copending application and switches which are the same as the switches **6**, **21** and **34** of said copending application play an important part in the following description of the present invention. Of these the relays **19** and **20** and the switch **21** are designated respectively by Y, Z and RP2, and are shown in Fig. 1 only. Switches **6** and **34** of said copending application are designated respectively MIN1 and OT1 and are shown in both Figs. 1 and 2 herein. However, the relays for operating these switches are shown only in Fig. 1. The tuning condenser that forms part of the tuning device **26** of Fig. 2 is not shown in Fig. 1, but the motor driving it is shown.

The filters **14**, **15** of the present case are modified from the filters **14**, **15** of said copending application in a manner to be explained later, but the modification is immaterial so long as coincidences with standard frequencies of the second

set (major intervals) are being considered. For then, whatever the nature of these filters, a "coincidence" occurs when the frequency of the variable oscillator comes within a range about the standard frequencies which is small compared with the interval between standard frequencies; it would make no difference if it were supposed that a "coincidence" was exact equality of the frequency of the variable oscillator with that of the standard. Accordingly consideration of these filters will be postponed until the account of setting to the second set of standards is complete.

In Fig. 1 all relays and the like are shown in their unoperated condition. The convention adopted for showing the relays is that the energising winding or windings of a relay are indicated by one or more rectangles which are interposed in the energising circuit or circuits and which are marked by a reference character consisting of a letter or letters denoting the relay. The contacts of the relay are shown underneath the rectangles and are denoted by serial numbers 1, 2, 3, etc., so that a reference such as SA2 in the specification denotes the number 2 contact of relay SA. The primary moving member in each relay contact is indicated by a plain arm without a contact head.

It will be assumed, that after the last use, the electric supplies were cut off leaving the wiper W in contact with some stud, other than 1*a*, which will be assumed to be different from that distinguished by the setting of N1 or N2 switches shown, which will be assumed to be the required setting.

The nature of the parts shown in the drawings will generally appear best, in view of what has been said already, by a description of their function; but it should be stated that the operating magnet M moves the wiper on one step when it is released, and that *m* is the self-interrupt contact that drives the wiper continually so long as the necessary voltage is applied to it. The symbols "1+3" attached to M refer to the one bank of studs (1*a*–25*a*) and the three contacts marked 111, 2025*a* and 2125*a*. The contact 111 is operated by 50, the third of the three cams associated with the wiper W as aforesaid, when and only when that wiper is at stud 1*a*.

When the "start" key is depressed, a contactor (not shown), which energises a motor-generator (not shown) supplying high-tension current to the associated apparatus, is closed. Simultaneously a 12 volt supply with earthed positive is connected between the bus-bars shown in Fig. 1.

The automatic selector switch magnet M is then energised via make-before-break contact SC2, the self-interrupting contact *m*, and the contact 111; the wiper W is driven clockwise until it reaches the "home" position, when the wiper is resting on stud 1*a* and the contact 111 is opened.

Relay OT (which operates via contact R2) operates switch OT1 and the tracking elements 33 are cut out. RP operates via the contact 2025*a* and DR operates via the cam 53 (which will be described later). RP1 applies an earth to one side of the make-and-break contact Y1 via the contact 2025*a*. RP2, DR1 and DR2 assume the positions in which both filters 14 and 15 feed relay Y and operate contact Y1. FC is not operated so that 12P remains in circuit.

When the wiper has homed, S relay operates via the contact 111, the contact CON, which is closed when the tuning condenser (forming part of 26) returns to its starting position under spring bias when the clutches are released, and the contact CPN, which is open if the tuning condenser is driven by accident beyond its normal limit corresponding to the highest frequency required of the variable oscillator. S relay then self-holds via CPN contact and S1. S1 also prepares to apply an earth to the contact arm of the N1 selecting switch. S2 applies an earth to one side of the magnet M, causing it to self-interrupt via *m* and SC2. S3 applies an earth connection to the contact arm of the N2 selecting switch which in turn earths a stud of the automatic selector switch corresponding to the N2 unit chosen. S4 prepares to selfhold relays SA and SC and also applies an earth to one side of the tuning motor via SA1, which drives the tuning condenser, thus starting the motor.

The magnet M continues to self-interrupt until its wiper reaches the stud earthed via S3, when the SC relay is operated and locks itself operated via SC1 and S4. The closing of SC1 also operates the "master clutch," which establishes a connection with the tuning condenser via the "fast clutch," so that the tuning condenser is driven at high speed. The magnet M remains operated, first through the upper contact of make-before-break contact SC3 and the wiper; after the said upper contact has opened, it remains operated via SC2, SA2, Y1, SA1, and S4, so that it will be released when Y1 breaks. Contact SC4 applies an earth to the stud corresponding to the position of the N1 selecting switch.

When the variable oscillator makes a coincidence with the first of the N2 series of standard frequencies, contact Y1 is opened momentarily by relay Y, releasing M and making the wiper take one step. This process continues on subsequent coincidences with the following members of the N2 set of standard frequencies until the wiper reaches stud 28, when contact 2025*a* opens. Relay RP does not relax immediately the coincidence occurs that causes the wiper to move to stud 20*a*; for it is self-held by contact RP1. It is released only when the coincidence ceases, i. e. when *f* passes beyond the range about the standard of the second set within which contact Y1 is operated. (The importance of this will appear presently.) When the coincidence ceases, the circuit of RP is broken and the RP contacts are operated. RP2 separates the pulses delivered by the rectifiers 17 and 18, and applies them separately to relays Y and Z. RP3 substitutes the "medium" for the fast clutch and therefore causes the tuning condenser to be driven more slowly as coincidence with the last of the standard frequencies of the second set is approached. When contact Y1 is operated by this approach, the wiper is stepped to stud 21*a* and the contact 2125*a* closes. Relay MIN is operated and changes over switch MIN1, thereby substituting the first set of standard frequencies (minor intervals) for the second set. Subsequent coincidences will be with members of the first set; the four positions e. g. A, B, C and D) in N1 with a single stud of the automatic selector switch are important. In order that their function can be appreciated it is necessary to consider the filters 14, 15 whose pass ranges determine the nature of the coincidence. They are chosen in accordance with a known principle, similar to but not identical with one described in the said copending application Ser. No. 484,332.

The oscillations from the variable oscillator are caused to beat with the oscillations of standard frequency, and the beat oscillations are

applied to the two filters. One of these passes frequencies between 0 (or substantially 0) and a limit slightly greater than $\frac{1}{4}f_0$, where f_0 is the difference between successive standard frequencies; the other passes frequencies between $\frac{1}{2}f_0$ and a limit slightly less than $\frac{1}{4}f_0$. Thus in the present example, where f_0=90 kc., the said limits may be 23 and 22 kc. respectively. If oscillations passing the first said filter cause the frequency of the variable oscillator to decrease and oscillations passing the second said filter cause it to increase, then the frequency of the oscillator will tend towards a value $\frac{1}{4}f_0$ less than the standard frequency, at which both sets of beats pass their filters owing to the overlap of these filters. It can be arranged that within this overlap neither set of beats causes the frequency of the oscillator to vary, so that this frequency will remain very near the said value. If the functions of the two sets of beats are interchanged, i. e. if those passing the first filter increase the frequency and those passing the second filter decrease it, then the frequency of the oscillator will remain very near a value $\frac{1}{4}f_0$ greater than the standard frequency.

The filter **14** has then a pass range $\frac{1}{2}f_0$ to just less than $\frac{1}{4}f_0$ (say, if f=90 kc., 45–22 kc.), and filter **15** a pass range from just more than $\frac{1}{4}f_0$ to substantially zero (say 23–0.2 kc.). The said interchange of the functions of the two sets of beats is effected by the contacts DR1, DR2, of relay DR which causes **14** to operate Y and **15** to operate Z or vice versa. The relay DR is operated by a first cam **53** on the shaft of the contact arm of selector N1 when that arm passes from the first to the second pair of contacts connected to the same wiper stud, e. g. from (A, B) to (C, D) or from (E, F) to (G, H). The passage from the first contact to the second contact of such a pair operates contacts via a second cam **54** on the shaft of the contact arm of N1 which operate a relay FC whose contact FC1 (Fig. 1) substitutes (as suggested in the said specification No. 484,332) for one crystal oscillator **12P** another **12Q** oscillating at a frequency $\frac{1}{4}f_0$ higher. It thus effectively raises the whole series of standard frequencies by $\frac{1}{4}f_0$.

Suppose then the arm of N1 is on contact A. Then the variable oscillator will set itself (by means about to be described to $nf_0-\frac{1}{4}f_0$, where nf_0 is one of the first set of standard frequencies. When the arm changes to B, **12Q** is substituted for **12P** and the oscillator sets itself to nf_0; when the arm moves to C, **12P** is replaced, but now the oscillator sets itself to $nf_0+\frac{1}{4}f_0$, in virtue of the changeover of the switches DR1, DR2. When the arm reaches D, the oscillator sets itself to $nf_0+\frac{1}{2}f_0$. When the arm reaches E, the oscillator sets itself to $(n+1)f_0-\frac{1}{4}f_0=nf_0+\frac{3}{4}f_0$.

The result is that the effective minor interval is not f_0, but $\frac{1}{4}f_0$.

The operation of the main device will now be further described. A "coincidence," operating contact Y1 and energising the magnet M, now occurs when f reaches a value $\frac{1}{2}f_0$ less than the standard frequency of the minor set, modified possibly by the substitution of **12Q** for **12P**; the coincidence ceases and the magnet is released when f reaches a value $\frac{1}{4}f_0$ higher. It is now clear why it is important that RP should not operate and throw over RP2 before the magnet is released; for if it did, the magnet would be released before the penultimate standard of the second set was reached and would be energised again soon after that standard was passed; there would be two "coincidences" with this standard. The holding up of RP ensures that RP2 is not operated until the said penultimate standard has been passed.

Relay MIN having operated and the first set of standards having been substituted for the second, each coincidence of f with a member of the first set moves the wiper on one step, by the action of contact Y1, until the stud selected by N1 is reached. Then relay SA is operated through contact SC3, which is still operated.

Relay SA locks itself in the operated position via SA5 and S4. Contact SA4 de-energises both the "fast" and "medium" clutches, and prepares to operate relay ME via contact Y1 or Z1, when either of the make-and-break these contacts is operated. Contact SA3 removes the −12 volt supply from one side of the tuning motor and substitutes a connection to the moving member of contact Z1. Contact SA1 removes the earth connection from the other side of the tuning motor, leaving it connected to the moving member of contact Y1. When both Y1 and Z1 are operated both sides of the motor are joined to the −12 volt supply and the motor does not run and ME is unoperated. Similarly, when both Z1 and Y1 are relaxed the two sides of the motor are connected to earth (direct and via SA2 respectively) and again the motor does not run and ME is unoperated. However, if Z1 is operated and Y1 relaxed the motor is driven in a forward direction, i. e. in the same direction as during the counting operation. Conversely, if Z1 is relaxed and Y1 is operated, the motor is driven in the reverse direction, ME being operated in either case.

The "slow clutch" relay is energised through contact ME2 in parallel with SA and causes the tuning condenser to be driven very slowly either forwards or backwards according as Z1 or Y1 is operated; f is thus automatically maintained in the desired relation with the selected standard. Contact ME1, being open, prevents the operation of relay R until the motor is de-energised for the first time, whereupon R operates and locks itself operated via R1, SA1 and S4. The "ready" lamp also lights, being effectively in parallel with R relay. The make-and-break contact R2, being operated, removes the earth from the relay OT and puts the tracking elements **33** in circuit; the control of switch OT1 by energisation of relay OT, and hence the removal or insertion of the tracking elements, is transferred to the "push-to-transmit" key. Contact R3 prepares to operate relay TD on depression of that key.

The apparatus now is in the state for the reception of signals. If signals are to be transmitted, the "push-to-transmit" key is depressed and the tracking elements are cut out by the operation of relay OT. The contacts of the relay TD and the contacts of the relays MIN and OT not explicitly mentioned perform certain operations incidental to transmission or reception, (e. g. the introduction of a side tone) which are not characteristic of this invention and therefore need not be considered further.

The "change" key shown in the drawings, when operated, releases the relays sufficiently to enable the variable oscillator to be tuned to a new standard frequency, determined by a new setting of the switches N1, N2, without the need for cutting off all supplies and operating the "start" key again. This it does mainly by releasing the relay S and therefore causing all S contacts to return to the unoperated state. Experts will understand

the exact operation without further description.

Having thus described our invention, we claim as new and desire to secure by Letters Patent:

1. Apparatus of the character described for tuning a variable electrical oscillator and including driving means capable of varying continuously in the same direction the frequency of said oscillator, means for generating alternatively a first set of standard frequencies spaced at minor intervals, to one of which the variable oscillator has to be tuned, and a second set of standard frequencies spaced at major intervals, an automatic selector switch including a wiper, a plurality of studs and electrically actuable wiper moving means, means responsive to coincidences between the varying frequency of said variable oscillator and said standard frequencies for applying to said automatic selector switch, on the occasion of each such coincidence, a pulse serving to move its wiper one step, change-over means associated with said automatic selector switch for causing said second set of standard frequencies to be replaced by said first set when the wiper reaches a predetermined stud of said automatic selector switch, means for varying at the will of an operator the number of steps that said wiper must take under control of said coincidences before it reaches said predetermined stud, and stopping means adapted to be associated at the will of the operator with different studs of said automatic selector switch and serving to put said driving means out of action when the wiper reaches the stud with which said stopping means are associated.

2. Apparatus of the character described for tuning a variable electrical oscillator and including driving means capable of varying continuously in the same direction the frequency of said oscillator, means for generating alternatively a first set of standard frequencies spaced at minor intervals, to one of which the variable oscillator has to be tuned, and a second set of standard frequencies spaced at major intervals, an automatic selector switch including a wiper, a plurality of studs and electrically actuable wiper moving means, means responsive to coincidences between the varying frequency of said variable oscillator and said standard frequencies for applying to said automatic selector switch, on the occasion of each such coincidence, a pulse serving to move its wiper one step, change-over means capable of being associated at the will of an operator with different studs of said automatic selector switch and serving to cause said second set of standard frequencies to be replaced by said first set when the wiper reaches the stud with which said change-over means are associated, and stopping means also adapted to be associated at the will of the operator with different studs of said automatic selector switch and serving to put said driving means out of action when the wiper reaches the stud with which said stopping means are associated.

3. Apparatus of the character described for tuning a variable electrical oscillator and including driving means capable of varying continuously in the same direction the frequency of said oscillator, means for generating alternatively a first set of standard frequencies spaced at minor intervals, to one of which the variable oscillator has to be tuned, and a second set of standard frequencies spaced at major intervals, an automatic selector switch including a wiper, a plurality of studs and electrically actuable wiper moving means, means responsive to coincidences between the varying frequency of said variable oscillator and said standard frequencies for applying to said automatic selector switch, on the occasion of each such coincidence, a pulse serving to move its wiper one step, change-over means permanently associated with a predetermined stud of said automatic selector switch for causing said second set of standard frequencies to be replaced by said first set when the wiper reaches said predetermined stud, means for varying at the will of an operator the number of steps that said wiper must take under control of said coincidences before it reaches said predetermined stud, and stopping means adapted to be associated at the will of the operator with different studs of said automatic selector switch and serving to put said driving means out of action when the wiper reaches the stud with which said stopping means are associated.

4. Apparatus of the character described for tuning a variable electrical oscillator and including driving means capable of varying continuously in the same direction the frequency of said oscillator, means for generating alternatively a first set of standard frequencies spaced at minor intervals, to one of which the variable oscillator has to be tuned, and a second set of standard frequencies spaced at major intervals, an automatic selector switch including a wiper, a plurality of studs and electrically actuable wiper moving means, means responsive to coincidences between the varying frequency of said variable oscillator and said standard frequencies for applying to said automatic selector switch, on the occasion of each such coincidence, a pulse serving to move its wiper one step, change-over means including a selector switch for selecting a predetermined stud of said automatic selector switch, a source of current, a relay and a circuit including said relay in series with said source of current and with said selector switch and capable of being completed by the wiper's reaching said predetermined stud and thereby causing said second set of standard frequencies to be replaced by said first set when the wiper reaches said predetermined stud, and stopping means adapted to be associated at the will of the operator with different studs of said automatic selector switch and serving to put said driving means out of action when the wiper reaches the stud with which said stopping means are associated.

5. Apparatus of the character described for tuning a variable electrical oscillator and including driving means capable of varying continuously in the same direction the frequency of said oscillator, means for generating alternatively a first set of standard frequencies spaced at minor intervals, to one of which the variable oscillator has to be tuned, and a second set of standard frequencies spaced at major intervals, an automatic selector switch including a wiper, a plurality of studs and electrically actuable wiper moving means, means responsive to coincidences between the varying frequency of said variable oscillator and said standard frequencies for applying to said automatic selector switch, on the occasion of each such coincidence, a pulse serving to move its wiper one step, change-over means associated with said automatic selector switch for causing said second set of standard frequencies to be replaced by said first set when the wiper reaches a predetermined stud of said automatic selector switch, means for varying at the will of an operator the number of steps that said wiper must take under control of said coincidences

before it reaches said predetermined stud, and stopping means including a selector switch for selecting a second predetermined stud of said automatic selector switch, a source of current, a relay and a circuit including said relay in series with said source of current and with said selector switch and capable of being completed by the wiper's reaching said second predetermined stud.

6. Apparatus of the character described for tuning a variable electrical oscillator and including driving means capable of varying continuously in the same direction the frequency of said oscillator, means for changing the effective speed of said driving means, means for generating alternatively a first set of standard frequencies spaced at minor intervals, to one of which the variable oscillator has to be tuned, and a second set of standard frequencies spaced at major intervals, an automatic selector switch including a wiper, a plurality of studs and electrically actuable wiper moving means, means responsive to coincidences between the varying frequency of said variable oscillator and said standard frequencies for applying to said automatic selector switch, on the occasion of each such coincidence, a pulse serving to move its wiper one step, change-over means associated with said automatic selector switch for causing said second set of standard frequencies to be replaced by said first set and for actuating said means for changing the effective speed of said driving means so as to cause the frequency of said variable oscillator to vary more slowly when the wiper reaches a predetermined stud of said automatic selector switch, means for varying at the will of an operator the number of steps that said wiper must take under control of said coincidences before it reaches said predetermined stud, and stopping means adapted to be associated at the will of the operator with different studs of said automatic selector switch and serving to put said driving means out of action when the wiper reaches the stud with which said stopping means are associated.

7. Apparatus of the character described for tuning a variable electrical oscillator, including a control member capable on continued displacement in the same direction of varying continuously in the same sense the frequency of said oscillator, a motor, a two-speed gear mechanism connecting said motor to said control member and including electrically-actuated gear-selecting clutch means, means for generating alternatively a first set of standard frequencies spaced at minor intervals, to one of which the variable oscillator has to be tuned, and a second set of standard frequencies spaced at major intervals, an automatic selector switch including a wiper, a plurality of studs and electrically actuable wiper moving means, means responsive to coincidences between the varying frequency of said variable oscillator and said standard frequencies for applying to said automatic selector switch, on the occasion of each such coincidence, a pulse serving to move its wiper one step, change-over means associated with said automatic selector switch for causing said second set of standard frequencies to be replaced by said first set and for actuating said clutch means so as to cause the frequency of said variable oscillator to vary more slowly, when the wiper reaches a predetermined stud of said automatic selector switch, means for varying at the will of an operator the number of steps that said wiper must take under control of said coincidences before it reaches said predetermined stud, and stopping means adapted to be associated at the will of the operator with different studs of said automatic selector switch and serving to put said driving means out of action when the wiper reaches the stud with which said stopping means are associated.

8. Apparatus of the character described for tuning a variable electrical oscillator and including driving means capable of varying continuously in the same direction the frequency of said oscillator, means for generating alternatively a first set of standard frequencies spaced at minor intervals, to one of which the variable oscillator has to be tuned, and a second set of standard frequencies spaced at major intervals, an automatic selector switch including a wiper, a plurality of studs and electrically actuable wiper moving means, means responsive to coincidences between the varying frequency of said variable oscillator and said standard frequencies for applying to said automatic selector switch, on the occasion of each such coincidence, a pulse serving to move its wiper one step, change-over means associated with said automatic selector switch for causing said second set of standard frequencies to be replaced by said first set when the wiper reaches a predetermined stud of said automatic selector switch, means for varying at the will of an operator the number of steps that said wiper must take under control of said coincidences before it reaches said predetermined stud, stopping means adapted to be associated at the will of the operator with different studs of said automatic selector switch and serving to put said driving means out of action when the wiper reaches the stud with which said stopping means are associated, and means for maintaining the frequency of said variable oscillator in a predetermined relation to a selected standard frequency after it has been brought, at least approximately, into such relation.

9. Apparatus of the character described for tuning a variable electrical oscillator and including driving means capable of varying continuously in the same direction the frequency of said oscillator, means for generating alternatively a first set of standard frequencies spaced at minor intervals, to one of which the variable oscillator has to be tuned, and a second set of standard frequencies spaced at major intervals, an automatic selector switch including a wiper, a plurality of studs and electrically actuable wiper moving means, means responsive to coincidences between the varying frequency of said variable oscillator and said standard frequencies for applying to said automatic selector switch, on the occasion of each such coincidence, a pulse serving to move its wiper one step, change-over means associated with said automatic selector switch for causing said second set of standard frequencies to be replaced by said first set when the wiper reaches a predetermined stud of said automatic selector switch, means for varying at the will of an operator the number of steps that said wiper must take under control of said coincidences before it reaches said predetermined stud, stopping means adapted to be associated at the will of the operator with different studs of said automatic selector switch and serving to put said driving means out of action when the wiper reaches the stud with which said stopping means are associated, and means for maintaining the frequency of said variable oscillator in a predetermined relation to a selected standard frequency after it has been brought, at least approximately, into such relation, the last-mentioned

means including two filters, one passing frequencies only between substantially zero and a limit slightly exceeding $\frac{1}{4}f_0$, where f_0 is the effective difference between successive standard frequencies of said first set, in the absence of the last-mentioned means, and the other filter passing frequencies only between $\frac{1}{2}f_0$ and a limit slightly less than $\frac{1}{4}f_0$, and two relays arranged to be actuated in response to passage of current through said filters respectively and to cause said driving means to operate in the one or the other direction according as only one or other of said relays is actuated.

10. Apparatus of the character described for tuning a variable electrical oscillator and including driving means capable of varying continuously in the same direction the frequency of said oscillator, means for changing the effective speed of said driving means, means for generating alternatively a first set of standard frequencies spaced at minor intervals, to one of which the variable oscillator has to be tuned, and a second set of standard frequencies spaced at major intervals, an automatic selector switch including a wiper, a plurality of studs and electrically actuable wiper moving means, means responsive to coincidences between the varying frequency of said variable oscillator and said standard frequencies for applying to said automatic selector switch, on the occasion of each such coincidence, a pulse serving to move its wiper one step, change-over means associated with said automatic selector switch for causing said second set of standard frequencies to be replaced by said first set and for actuating said means for changing the effective speed of said driving means so as to cause the frequency of said variable oscillator to vary more slowly when the wiper reaches a predetermined stud of said automatic selector switch, means for varying at the will of an operator the number of steps that said wiper must take under control of said coincidences before it reaches said predetermined stud, stopping means adapted to be associated at the will of the operator with different studs of said automatic selector switch and serving to put said driving means out of action when the wiper reaches the stud with which said stopping means are associated, and means for maintaining the frequency of said variable oscillator in a predetermined relation to a selected standard frequency after it has been

brought, at least approximately, into such relation, the last-mentioned means serving to control said driving means in such a manner that the frequency of said variable oscillator is varied for the purpose of maintaining said frequency more slowly than just after said change-over means have operated.

11. Apparatus of the character described for tuning a variable electrical oscillator and including driving means capable of varying continuously in the same direction the frequency of said oscillator, a first generator of a set of standard frequencies spaced at uniform intervals f_0, a second generator adapted in two alternative conditions to generate respectively two frequencies differing from each other by $\frac{1}{4}f_0$, means for mixing the outputs of said variable oscillator and of said first and second generators, two filters for receiving such mixed output, one passing frequencies only between substantially zero and a limit slightly exceeding $\frac{1}{4}f_0$, and the other passing frequencies only between $\frac{1}{2}f_0$ and a limit slightly less than $\frac{1}{4}f_0$, an automatic selector switch including a wiper, a plurality of studs and electrically actuable wiper moving means, means responsive to the passage of a current pulse through at least one of said filters for applying to said automatic selector switch a pulse serving to move its wiper one step, a selector switch for selecting a predetermined stud of said automatic selector switch, said selector switch having four positions associated with each stud of said automatic selector switch, stopping means serving at least momentarily to put said driving means out of action when the wiper reaches the selected stud, two relays arranged to be actuated in response to passage of current through said filters respectively and to cause said driving means to operate in the one or the other direction according as only one or other of said relays is actuated, and means actuated by said selector switch for interchanging the functions of said filters as said selector switch changes from the first pair to the second pair of said four positions and for changing the condition of said second generator as said selector switch passes from the first to the second of each of said pairs of positions.

NORMAN RICHARD BLIGH.
DOUGLAS MAX HELLER.
LUIS CHARLES STENNING.
ALEXANDER ALBERT CHUBB.