The Wireless World

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CONTENTS

EDITORIAL COMMENT

Quality Transmission

Lessons from "Television Sound"

*J*UDGING both from our own observations and from the opinions of readers, it seems clear that the high quality associated with the sound accompaniment of television is not accounted for solely by the extended range of frequency response which the use of an ultra-short-wave transmitter makes possible. Evidence in support of this argument began to accumulate before the Alexandra Palace transmitter was put into service. For instance, the reproduction from the experimental short-wave transmitter on the top of Broadcasting House showed a marked superiority over that of the same programme from the Brookmans Park station, in spite of the fact that the loud speaker used in the test we have in mind was known to have a sharp cut-off at 6,500 c/s.

Land-line Effects ?

At the time this was attributed to the fact that the U-S-W transmitter was taking its modulation directly from the studio amplifiers without the intervening land-line to Brookmans Park. However, we can now eliminate the short land-lines in the London area as possible causes of discrepancies in quality, since the recent broadcast by the Director of Television, referred to by a correspondent in this issue, had all the earmarks of television sound quality in spite of the fact that it had to traverse not only the new line from Alexandra Palace to the B.B.C. headquarters at Broadcasting House but also the permanent link from the Broadcasting House control room to Brookmans Park.

We are assured that standard microphones and amplifiers are used in the television studio and this narrows down the enquiry to the characteristics of the studio itself. Unlike the studios at Broadcasting House, which have been measured, adjusted and made to conform carefully to the latest precepts of architectural acoustics, the television studio, with its multiplicity of scenery, " props " and electrical apparatus, has an extremely complex standing wave pattern which probably accounts for the characteristic quality of television sound. Another difference is to be found in the placing of the microphones which must always be outside the field of view of the camera and several feet from the speaker, who may, therefore, be weaned from the subconscious urge to adopt the crooning manner of speech which the proximity of a microphone seems to engender.

Proposal for a Test

So far as music is concerned, we suggest that a most instructive programme would be an " exchange " concert between the Television Orchestra at Alexandra Palace and a similarly constituted orchestra playing in one of the studios at Broadcasting House. The whole programme would be radiated through the television sound channel, with London Regional transmitting it on the medium waves as a further check. The effects of land-lines and different studio acoustics and technique could then be studied.

Ultra-short-wave quality is not a myth and although there may be an occasional broadcast which is below par there is no mistaking the outstanding quality resulting from the combination of the unique studio characteristics at Alexandra Palace with the wide frequency range of the U-S-W transmitter taking its modulation on the spot.

High-Fidelity Transmission

Programmes on 7 Metres

IT is good news that the B.B.C. has decided to radiate either the National or London Regional programme between about 8 and 9 p.m. each evening through the Alexandra Palace transmitter. We hope that this is only a preliminary to a wider use of ultra-short-waves for sound broadcasting.

In view of the discussion now proceeding in our columns on the quality of transmissions on these wavelengths, it is interesting that musical items which stand to gain most from an extended frequency range are to be chosen.

If 7-metre sound transmissions become a regular feature, designers of television receivers will have to consider the question of providing means for switching off the vision section; facilities for doing so are now comparatively rare, but will be necessary in the interests of tube and valve life.

Standardised HT Batteries

Congratulations to the R.M.A.

THE RADIO MANUFACTURERS' ASSOCIATION is to be congratulated on having issued a specification for dry batteries as used in wireless receivers. It is to be hoped that this move will abolish the abuses that undoubtedly exist in certain sections of the trade.

In addition to laying down sizes of cells for batteries of four standard capacities, the specification also sets forth a series of nominal initial voltages that should be sufficient for all ordinary requirements.

Second-hand Sets

The Problem of Disposal

IF you want to buy a new set and take your present one to your dealer, hoping to get an allowance for it, you will probably be sadly shocked at the price he will offer you for it; generally speaking, you will find it far more satisfactory to sell your present set privately before you buy the new one.

The reason is that your set is probably worth much more to a private purchaser than it is to a dealer who may have some difficulty in disposing of it, and, in any case, may have to recondition it before he tries to find a buyer.

There are some wonderful bargains to-day in sets of a year or two years old which ought to find a market to replace sets of earlier vintage, which, by now, are probably giving very poor service indeed. From the manufacturers' point of view, it is very important that the public should be able to find a market at a fair price for their existing sets, because until they do there is little hope of any large buying of new sets, now that there are very few purchasers who are not already owners of a set of some kind.

Misleading Terms

Everybody's Responsibility

A LETTER published in our Correspondence columns this week draws attention to as pretty an example as could be found of an unfortunate and confusing piece of technical jargon.

The expression "all-mains," which is the culprit, admittedly, had a limited currency in informed wireless circles for a short while during the transition period from battery to mains operation of broadcast receivers. It was then used to describe a set deriving all its working voltages—heater, anode and grid—from the mains, and served to distinguish such sets from others in which an LT accumulator (and perhaps a dry-cell bias battery as well) was retained.

It would now appear that an unfortunate purchaser of a broadcast set, knowing nothing of this fragment of wireless history, assumed the expression "all-mains" to mean that the receiver would work on any type of supply mains, AC or DC. Although we may smile at such a misunderstanding, it is only fair to admit that the purchaser's interpretation of the description was natural enough.

In a new and rapidly growing art such as ours, one cannot be too careful about these matters, and it is the responsibility of everyone to see that our jargon, if it cannot be made comprehensible to the layman, at least will not confuse him.

In this Issue

Features for 1939

AS a result of the growing interest in amateur transmission we are publishing a series of articles which will treat this subject for the benefit of readers who have no previous knowledge of transmitting practice. Although dealing primarily with the design and construction of a low-powered amateur transmitter, the articles will also include information on adjustments and operation, as well as on the choice of components and accessories.

For reasons explained in the opening article, which appears in this issue, a start is being made with a transmitter suitable for the 40- and 20-metre wavebands, perhaps the most popular of those open to the amateur. Later, however, it will be shown how the set may be modified for 10-metre working.

Another feature beginning in this issue is of quite a different nature, and is designed to appeal to those readers who wish to test their powers of logical deduction. Would-be solvers of the problems should perhaps be warned that, although the letters addressed to the mythical Henry Farrad are couched in disarmingly simple terms, every word is significant.

Next week's issue will be devoted largely to the subjects of measuring instruments and measurements, and will include a review of apparatus of wireless interest shown at the Physical Society's annual exhibition, which closes to-day.

AMATEUR TRANSMITTING STATION G2UV. This station owned and operated by Mr. W. E. Corsham, at Wembley, Middlesex, normally works on the 14-Mc/s band (21.42-20.83 metres) using both telephony and CW system of transmission. The station can often be heard working in the evenings and most mornings at 9 a.m., at which hour Mr. Corsham usually carries out tests with amateur transmitters in New Zealand.

The Amateur Transmitting Station

Part I.—SIMPLE CRYSTAL- CONTROLLED OSCILLATORS

This is the first of a short series of articles on design and construction, written for the benefit of the would-be amateur transmitter. No previous knowledge of transmitting practice is assumed.

By H. B. DENT (G2MC)

HAVING already discussed the procedure to be followed in applying for a transmitting licence,[1] we now come to what might be described as the immediate post-licence period when the successful applicant is about to build his first transmitter.

At the outset, this will probably be mainly a communication type of set; the experimental apparatus, which may or may not be subsidiary to it, can be evolved later. Exchange of ideas with other amateurs, arrangements for co-operation in future tests and the acquisition of experience in the adjustment and operation of transmitters will be the main purpose for which the set is required. It goes without saying that the newly licensed amateur has by now a reasonably good knowledge of the fundamental principles of wireless transmission, though, so far, he has had no opportunity to put this knowledge into practice.

Since many alterations will certainly be made from time to time, a baseboard layout, with ample space for modifications, is preferable to the less adaptable rack-built assembly. This form of construction might well be deferred until a semi-permanent design has been evolved from the experimental baseboard equipment.

The Best Wavelength

A decision must be made regarding the waveband in which transmission is to be effected initially. Unless there is any special reason why a particular frequency should be chosen then it would be best to build the transmitter for use on one of the lower amateur frequencies, such as 1.7 or 7 Mc/s (160 or 40 metres).

The latter is possibly the better of the two as it is of a sufficiently high frequency to show up defects in the design of the apparatus yet not so high that the beginner is likely to encounter any serious difficulties in obtaining a reasonably good performance from the outset.

The temptation to make the set so that it can be switched from one waveband to another quickly should be resisted, or at least deferred until a little practical experience has been acquired in the adjustment and operation on a single wavelength.

A simple form of construction should be adopted and ample space allowed for

additions and modifications. The licence usually restricts the input to 10 watts; this is not the total consumption of the transmitter, but the power supplied to the anode of the valve that is coupled to the aerial.

There is no restriction on the power consumed by any other stages in the set, so the main concern is to extract as much RF energy as possible from the last valve, i.e., a high efficiency is necessary in order to obtain the best performance with the power permitted. This is of paramount importance in the design of every amateur transmitter, even though it may mean uneconomical operation of stages that precede the final valve.

A single valve functioning as an oscillator would serve the purpose of the RF generator for delivering power to the aerial in a small transmitter, but this arrangement is not very efficient and does not make the best use of the 10 watts available.

Some means must be found to ensure operation on a fixed frequency, or at least to confine the oscillations to the band of frequencies allotted for amateur use, for working outside the authorised band is of all offences the most unpardonable that any amateur transmitter can commit!

Unless some form of frequency control is embodied in the transmitter constant checking of the frequency is necessary, and an accurately calibrated wavemeter becomes an essential part of the equipment.

As it is obligatory for every amateur station to possess a piezo-electric crystal, with either its fundamental frequency or one of its harmonics falling within the band in which transmission is being made, it has become the customary practice to use this crystal actually to control the frequency of the valve that generates the RF oscillations, which may or may not be the valve feeding energy into the aerial.

A quartz crystal having a fundamental frequency of, say, 7.2 Mc/s is less than $\frac{1}{16}$in. thick and though quartz is a very tough material it could be fractured if the plate is allowed to vibrate too vigorously. This condition might obtain in an oscillator stage with a power input of 10 watts. It has also been noticed that, with moderate high-power oscillators of this kind, the frequency tends to drift as the crystal warms up, the heating of the crystal being due partly to its frictional loss at large amplitudes of vibration and partly to the RF current circulating in the crystal circuit. Actually the two effects are complementary, for it is the RF potential across the crystal that governs its amplitude of vibration.

We therefore arrive at this conclusion: the RF generator when crystal controlled should be operated at comparatively low power and its output amplified by a stage coupled to the aerial and operating at maximum possible efficiency. In this way we obtain the largest amount of RF power for a given input to the transmitter, and at the same time have a master oscillator which can be maintained at a constant frequency by means of a piezo-electric crystal.

The logical thing to do is to design the crystal oscillator and get this working satisfactorily before tackling the amplifier. For this, a pentode, a tetrode or a triode valve can be used. The choice is not based solely on the relative efficiencies of each type, but consideration ought to be given to possible future requirements as all valves and parts purchased for the first transmitter should be suitable also for any set that might be built in the near future.

Let us say that a beginning is to be made with a 7-Mc/s transmitter. We will naturally want the set to be as flexible as possible so that should a move be made later to the higher frequency bands, such as 14, 28 and possibly 56 Mc/s, some of the parts now being used will be easily adaptable to the new transmitter.
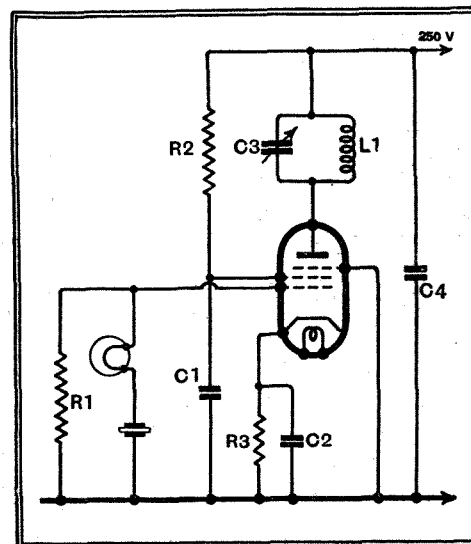

Fig. 1.—The simplest form of crystal-controlled oscillator.

[1] " First Steps to Transmitting," *The Wireless World,* August 11th, 1938.

The Amateur Transmitting Station—

It might, therefore, be a good idea to build the crystal oscillator and the 7-Mc/s power amplifier on separate chassis, for the former at least could be designed now with this possibility in mind without detracting from its efficiency on the initial frequency chosen, and this is quite practical, for all the amateur wavebands are harmonically related.

For operation on any of the higher frequencies the crystal-controlled oscillator can be made to give an output at twice or four times the fundamental frequency of the crystal, and the valves which function best in this way are either pentodes or tetrodes. A typical pentode or tetrode oscillator giving an output at the crystal frequency is shown in Fig. 1; when the circuit L_1, C_3 is tuned to approximately the crystal frequency the valve begins to oscillate, the precise frequency of the oscillations being determined by the crystal and not by L_1, C_3. The cathode resistance R_3 (shunted by C_2 to by-pass the RF) is included to provide sufficient grid bias to keep the anode current at a safe value when the valve is not oscillating, but when oscillation starts additional grid bias is provided by R_1. This resistance also serves the purpose of completing the DC path of the grid circuit, as the crystal is a non-conductor, so far as DC is concerned.
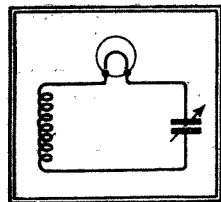
When the valve is oscillating the RF on the grid is rectified (the grid and cathode form a diode rectifier) and the DC component flows through R_1; the flow of current external to the valve as measured by a meter is from cathode to grid. As the grid end of R_1 is negative in relation to the earthed end the potential difference acts as additional grid bias when the valve is oscillating.

In most oscillators of this kind R_1 is made 50,000 ohms but if for any reason it is necessary to lower it an RF choke should be joined in series with it as this resistance is in parallel with the crystal and if its RF impedance becomes too low the valve will not oscillate.

The small flash-lamp in series with the crystal acts as an indicator of the RF current flowing through the crystal. A low-consumption lamp of, say, the 60- or 100-mA type is best for this position. Normally it should not glow brightly, though a dull glow will not indicate an overload. The tuning of L_1, C_3 governs the amplitude but, as already stated, not

Fig. 2.—Wavelength checking circuit with lamp for indicating resonance.

the frequency of oscillations, and the correct adjustment is when this circuit is tuned to a slightly higher frequency than that of the crystal but sufficiently close to resonance to give an adequate RF output
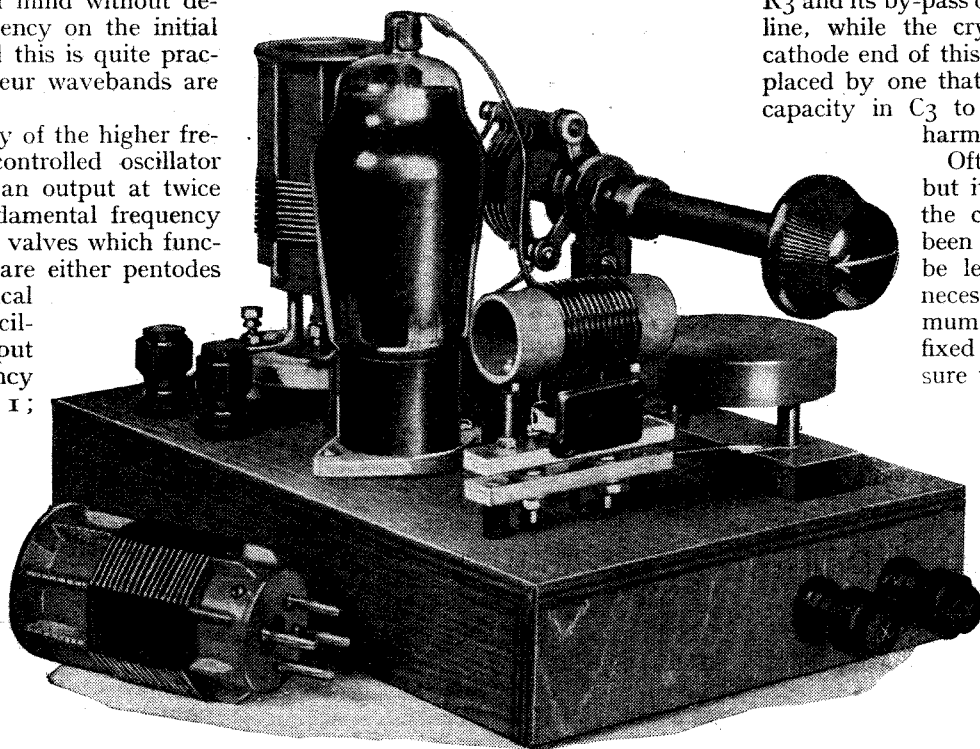
without excessive current flowing through the crystal.

Various adjustments of L_1, C_3 and of R_2, which initially should be about 5,000 to 10,000 ohms, according to the type of valve employed, can be tried and the output observed by means of an RF indicator coupled to L_1, C_3. The simplest form of indicator consists of two or three turns of wire joined to a small flash lamp and mounted on the end of a wood or ebonite rod.

An RF meter with which actual measurements can be made was described in *The Wireless World* of March 24th last and this will be found very useful when adjusting transmitters for maximum power output. An absorption wavemeter with a small flash-lamp joined in series with the coil as shown in Fig. 2 also forms a useful indicator.

If the crystal oscillator is made as a separate unit it is worth while paying some attention to its construction for it will serve for almost any future transmitter working on 40 metres or lower. With this possibility in mind sufficient space should be left on the chassis to accommodate the few extra parts needed to obtain an RF output at twice or four times the fundamental frequency,

the modifications to the circuit are shown in Fig. 3.

Comparing this with Fig. 1 it will be seen that a tuned circuit L_2, C_5 is now interposed between the grid bias resistance R_3 and its by-pass condenser and the earth line, while the crystal is joined to the cathode end of this circuit. Coil L_1 is replaced by one that tunes with very little capacity in C_3 to the frequency of the harmonic required.

Often C_5 is made variable but it need not be, as once the correct adjustment has been found it can henceforth be left alone. It is only necessary to find the optimum value for L_2 with a fixed capacity at C_5 to ensure the same results. The tuning of this circuit is not critical, and if it is made to resonate at a frequency slightly lower than twice that of the crystal the oscillator functions quite satisfactorily.

A simple way of allowing for this conversion would be to arrange for L_2, C_5 to plug into a two-pin socket for harmonic operation, and this socket is fitted with a two-pin shorting plug for fundamental frequency operation. This idea has been used quite successfully in several experimental transmitters made by the writer, and a crystal oscillator unit with this feature is shown in the illustration.

It is possible to obtain a modest output at four times the fundamental frequency of the crystal but the power is small and generally one is content to frequency-double only in this stage, when sufficient
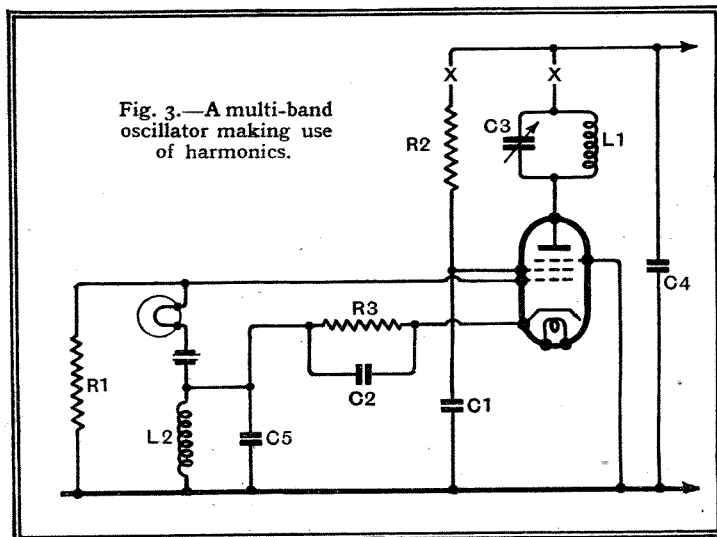
Fig. 3.—A multi-band oscillator making use of harmonics.

power is available to load fully a 10-watt power amplifier.

The screen-feed and the anode-feed leads should have inserted at the points marked X either a jack or a pair of terminals for connecting a milliammeter.

Resistance-Capacity Tuning

STAGES IN THE DEVELOPMENT OF PRACTICAL RESISTANCE-CAPACITY CONTROLLED OSCILLATORS

THE purpose of this article is to recapitulate some of the principles governing the operation of resistance-capacity oscillators and to describe some recent practical developments.

By P. W. WILLANS, M.A., M.I.E.E.

IT has been known for some twenty years that retroactively coupled valve circuits comprising only resistances and condensers can be made to generate oscillations.

The best-known device of this kind is, of course, the two-valve multivibrator of Abraham and Bloch, which generates oscillations of extremely irregular waveform. More recently, circuits have been described which generate or selectively amplify sinusoidal oscillations, and an article on this subject by Colebrook appeared in *The Wireless World* of February 8th, 1935, under the title of "Resistance-Capacity Tuning."

The reason why a multivibrator should work in the way it does has occasioned some theoretical difficulty. At first it was held that there must, so to speak, be a catch somewhere, and that the oscillations could only take place by virtue of the presence of residual inductance in the circuit. The analytical discussion of the multivibrator on this hypothesis was published by van der Pol in a very well-known paper (*Phil. Mag.*, Vol. 2, November, 1926).

In a later publication (*Zeitschrift für Hochfrequenztechnik*, XXIX, p. 114) van der Pol, dealing with an analogous circuit, has presented an alternative explanation, stated to be due in the first instance to Roosenstein, which does not appear to be generally appreciated. According to the views therein put forward, the shunt capacities in a circuit of the multivibrator type may play the same part as an inductance in explaining the generation of oscillations and, having regard to the dimensions of practical circuits, such capacities come into question before any stray inductance could exercise an appreciable effect.

The bearing of this explanation upon possible developments in resistance-capacity tuning apparatus seems to have been ignored, although the multivibrator itself was known to be capable of critical adjustment so as to generate sinusoidal oscillations. (*W.W.*, *loc. cit.*, also May 14th, 1937, article by Ledward). Until recently, the only practical proposals for this purpose have been along entirely different lines.

It will be convenient to deal with the subject in chronological order and to begin with a short description of some of these earlier devices.

In the article above referred to, Colebrook deals with a proposal, due to van der Mark and van der Pol, to generate sinusoidal oscillations by means of a retroactive arrangement comprising an odd number of amplifying stages with resistance-capacity couplings between the stages and between the first and last valve (see Fig. 1). A fuller description of the working of this apparatus is given in the original paper (*Physica*, Vol. 1, 1934, p.

437) and in British Patent Specification No. 395,596.

To appreciate how this device works we may consider the feed-back lead of the arrangement to be broken at the points X, X, and imagine that we introduce a sinusoidal voltage V_1 at the input of the amplifier and obtain at the output a voltage V_2 which for simplicity's sake we will assume also to be a sine wave.

If the condensers and resistances have fixed values, the same for each stage, the phase of V_2 in relation to V_1 will be governed by the frequency of oscillation.
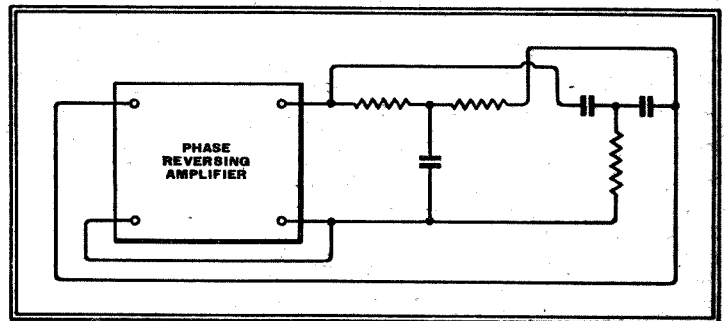

Fig. 2.—Coupling network with resistance-capacity alternators in parallel, due to H. H. Scott.

At very low frequencies the resistance-capacity coupling will advance the phase at each stage by nearly 90 deg., and there will, of course, be a phase-reversal at each stage due to the operation of the valve. The net result will be that the phase will be advanced nearly 90 deg. If progressively higher frequencies are chosen the phase-lead per stage will decrease and a value will be reached at which the total phase-lead becomes zero, and thereafter, for still higher frequencies, changes sign, becoming a phase-lag. The critical frequency is that for which the phase-angle is zero; if at this frequency we adjust the amplification so that $V_2 = V_1$ in magnitude as well as in phase, we may then take away the external source, join up the points X, X, and the amplifier "won't know the difference."

Negative Feed-back Action

The condition for oscillation in any retroactive system is thus that if we divide the retroactive "chain" at any point, a sinusoidal input voltage at this point of some frequency will generate "on the round trip" a voltage equal to and in phase with itself. In the case just considered, the frequency is that for which the phase-lead due to each coupling is exactly 60 deg. For higher frequencies the phase shift of the couplings tends to zero and the overall phase shift thus approximates to 180 deg. As a result of
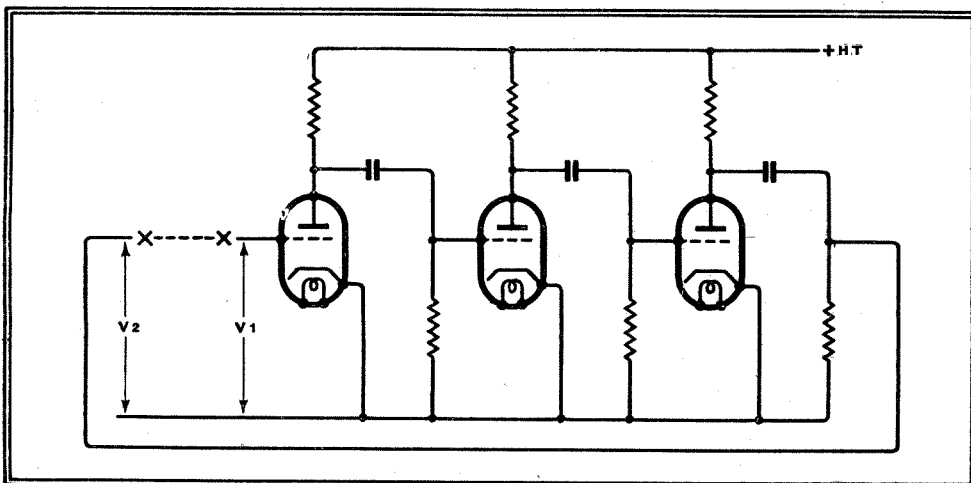

Fig. 1.—Basic resistance-capacity sine-wave oscillator circuit employing an odd number of stages.

Resistance-Capacity Tuning—
the strong negative feed-back action there is no tendency to instability at high frequencies even though the amplification per stage is high.

The undoubted usefulness of such circuits lies in their flexibility and ease of adjustment over a large range of frequencies, also more particularly to the readiness with which oscillations of very low frequency can be generated without the necessity for massive iron-cored inductances, often of dubious quality as regards constancy of value and linearity of wave-form. A further special characteris-
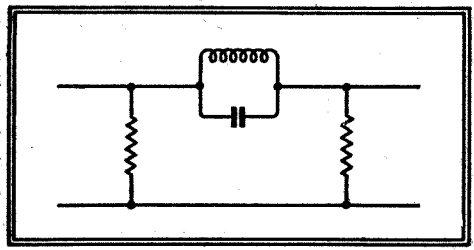

Fig. 3.—Equivalent circuit having same voltage attenuation as Fig. 2, though a different impedance characteristic.

tic of this particular circuit is the possibility of easily obtaining a three-phase supply on any desired frequency.

A further proposal, involving an arrangement giving negative feed-back at all but one frequency, is due to H. H. Scott (*P r o c. I.R.E.,* February, 1938). According to this arrangement a phase-reversing amplifier is retroactively coupled by a network consisting of two T attenuators connected in parallel (see Fig. 2).

It can be shown

Fig. 4.—Two-valve multivibrator circuit modified to give sine-wave output.
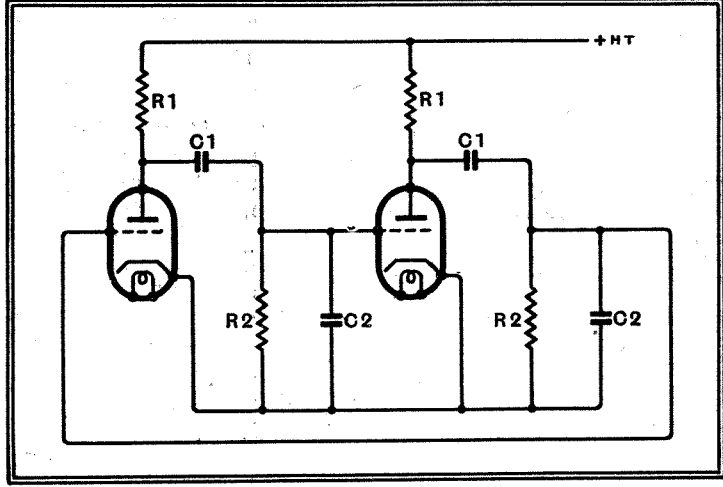
that such a network (which passes both very high and very low frequencies without attenuation or phase-shift) can be made to give infinite attenuation at a single frequency, so that the amplifier at that frequency has full gain and at other frequencies has a gain which is more or less drastically reduced by the operation of negative feed-back. The voltage attenuation characteristic of the network, subject to the values of the constituent resistances and condensers being correctly related, is the same as that of an equivalent π network, as shown in Fig. 3, although the impedance-characteristic is different. It will, of course, be appreciated that in this figure the inductance and capacity are taken to have zero resistance, thus giving an extinction at the frequency of resonance.

An arrangement according to Fig. 2 can

obviously be adapted to give selective amplification and is stated to have been employed as a harmonic analyser. By the addition of a device giving a measure of aperiodic positive feed-back it can be made to generate oscillations, and a circuit for this purpose is also given in the paper referred to.

With the object of simplifying apparatus of this kind, attention has recently been given to a class of circuit involving an even number of valves or a single valve having a negative slope. The approach to this subject may most conveniently be by way of the multivibrator in the light of Rossenstein's above-mentioned theory.

In Fig. 4 a conventional multivibrator circuit is shown, with the addition of condensers across the grid resistances to represent the valve capacities (assumed to be of small value compared with the coupling capacities). The operation of this circuit as a sine-wave generator may be roughly understood by considering the effect of the shunt capacity C2 (which gives an increasing phase lag with increasing frequency) as being balanced at the frequency of oscillation by that of the capacity C1 (which gives an increasing phase lead). As in the previous case, assuming the system set at the threshold of oscillation, a voltage of the correct fre-

quency applied to the grid of the first valve generates "on the round trip" a voltage equal to and in phase with itself.

An inspection of Fig. 4 indicates that one of the two RC networks is redundant and can be replaced by a coupling which
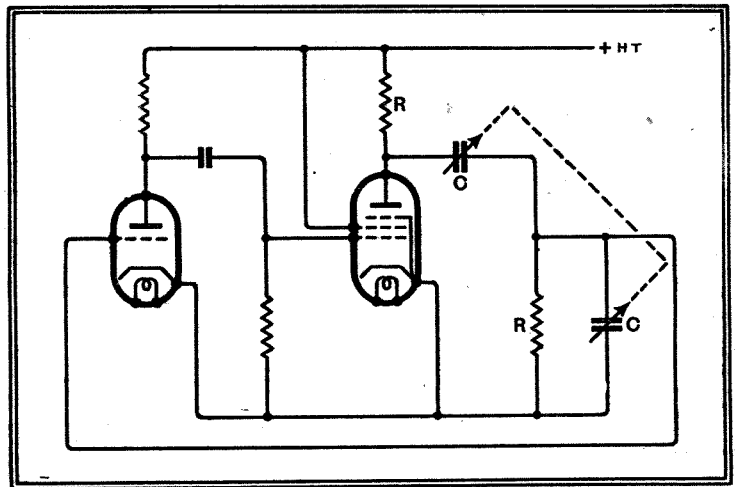

Fig. 5.—Simplified version of the circuit of Fig. 4 with control concentrated in a single coupling.

is made as free as possible from phase-shift. The circuit then takes the form of Fig. 5.

Here, in the first stage of amplification, a normal "aperiodic" coupling is employed. In the anode circuit of the second valve (assumed to be of high impedance, e.g., a pentode) is placed a resistance R coupled by a condenser C to a second equal resistance R shunted by a condenser of equal capacity C. The two condensers are now assumed to be of substantial value in comparison with stray capacities, e.g., they may be air condensers ganged together.

With this arrangement oscillations are generated at a frequency given by $2\pi fRC = 1$, and if the condensers C are simultaneously varied the frequency will vary in inverse ratio. The advantage of such an arrangement is that a very wide sweep of frequency can be obtained by operation of the ganged condenser, unlike the case of a tuned circuit where the frequency only varies as the inverse of the square root of the capacity.
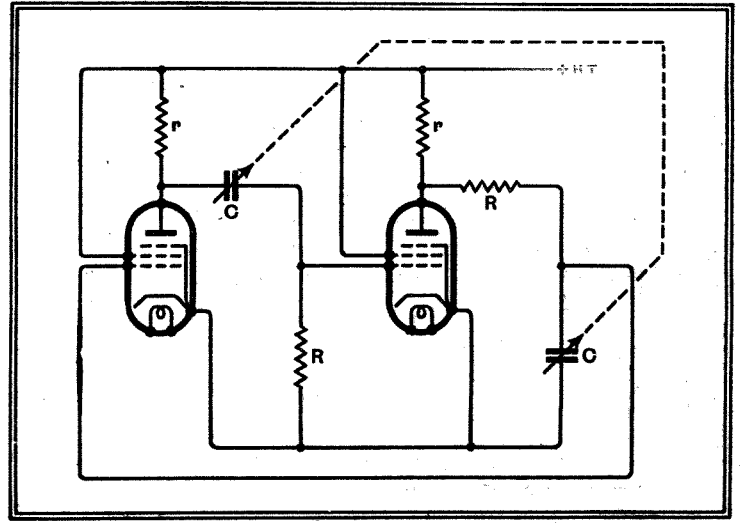

Fig. 6.—Resistance-capacity oscillator due to Dr. N. L. Yates-Fish.