RADIO and AUSTRALIAN ELECTRONICS

INCORPORATING AUSTRALASIAN RADIO WORLD

FEBRUARY, 1951 Registered at G.P.O., Sydney, for transmission by post as a periodical. VOL. 15, NO. 7 1'6

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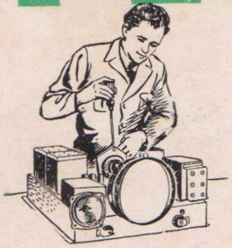

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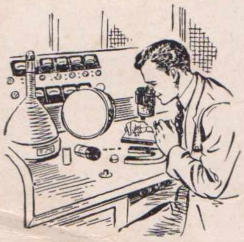

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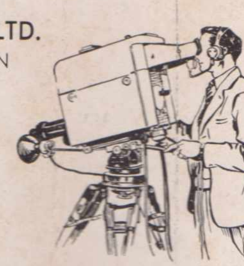

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AUSTRALASIAN RADIO WORLD

Vol. 15 FEBRUARY, 1951 No. 7

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Published by the Proprietors:

RADIO & ELECTRONICS (N.Z.) LTD.

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17 Bond Street, Sydney, N.S.W.

Telephones: BU 3879, BW 7746

Telegrams and Cables: "Cranlay," Sydney

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EDITORIAL

AUSTRALIA DAY—January 26th, 1951—officially ushered in the Jubilee of the Commonwealth of Australia, which was celebrated throughout the Continent by processions and pageants depicting the various changes that have taken place in our civil and commercial life during the period 1901 to 1951.

Amongst these marched the science of Radio and Electronics and today we have our Radio and Electrical Industry as one of the three largest secondary industries in the Commonwealth, producing hundreds of thousands of pounds worth of essential equipment for our modern way of life, and employing directly and indirectly thousands and thousands of skilled and semi-skilled workers.

We have viewed many and varied changes from the old spark transmitter and crystal set days to modern Radio as we know it, which has given mankind the marvels of Radar, untold numbers of electronic devices and last, but by no means least, TELEVISION.

Home recording on disc, wire, tape, etc., is also practised by many enthusiasts, and really excellent recordings can be made by the average person (without any technical knowledge whatsoever) due to the high standard reached by commercial manufacturers of these units.

Most of the old hands in the game, started their careers in the crystal set era, and your Editor can still recall his first **variable** condenser—which consisted of one aluminium "billy can" covered with waxed brown paper, sliding inside another one of slightly larger diameter. **Compare that crude device with the modern gang condenser of today . . . . such is progress!**

Television is with us to stay, in both black and white, and colour, and although it may be some time before T.V. is actually transmitted in Australia, we feel it our duty to assist those interested, by providing them with such practical data that will enable the enthusiast to understand "what it is all about."

Even in America, there are not enough skilled T.V. engineers or servicemen, so that it behoves us to assist in the training to provide skilled television personnel for the Industry—hence, our decision to proceed with the R. & E. Television Project.

One thing we must also face is the effect of disruptions to our Industry through strikes, blackouts, shortages of materials, go-slow methods, etc.

It is indeed heart-breaking to see one's plans knocked from pillar to post, through reasons beyond individual control, when we have the skill, equipment and enterprise, unsurpassed by anyone in the world, and an increasing population to absorb our products at reasonable cost.

Therefore, let "the powers that be" take another good look at the ridiculous 25% Sales Tax applied to Radio, which has been classified as a luxury.

Radio is **NOT** a luxury by todays standards, but is a **necessity** to our every day life, as through its medium, our physical, moral, mental and cultural well being is fostered. If it was good enough during war time to exempt certain trained service personnel to keep domestic receivers and the like working and allow the production of domestic receivers and parts, surely it is just as desirable in peace time to produce the requirements of the nation at a price commensurate with the living standards of the day.

Less industrial strife, plus greater production is the answer which would provide more revenue at the normal tax rate, through greater volume of sales, but apparently, this is beyond those responsible, and the easiest way out is to "slam on extra tax," and place our industry in the luxury category, which is altogether ridiculous.

If by virtue of the high Sales Tax, sales of radio receivers and parts to the public are made prohibitive purchases, it does not need much reasoning to see that certain manufacturers will close down, and skilled personnel will then drift into other industries.

Should this be so, what would be the position if we had to urgently gear up the radio industry for defence purposes?

Sales of component parts to "Hams," Home Constructors, Servicemen, etc., cannot be classed a luxury either, as building radio and electronic equipment at home, must provide technical training to the party concerned, which could be used to advantage in times of need. This was proved by the Signals Personnel of the Armed Forces, the majority of whom were recruited from the wide circle of "Hams," Radio Servicemen and enthusiasts during the last war.

This journal adds its voice to the official body representing the Radio Industry, and would like to record our disapproval of the Ministers' action, and commend a realistic attitude by reverting to the normal 8⅓% Sales Tax, and removing the classification of radio as a non-essential luxury.

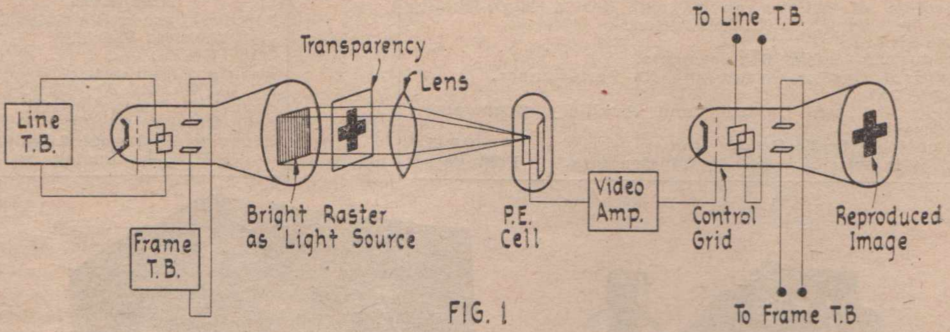
Our reason is, that we, amongst many others, consider **RADIO TO BE A PUBLIC NECESSITY.**

The "R. & E." Amateur Television Project for Home Construction

PART II

THE LINE AND FRAME TIME-BASE UNIT

In Part I of this series of articles the principle of the flying-spot scanning system was described in general terms, and the equipment units that would be needed in order to put the system into operation were outlined. This month's instalment describes some of the difficulties that we can expect to meet, how it is proposed to overcome them, and then describes the circuit of the line and frame time-bases that have already been developed for this purpose in our laboratory.



Diagrammatic representation of the scheme to be used, showing how one cathode ray tube, together with a transparency and a P.E. cell, produces a video signal which is reproduced on the "receiving" C.R.T.

SOME DIFFICULTIES THAT CAN BE EXPECTED

As readers will probably have realized before now, the principle of the arrangement for transmitting still transparencies is really quite simple. There are, however, certain things that will not be too easily overcome in practice, owing mostly to the fact that it is intended to use, as far as possible, standard parts. For instance, the performance of the whole system will depend to a large extent on the quality of the cathode ray tubes used. If the supply of gear were no difficulty, the proper way to tackle the job would be to use magnetically deflected tubes with white screens. In short, standard receiving tubes as used in TV sets. Unfortunately, these are as yet unavailable, and even if they were, they would probably be rather expensive for the amateur experimenter to purchase two of them easily. The alternative, of course, is to use ordinary oscilloscope tubes, with green screens and electrostatic deflection. These are certainly available at prices within the amateur experimenter's pocket. which is, perhaps the first essential. Unfortunately, however, the characteristics of the screen material are not all that could be desired for the purpose in hand. We do not refer to the geeen colour of the trace, which can be tolerated, especially if the resolution is good enough to give a high-definition picture. The trouble is due to the persistence characteristic. The various materials used to coat the screens of cathode ray tubes differ most markedly in their colour, and in their persistence. By the latter is meant the rate at which the light from the screen decays after the electron beam has passed on to another part of the screen. Ideally, of course, there should be no persistence at all, the light decreasing immediately to zero as soon as the stimulus, in the shape of the electron beam, has been removed. The white-screen materials used for proper TV tubes has a short persistence, and the light blue screens of tubes specially designed for observing high-speed waveforms that are not recurrent, have a shorter persistence still. In fact, of all the usual types of screen material, the one used in the common green tube has the longest persistence. What, then, is the effect if we use a long-persistence screen, and how, if at all, does this degrade the image?

Just how can easily be seen by anyone who has an oscilloscope. If the tube is adjusted to give a spot, undeflected by any time-base or other voltage applied to the deflecting plates, it is possible to move the spot reasonably fast by taking the shift control and rotating it quickly. When this is done, the persistence of the screen, together with the persistence of vision, makes the spot look rather like a comet with a "tail" rather than just a moving spot. As a result, if such a tube is used to produce moving images, there will be what is usually called a "trailing ghost" when the image moves. However, for still transparencies, the effect just mentioned will be absent, because the image does not move. It will thus be a matter for experiment to see whether the green-screen tubes will give satisfactory results. At this juncture, we would like to ask readers not to take to heart too much the so-called difficulties that we are describing. When we say "difficulties" we do not mean that they will prevent us from getting a picture at all. For experimental work of this kind we will be more than satisfied if we get a result even half as good as a standard TV picture, because we realize that the equipment we are working with is not really designed for the purpose for which we will use it. Even so, there are certain saving graces that lead us to believe that our efforts will be far from wasted. For example, those who read English radio periodicals will no doubt have been struck by the fact that certain firms regularly advertise TV kits for constructors' use that feature the well-known VCR97 as the receiving tube. If the results on the standard transmissions of the B.B.C. are not reasonably satisfactory even with these tubes, which are 6 in. ones with the ordinary green screen material, it is hardly likely that the kits would continue to find a sale.

Another difficulty of which the proof will, as it were, be in the eating, is that of obtaining a sufficiently high signal-to-noise ratio to get a satisfactory picture. Now this aspect of the problem depends on two things. First, the strength of the light source, and secondly, on the sensitivity of the P.E. cell used to pick up the video signal. As can readily be appreciated, the light source with which we have to deal is the spot of the transmitting cathode ray tube, and this is a very weak source indeed in the ordinary way. Nor is there very much we can do about making it stronger. The other factor is a most important one, and it appears that it may possibly be the limiting factor with which we will have to contend. However, time and laboratory work will tell, and we hope to have the full story at a later date. The trouble is that the photocells that it is possible to use are very insensitive. These are of the vacuum type; gas-filled cells, such as are used in talkie projectors are impracticable, because their frequency response is not nearly wide enough. Their response starts to fall off inside the audio frequency range, so that there is no chance at all of using them here, where they are asked to respond to frequencies of several megacycles per second. The vacuum phototube, on the other hand, has a frequency response that is limited almost solely by transit time, so that no difficulty need be expected on that score. The only trouble is, that their sensitivity is several times smaller than that of the gas phototubes which cannot be used. The current sensitivity of almost all vacuum cells is of the order of 20 microamps per lumen, which is itself not a very great quantity of light. The amount of light output from the C.R.T. spot is only a very very minute fraction of a lumen, so that when this varies in accordance with the light and shade of the scene being scanned, the variation in the output current of the cell can be expected to be only a very small fraction of a microampere.

In order to convert this current change into an output voltage, we do the obvious thing and connect the cell in series with a load resistor, so that the change of cell current through this resistor produces a voltage across it. This voltage is then applied to the grid of the first video amplifier tube, and if we have a very high-gain amplifier, it should be possible to obtain enough output voltage from the last amplifier stage to modulate the grid of the receiving cathode ray tube. There is only one snag to this, however, and it is that the original voltage to be amplified is so small as to be likely to be masked by the amplifier noise. In other words, the required amplifier gain is likely to be so high that valve noise, and thermal agitation noise arising in the load resistor of the photocell, may be of the same order of amplitude as the voltage we are trying to amplify. One obvious way out of this dilemma is to increase the size of the original voltage from the P.E. cell by increasing the intensity of the light source until the output voltage is much greater than these two kinds of noise. Another way is to produce out of the hat a photocell which has a much greater sensitivity, but little or no increase in noise output. Such a photocell is the electron-multiplier type of photocell. This tube has an ordinary vacuum type of photocell inside it, but in addition, it has a nine-stage secondary emission amplifier built into the same envelope. This type of amplifier has a much better signal-to-noise ratio than a conventional valve amplifier of equivalent gain, because it uses no resistors which can generate noise, the amplification arising purely through the action of the stream of electrons, which gets larger and larger as it passes through each secondary emission stage. It is this kind of tube, therefore, that is used in commercial film scanners, used in TV broadcast stations for transmitting film instead of direct camera scenes. Unfortunately, these **multiplier phototubes**, as they are called, are extremely expensive in the ordinary way—about £12 to £15 each—so that they, too, would appear to be completely ruled out on the score of expense. Luckily however, it appears that great numbers of them were used for special purposes during the war, with the result that both in Britain and America they are available from war surplus stocks at about 30s. each. The tubes we are referring to are the R.C.A. 931A. With the followers of this Project in mind, we are arranging for some importers to bring in some of these tubes so that they will be available for those who wish to build the gear we will be describing. However, before they arrive, we intend to see just to what extent it may be possible to use an ordinary vacuum photocell, together with a high-gain video amplifier.

In doing this, it is also intended to tackle the problem from the other end at the same time. It is always possible to increase the brilliance of the spot of a cathode ray tube by putting an increased E.H.T. voltage on the final anode. The VCR97s that we will use for our own experiments (since these are considerably better than 5BP1s) are rated to take a maximum voltage of 2000 volts. Now, the almost identical C.R.T.s that have been produced since the war under individual firm's type numbers are rated to take 5000 volts on the final anode, and 2500 on the first anode. It may be, therefore, that the VCR97s will quite well take the some voltages. It is highly probable that for Service purposes, they were rated rather lower than necessary, in view of the fact that they were carried in high-flying aircraft, where the reduced atmospheric pressure would impose lower voltage limits on the insulation in the bases of the tubes. Thus, it does not seem likely that in ordinary use, the VCR97 will not stand an anode voltage of 5000. It is also a common practice to over-volt some oscilloscope tubes in order to brighten the spot for observing high-speed traces. Thus, we should be able to get a much brighter light source by increasing the E.H.T. voltage, and it does not seem likely that the cathode ray tubes will come to any harm. It will not be necessary to increase the voltage on the receiving tube, which can be run under ordinary conditions.

From the above, it will be seen that there are plenty of things to think about if the project is to be fully successful. However, several aspects of the project present very little difficulty, and on the constructional side, the first piece of equipment to be tackled successfully has been the time-base unit.

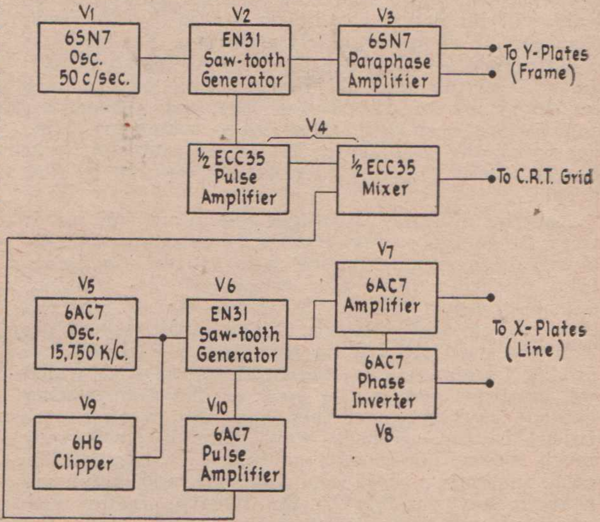


Fig. 2—Block diagram of the deflecting and blanking circuits shown in detail on Page 7.

THE TIME-BASE UNIT

The first piece of circuitry that has been developed to date is the time-base and deflection amplifier unit, whose circuit is printed here. The scheme of the unit can perhaps be better appreciated from the block diagram, Fig. 2. The job of the time-base and amplifier unit is to produce the raster on the face of the transmitting tube, and in the first instance it will also be used to deflect the receiving tube at the same time, as indicated on the schematic diagram, Fig. 1.

The unit subdivides itself readily into two main portions. These are the horizontal time-base and amplifier circuit, and the vertical time-base and amplifier circuit respectively. In addition, there are two extra valves whose job it is to provide a black-out voltage, which is applied to the C.R.T. control grid, in the case of the transmitting tube only. Both horizontal and vertical deflecting voltages are of the usual saw-tooth waveform, and while steps have been taken to make the flyback in each case as rapid as possible, it is not difficult to arrange that the flyback in each deflection will be invisible. This is a refinement in the present case, but one that will be found well worth-while. In standard television transmission it is not regarded as anything but a necessity, and is always done. In TV receivers it is not necessary to do anything about it, because the transmitted video signal performs the black-out function automatically when the receiver's time-bases are locked to the transmitted synch. pulses, as they must be for proper operation of the set.

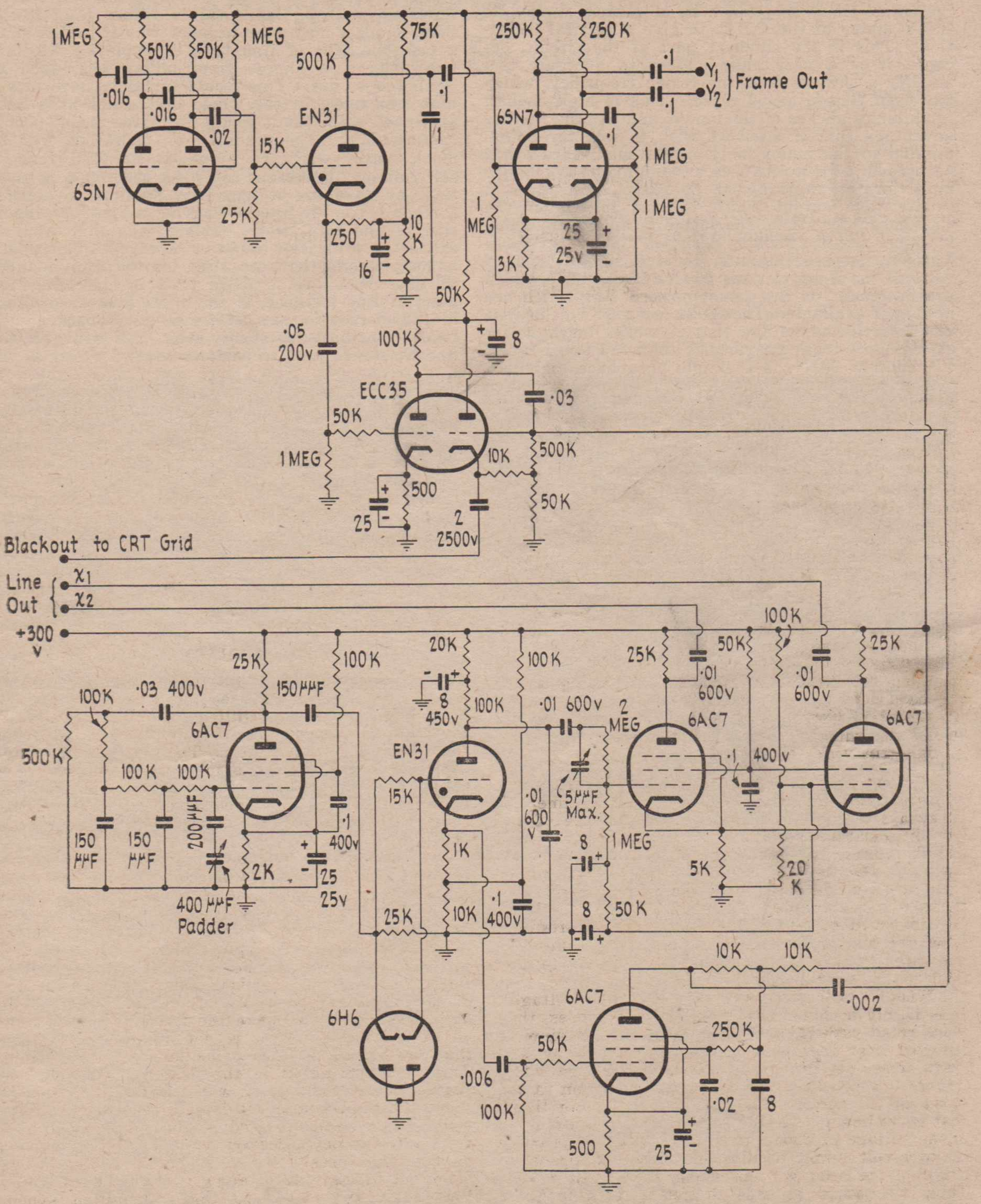


Fig. 3.—Complete circuit for the frame and line deflecting units, together with arrangements for blacking out, or blanking, the flyback of both time-bases.

On the block diagram, V1, V2, and V3 provide the frame time-base, which is, of course, applied to the Y plates of the C.R.T. to give a vertical deflection. This is the simplest part of the circuit, because it is a very easy matter to generate and amplify a saw-tooth at the frame frequency, which has been chosen as 50 c/sec. This is high enough to eliminate flicker of the image, and has the further advantage that if later we wish to lock the transmission to the mains, only simple modification will be needed. V1, a 6SN7, is a straightforward triode multivibrator, working at 50 c/sec., and gives a square-wave output which is used to trigger the time-base tube, V2. The latter is an EN31, which is a gas triode specially designed for use in oscilloscope time-base circuits. It is a similar sort of valve to the American gas triodes 884 and 885, which are designed for the same purpose, but which are no longer available. The EN31 has a 6.3 volt heater, and has the advantage that it works much better at high saw-tooth frequencies than the other tubes. V3, another 6SN7, is a simple paraphase amplifier, giving a push-pull output so that we can have balanced deflection on the Y plates. This is a slight extra complication compared with the ordinary single-ended deflection most commonly used with oscilloscopes, but in the case of television is well worth it, because balanced deflection improves the overall focus of the spot, and gives an equally well-focused spot all over the screen. Single-ended deflection on the other hand does not do this, and the use of the balanced type will result in a much improved picture. Readers can see from this that although we have set out to produce some simple gear, we are not sacrificing performance to simplicity. We do not mean by "simple that the gear will contain only a very few valves. What we do mean is that the circuits used will be easy to get going, and simple to operate, and this will sometimes mean using more valves rather than fewer. Some readers may wish to know why it is that since a gas-tube type of time-base is employed, we have not made it a simple free-running one, such as oscilloscopes use. This would certainly have meant that two tubes in the whole unit could have been dispensed with, but it would also have meant poorer performance. The stability of operation will be much better with the arrangement used than if self-running time-bases had been used, and, in addition, by so doing it has been possible to achieve a much better fly-back, occupying a smaller proportion of the total time. This means that what is called the **utilization ratio** is improved. This is the name given to the percentage of the total number of lines that are actually **used** in producing the image. For instance, if the total number of lines in the picture is, say, 300, and the flyback of the frame time-base lasts very long, this will give the line time-base time to perform several cycles at the line frequency. Now, since the frame flyback is blacked out, and is not part of the picture proper, those line scans which occur during the frame flyback cannot be used in producing the picture, and the utilization ratio is low. It is thus an advantage to have a frame flyback of as short duration as possible. Similarly, if the line flyback is not short compared with the time of one whole line cycle, then a goodly proportion of the time is wasted during the retrace of the line time-base, because during this period, too, the spot cannot be used for producing the picture.

Transferring our attention now to the line time-base generator and amplifier circuit, we find that considerably more valves have been used than in the

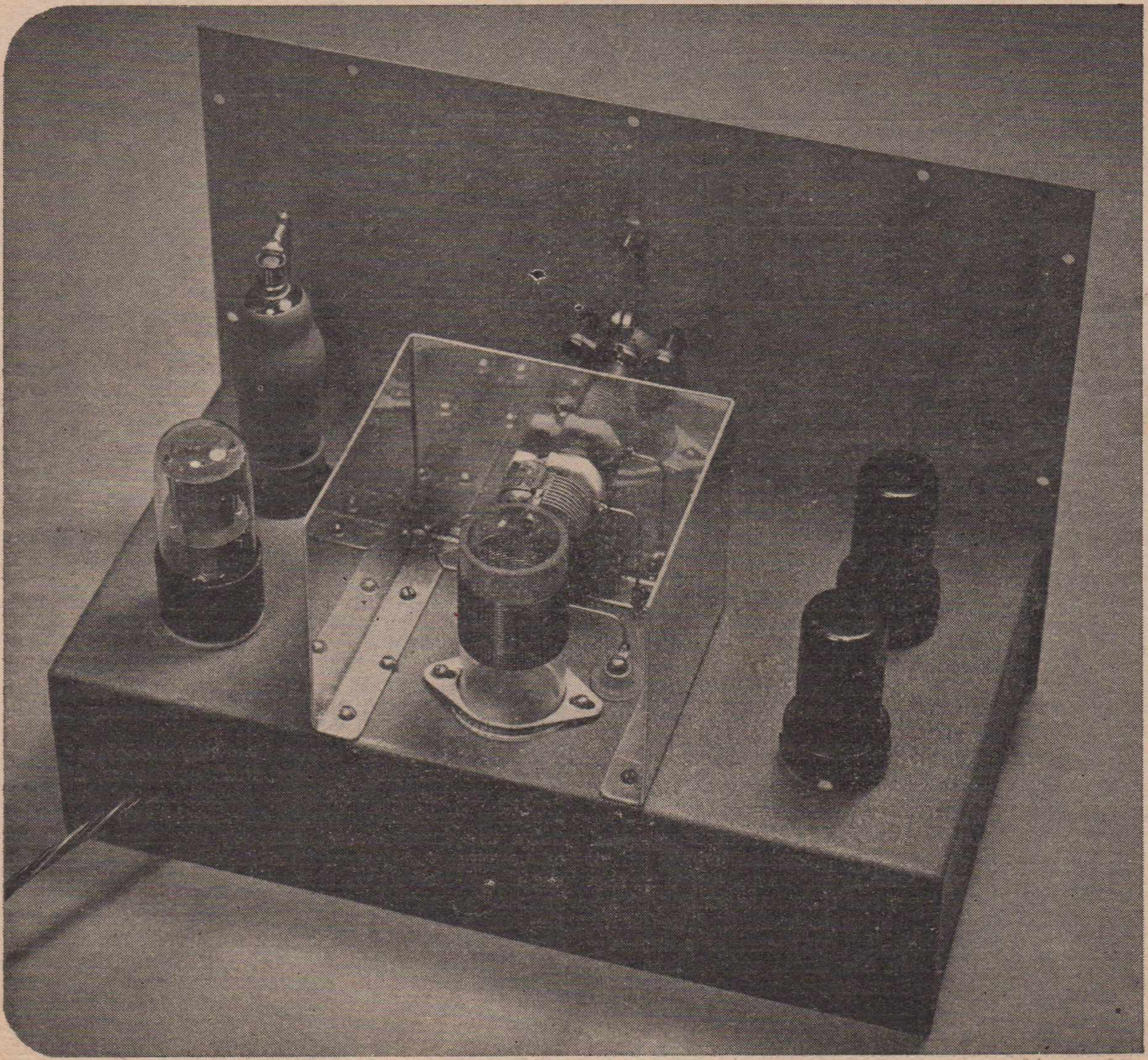
Cont. on Page 21

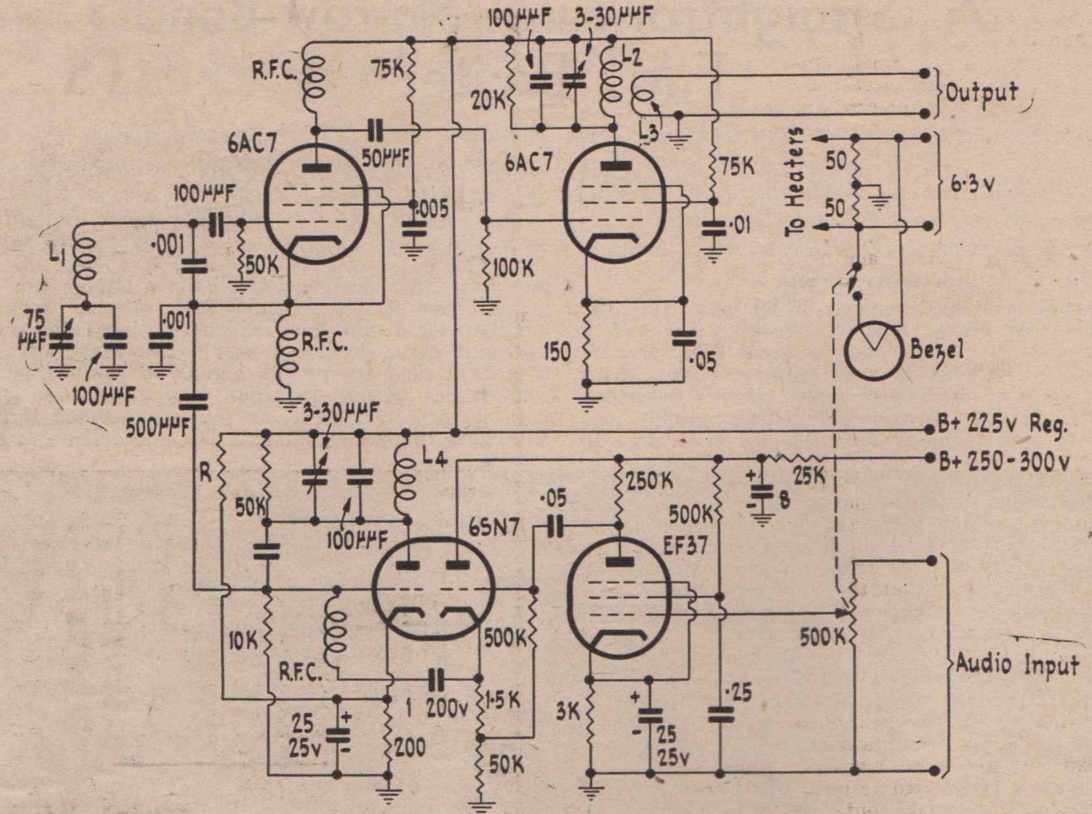
A Straightforward Narrow-Band F.M. Exciter

One of the reasons why so few amateurs seem to indulge in N.B.F.M. transmission is that not very many suitable circuits exist for producing a satisfactory frequency-modulated signal. Another is the difficulty of receiving this kind of transmission with standard receivers. This month we present a narrow-band F.M. exciter which is easy to make work, requires only four tubes, including the speech amplifier, and which is stable enough to be used as an ordinary V.F.O. for C.W. or A.M.

INTRODUCTION

Although overseas journals which cater for the amateur transmitter have of recent years had a good deal to say about narrow band F.M., and its advantages in these days of crowded bands, there do not seem to have been many circuits described which enable the amateur to change quickly and easily to this form of modulation. With this in mind, we have designed and built a simple exciter which gives a narrow-band F.M. output of high quality with a minimum of constructional difficulty. The unit to be described uses four valves, and all that is needed to put its signal on the air is to connect its output to what may have been the crystal oscillator stage, or the low-powered buffer following the V.F.O., plug in the microphone to the





jack provided, and talk! By the simple expedient of turning off the gain control to the speech amplifier, the unit may be used as a very stable V.F.O., with bandspread over the 80 metre band. If anyone is contemplating building a V.F.O., he could do worse than use the present circuit, for its frequency stability is that of the now well-known Clapp oscillator, and for the addition of a modulator and one audio amplifier stage, it is capable of giving substantially distortionless F.M. over a wide enough band for use on 80 metres. For use on the higher bands, the extent of the F.M. must, of course, be limited, since each frequency multiplication multiplies the deviation by a similar amount, but in this case all that is necessary is to turn down the audio gain control to a pre-determined lower setting, which gives correspondingly less F.M. at the fundamental frequency.

THE GENERAL ARRANGEMENT

In the top left-hand corner of the circuit we have a 6AC7, which is used as the modulated oscillator. This feeds its output to a second 6AC7, which is a broad-banded buffer, and has link coupling to the output terminals. Then we have an EF37, as a high-gain audio amplifier. It can be regarded as the microphone preamplifier, but it is hardly that, since no further A.F. amplification is needed! The EF37 feeds one-half of a 6SN7-GT, connected as a cathode follower, and this feeds the audio signal into the grid of the Miller type reactance modulator, which is connected to the oscillator circuit and produces the frequency modulation. This is perhaps the simplest type of reactance modulator, and has no vices whatever. It is simple to tune up and to get going, and can be expected to be as trouble-free as the rest of the circuit.

THE OSCILLATOR CIRCUIT

The Clapp oscillator circuit, so called, is by now well enough known to need little description here. It is eminently suited to the production of an F.M. signal, since it is inherently exceedingly stable, which is a first requisite of an F.M. oscillator. This may sound a contradiction in terms, but it really is not, because apart from the intentional frequency shifts, giving the modulation, the frequency should be as stable as we can make it. Not only is the Clapp circuit inherently stable, in its own right, but it also has the possibility of connecting the modulator to it in such a way as to cause the least possible disturbance to the frequency stability.

This is effected by connecting the modulator, not, as in the ordinary type of F.M. oscillator, directly across the tuned circuit, but across one of the large coupling condensers which effectively tap the valve down the tuned circuit, thereby reducing the effect of varying valve capacities to a bare minimum. In the Clapp circuit, which is sometimes wrongly called "series tuned," the valve is coupled very lightly to the tuned circuit, and at points of very low impedance, so that if the reactance modulator is connected across cathode and ground, as here, the same advantages as the circuit possesses as an ordinary oscillator accrue for the F.M. modification, too.

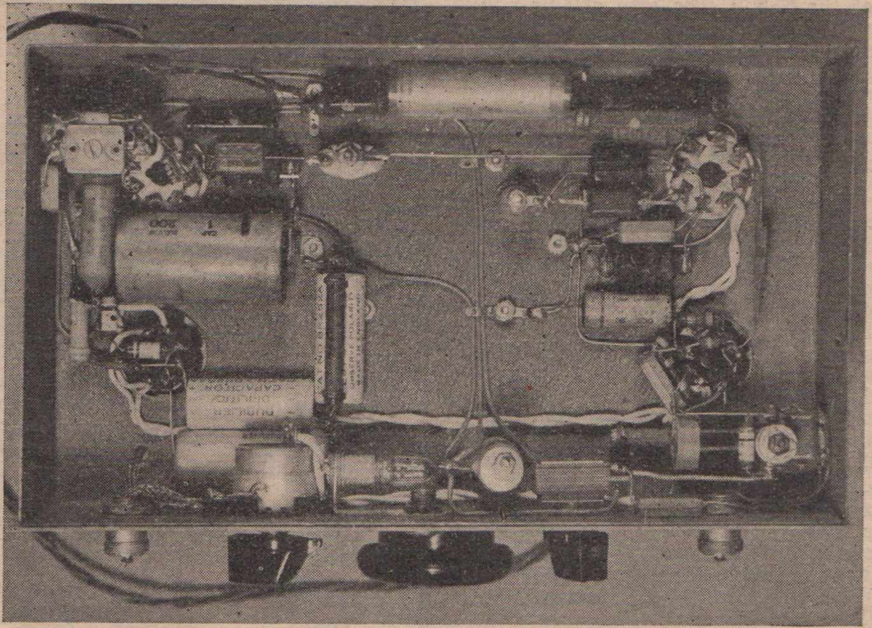
The reactance modulator circuit is essentially a simple one. In the circuit diagram, it consists of the left-hand half of the 6SN-7. The grid of this valve is capacity coupled to the cathode of the oscillator, and so receives a small input voltage from this point. In the plate circuit there is a circuit tuned to the oscillator frequency, and quite heavily damped by a 50k. resistor shunted across it. The modulator thus acts as an amplifier at the frequency of the oscillator. It would in theory have been possible to use a plain resistor as the plate load for this tube, but in practice this would not have worked so well, because the action of the modulator depends on the tube having some amplification at the radio frequency. It is well known that a triode resistance-coupled amplifier has little or no gain left at frequencies as high as 3.5 mc/sec., and so it is necessary to use the tuned circuit as the plate load impedance. It might be thought that this arrangement would oscillate, and so it would if the grid circuit were a high-impedance one, but because the grid is connected to a point of such low impedance, the feedback through the grid-plate capacity is so small that oscillation cannot occur.

Now when a triode has a resistive load in the plate circuit, and is amplifying, the input capacity is much higher than simply the sum of the grid-plate capacity and the grid-cathode capacity. In fact, it is much greater than this, and depends in a simple way on the amplification. The simple formula which gives the actual input capacity is:—

$$\mathrm{Cin}=\mathrm{Cg{-}c}+(G+1)\,\mathrm{Cg{-}p},$$

where Cin is the effective input capacity,
Cg—c is the grid-cathode capacity,
Cg—p is the grid-plate capacity, and
G is the amplification.

Thus, in an audio amplifier stage using, say, a 6J5 with a 100k. load resistor and having a gain of 14 times, Cin works out, according to the above formula, to 54.5 uuf. whereas the grid-cathode capacity is only 3.4 uuf. Since the effective grid input capacity depends on the gain of the circuit and not just on the valve capacities themselves, this gives a clue as to how this Miller effect, as it is called after its discoverer, can be put to use in a frequency modulator. If we make the amplification occur at the radio frequency of the oscillator, and vary the amplification by means of an audio signal on the grid, then the input capacity will vary too, and can be used as part of the oscillator's tuned circuit, in which case it will cause an electronic variation of the tuning capacity when the audio signal is fed in, giving the frequency modulation we want. The Miller effect frequency modulator is not often used these days because other circuits can give a greater linear frequency change, and so, wider frequency deviation. In the case of narrow-band F.M., however, this narrow linear sweep does not matter very much, because we are only interested in a narrow deviation, and so can make use of the present simple circuit. The modulator is given fixed bias by means of a bleed from the H.T. line, and this bias can be adjusted to the right value to give the most linear frequency sweep. The value of the resistor R may vary somewhat with the tube used, and a method of finding the right value for it in any particular instance will be given later. The modulator tube has a grid leak of only 10k., since a low value was found to give the best linearity of frequency sweep. This means that the audio amplifier looks into an impedance of only 10,000 ohms, which is too low to enable a resistance-coupled stage to be fed in directly. Two ways of overcoming this are possible. The first, and perhaps most



obvious method is to use a transformer in the plate circuit of the audio amplifier valve, but this is not the simplest or least expensive solution, for the following reasons. If a transformer is used, it will be necessary to feed it from either a small triode, such as a 6J5, or from a small power pentode, because it is not possible to transformer couple a voltage amplifier pentode unless a very special transformer were available. In any case, such transformers do not exist as stock lines, so that if a small triode were used with an output transformer having a ratio of about 2:1 step down, as would be necessary for correct matching, it would be essential to have a further voltage amplifier ahead of it. This would entail two valves and the transformer. But by utilizing the alternative scheme, illustrated here, the transformer is eliminated, and no further valves are used. The modulator is made one half of a 6SN7, leaving the other half free for use. This we make a cathode follower, which has a voltage gain of approximately 0.95, and can also feed the low-impedance grid circuit quite satisfactorily. Since the cathode follower virtually introduces no loss, and in addition to its low output impedance has a very high input impedance, we can use a high-gain pentode audio amplifier stage ahead of it. This stage will work under even more favourable conditions than usual, and will give somewhat higher voltage gain than is indicated in the resistance-coupled amplifier tables, because instead of working into a grid leak of about 500k., it is feeding an impedance of approximately 20 megohms. It is thus possible to get away with only one amplifier stage, excited straight from a low-level microphone. For example, in testing out the unit in the laboratory, a miniature crystal hearing-aid microphone was used with complete success. The audio circuit will thus have ample gain for almost any microphone that the amateur is likely to use. In any case, if a less sensitive mike is to be used, it will be a simple matter to add a low-gain triode amplifier stage as a pre-amplifier, and there will then be ten to 14 times as much gain as with the present set-up.

USE OF A BUFFER

It is always desirable to use a low-powered buffer stage between a V.F.O. and the transmitter proper, because however stable the oscillator, it is essential to reduce variable loading effects to a minimum. By the latter is meant that when the following stage is liable to be altered, as it probably will be when band changing, from a straight amplifier to a doubler, the loading on the oscillator will be different under the two sets of conditions, and could possibly have an effect on the oscillator frequency. The use of a low-powered buffer after the oscillator, therefore, has two desirable effects. First, it steps up the power output slightly. This is very necessary, especially with the Clapp oscillator circuit, because this oscillates very weakly, and produces very small power output. Secondly, the loading on the oscillator is rendered constant at all times, irrespective of what the second stage after the oscillator is called upon to do. Here, we have indicated a tuned buffer, with a resistance-loaded plate circuit to broaden the response, and make adjustment to the tuning less necessary as one tunes over the band with the oscillator. However, if the output of the V.F.O. is to be fed into what was the crystal oscillator valve, used for the purpose as an extra low-powered buffer, it will probably be possible to get enough drive for this tube without tuning the second 6AC7 at all. If this is contemplated, it is suggested that a load resistor of approximately 5000 ohms be used instead of the tuned circuit. In this case, it will be necessary to have the unit close to the input stage of the transmitter, so that capacity coupling can be used from the buffer to the first valve in the transmitter. With the present set-up, the oscillator unit can be at any desired distance from the main rack, and link coupling used. This will usually be an advantage, since it will allow the frequency to be altered slightly without leaving the

operating position, and also will enable the A.F. gain control and the microphone input to be right at the operating table. If it is found that the output of the unit falls off too much to enable the whole band to be covered without re-tuning L2, it will be in order to decrease the value of the 20k. shunt resistor. This will reduce the output somewhat, but this will probably not matter at all.

CONSTRUCTION

The accompanying picture shows the upper chassis construction of the prototype constructed in our laboratory. This chassis is 10¾ in. x 6 in. x 2½ in. deep. The layout is so simple that no chassis drawing has been given. A piece of 18-gauge sheet aluminium is bent up to form the mount for the tuning condenser and the baffle-shield round the coil L1, which is mounted above the chassis, by a simple but ingenious method which gives great rigidity. The total length of the shield partition is eleven inches, the part parallel with the panel being four inches long, and the side pieces 3½ in. each. A half-inch flange is bent up for mounting, and when the whole is bolted to the chassis it makes a very rigid structure. The midget tuning condenser is mounted by a single ⅜ in. hole in the middle of the back portion of the shield, and the ends of the side pieces are placed flush with the back edge of the chassis. This leaves approximately 2½ in. between the panel and the shield, and this is plenty for installing a flexible coupler and the "works" of a slow-motion dial. On the right in the photograph are the two 6AC7s, with the oscillator valve nearest the back of the chassis. The other is, of course, the buffer. Immediately in front of this tube, on the front panel, is a connector from which the output is taken. The connector is of the Amphenol single-conductor type, as used for microphone inputs, and in a corresponding position on the other side of the chassis is another of the same kind, for the microphone input. On the left in the photograph are the remaining two tubes.

In the underneath photograph can be seen the lay-out for the rest of the wiring. Here, the oscillator and buffer are on the right, with the front of the chassis at the bottom of the photograph. Near the oscillator socket is a feed-through insulator, which takes the connection from the lower end of the coil (which is the grid end) through from the top down to the grid pin on the oscillator socket The coupling condenser of 100 uuf. can be seen going from the feed-through to pin No. 4 on the oscillator socket. A point to note about the wiring of the oscillator circuit is that one of the mounting screws for the shield partition is used as a common earth point for the oscillator tube. This can be seen immediately in front of the feed-through insulator, and from it a wire is run straight to the shell pin on the socket. On top of the chassis, this same screw is used as an earth point for the tuning condenser. Although this is mounted on the metal partition, this is not relied upon for an R.F. earth, and instead, a wire is taken from the rotor's wiping contact down to a solder lug under the screw head. It is attention to small details like this that can make all the difference to the operation of R.F. equipment, for doing the earthing properly in this way, and not relying on the chassis for earthing ensures that as little R.F. current as possible flows through the chassis, and eliminates the cause of numerous somewhat "foxing" faults.

In the right-hand front corner can be seen the output circuit for the buffer stage, while in the

left-hand back corner, as far away from it as possible, is the tuned circuit for the modulator plate.

Near the electrolytic condenser that can be seen in the middle of the back of the chassis can be seen a stand-off insulator. From this insulator a heavy bare wire goes off to the right to the cathode pin on the oscillator socket. Then on the other side, the 500 uuf. coupling condenser can be seen, going to the grid of the modulator valve. The stand-off is there merely as a tie-point, which will make the rather long connection between the two valves a strong and rigid one. Since this lead is part of the oscillator circuit it is essential that it be firm, otherwise handling of the controls, or the unit itself, may cause undesired frequency shifts.

In front of the chassis, mounted on the panel, can be seen the connectors for the output and the audio input, the audio gain control with switch, and on the other side, the stand-by switch. This latter has not been shown on the circuit diagram, but is merely connected in the 225v. regulated supply lead.

If the unit is to be used as a V.F.O. without N.F.M., the best way to do this is merely to turn off the audio input control. This leaves the modulator and audio amplifier running, which is desirable. for if the modulator were turned off there would be a slight shift in the frequency of the oscillator, and the calibration would be altered. It is for this reason that the bezel lamp and switch have been incorporated. They show that the volume control is turned right off, and that unintentional modulation cannot occur when the lamp is off.

COIL DATA

The oscillator coil, L2, consists of 24 turns of 28-gauge enamelled wire, double-spaced on a 1¼ in. diameter former. The latter started life as a plug-in former, made of polystyrene, and of Australian manufacture. It was modified by cutting off the end with the valve pins, and fitting two solder lugs into the former itself. These lugs are of the type that end in a tubular rivet, and are pressed into an ⅛ in. hole in the former. However, before this is done, the mounting ring must be made. This is made from the mounting ring belonging to an Amphenol type valve socket, simply by filing it out until it will slip over the 1¼ in. former. The latter has a rim round what was the top, and this rim sits on the chassis, and is clamped by the mounting ring. The latter is attached to the chassis by means of two bolts through the existing mounting slots. Do not forget to make the mounting ring, and slip it over the former **before** the solder lugs are fitted.

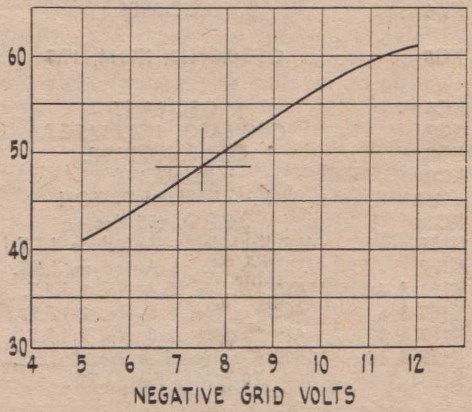
The amplifier coil, L2, is made by winding 30 turns of 28-gauge enamelled wire on a ¾ in. former, close wound. The coupling loop, L3, consists of three or four turns of the same wire about ⅛ in. from the H.T. end of the other winding.

The modulator coil, L4, can be of the same dimensions and number of turns as the amplifier plate coil. Alternatively, both these coils can be made from existing commercial coils. The one to use is one intended as the oscillator coil for the medium-wave range of an all-wave receiver.

TESTING FOR FREQUENCY DEVIATION AND LINEARITY

After a circuit like this has been built, it is desirable, though not essential, to carry out tests in order to make sure that the frequency deviation is great enough, and that over the required frequency swing, the frequency deviation is a linear function of the audio input voltage. In order to do this, it is necessary to have an accurate means of measuring the frequency, and not every builder will have this. However, those who cannot perform the tests will not need to worry. The proof of the pudding is in the eating, and if the circuit is well-built, and uses the recommended circuit values, there is very little that can go wrong with it. However, for those who have the facilities, it is interesting and instructive to test the modulator fully, and so we will describe the process here. The gear needed is as follows: (1) An accurate beat frequency meter, or a direct-reading audio frequency meter; (2) a battery of about 18 volts; (3) a voltmeter (1000 ohms per volt) and a 10 or 20k. potentiometer. The procedure is then as follows:—

(1) The 200-ohm cathode resistor of the modulator tube is short-circuited to ground.
(2) The grid R.F. choke is disconnected from the 1uf. coupling condenser.
(3) The battery is connected across the potentiometer, and the positive terminal is earthed to the chassis.
(4) The voltmeter is connected from the moving arm of the potentiometer to earth, and the moving arm is connected to the now free input end of the R.F. choke.



Curve showing the frequency-shift characteristic of the unit. The vertical scale is in arbitrary units representing frequency.

It should now be fairly obvious what we are going to do. The scheme is to apply known D.C. voltages to the grid of the modulator, and for each voltage, measure the frequency. Then, when a number of readings have been taken, a curve can be plotted showing frequency against D.C. grid voltage. The curve will then show what part of the deviation characteristic is linear, and therefore the correct spot to bias the modulator, and also how much linear frequency sweep can be had from the circuit, and how much peak-to-peak audio voltage is needed for a given amount of deviation. (In this country, the maximum allowable deviation for N.B.F.M. according to the regulations, is plus and minus 3 kc/sec.).

Thus, with the curve plotted in this way, we can tell everything we may want to know about the performance of the unit.

(Continued on Page 28)

A Direct-Reading Meter for Measuring Audio Frequencies

The direct-reading audio frequency meter is not a new thing, satisfactory instruments of this type having been designed several years ago. The present circuit is an improvement on one developed in Australia in 1944, but the principle of operation is one with important applications in other directions. In its own right, too, the meter is an exceedingly useful one, and can be built successfully by anyone without the aid of elaborate instruments.

INTRODUCTION

There are many purposes to which an audio frequency meter can be applied, and to any serious worker in the audio field it can be a very useful device. There are perhaps more uses for it, however, where radio frequencies are being dealt with, and anyone who has occasion to measure frequency at all often can find it a great time saver. Now there are many reasons for wanting to know radio frequencies with some accuracy, and there are reasons, too, for wanting to know small frequency differences as well. In all of these cases, the direct-reading audio frequency meter can be used, and will cut down the time taken to do the same things by more conventional means.

That this is true, will be readily appreciated by anyone who has had to do much audio frequency measurement by means of oscilloscope patterns. This method undoubtedly gives the answer, and the right one, if the operator is careful, but it is a time-consuming process and leaves quite a large margin for human error. The direct-reading meter, on the other hand, finds it difficult to give a wrong answer, and is exceedingly quick to use. As against these advantages, though, one has to be content with an accuracy of approximately two per cent., whereas the oscillographic method has a potential accuracy limited only by the time spent on taking an observation.

A further advantage of the direct meter, and one not lightly to be discarded, is that it is completely self-contained. The oscillographic method on the other hand, requires quite large quantities of auxiliary equipment, which is costly as well as slow to work. For all these reasons, therefore, the direct-reading meter is infinitely preferable to other methods, except in the few cases where an accuracy of two per cent. is not good enough. Let us take some examples of the type of thing that can be done with it.

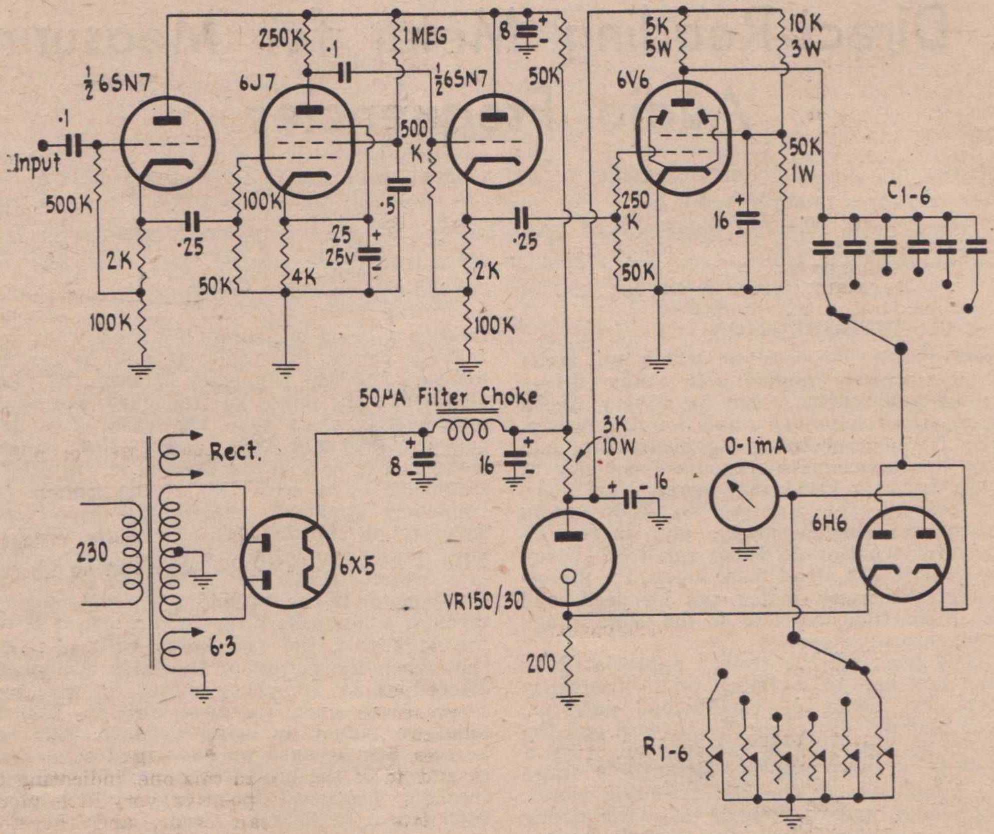
USES OF THE METER

Let us take first of all the case of straight-out measurement of radio frequencies. At the outset, we should make it plain that in taking a reading with the instrument we are about to describe, all that we have to do is to apply the audio voltage whose frequency we wish to know to the input terminal, turn the range switch to the position that gives a reading within the range of the meter, and read the frequency from the scale, which has the advantage of being a linear one.

Suppose then, that we are measuring a radio frequency by means of a precision frequency meter which provides crystal-controlled check-points every 10 kc/sec. By the ordinary methods, it is possible to say which 10 kc/sec. point is closest to the frequency being measured, but if we want an answer that is closer than this, it will be necessary to measure the beat frequency between the check point signal and the unknown frequency. For the sake of argument, let us take the case of a frequency between 3820 and 3830 kc/sec. Now if the actual frequency is, say, 3822.4 kc/sec., it will produce low-frequency beats with two of the signals from the frequency standard, namely, 2.4 kc/sec. with the 3820 signal, and 7.6 kc/sec. with the 3830 one, and both these frequencies will appear in the output of a detector which will be used to produce the beat frequencies. If the output of this detector is passed through a low-pass filter cutting off at 5000 c/sec., the higher of the two beats will be rejected, so that when the output of the filter is applied to the direct-reading frequency meter, it will read 2400 c/sec. Now since we have already identified the unknown signal as being between 3820 and 3830 kc/sec., and because we have used a low-pass filter to get rid of the high-frequency beat, we now know that the measured frequency is 3820 kc/sec plus 2400 c/sec., or 3822.4 kc/sec.

In order to see what effect the accuracy of the A.F. measurement has on the overall accuracy of the R.F. measurement, we can calculate the accuracy of the latter. The secondary standard gives the frequency to within plus or minus 5 kc/sec. At the R.F. of 3822.4 kc/sec., this represents an accuracy of 0.131 per cent. Now, if we measure the A.F. beat frequency to an accuracy of 2 per cent., we have an overall accuracy of 48 c/sec., which is only 0.0012 per cent. of the radio frequency. Thus, by using the A.F. meter, we have increased the R.F. measurement accuracy from 0.13 per cent. to 0.0012 per cent.—just over a hundredfold.

Another use for the frequency meter is in testing F.M. equipment. For instance, suppose one has developed a circuit for giving narrow-band F.M. signals, which are allowed on certain amateur transmitting bands. When this is done, it is almost essential to test the unit for linearity of modulation, so that the limits for distortionless operation can be found. In the case of amateur N.B.F.M., we are limited to a frequency swing of plus and minus 3 kc/sec. Thus, our imaginary exciter would need to give linear modulation to wider limits than this so that we can be sure that under the output will be distortionless. Also, we need to know what gain setting will give the maximum allowable frequency sweep of 3 kc/sec. on either side of the centre frequency. For doing tests like this, the frequency meter is invaluable, because all one has to do to measure the frequency deviation for a given D.C. control voltage on the reactance tube, is to zero-beat the oscillator with a fixed frequency oscillator,



Circuit of the frequency meter. The shunts, R1—6 can be wire-wound potentiometers of 1000 ohms, while the condensers can be chosen to give the required full-scale ranges. Suggested values, with their ranges are:—

C = 0.08 uf.	0-100 c/sec.	C = 0.0027 uf.	0-3000 c/sec.
C = 0.027 uf.	0-300 c/sec.	C = 0.0008 uf.	0-10,000 c/sec.
C = 0.008 uf.	0-1000 c/sec.	C = 266 uuf	0-30,000 c/sec.

in the absence of any control voltage, and then, with the frequency meter connected to the output of a detector, apply the D.C. control voltage. The meter then reads the audio beat frequency directly, and this is a direct reading of the number of cycles the modulated oscillator has shifted. In order to plot the performance curve of the modulator, all that has to be done is to take a number of readings of the frequency shift for a variety of D.C. control voltages. The graph is then plotted of frequency versus control voltage. Where this curve is a straight line, the modulation is linear and distortionless, so that to fix the right operating conditions for the reactance modulator, it is only necessary to find what D.C. grid voltage corresponds to the middle of the straight portion of the curve, and this voltage is the required bias for the modulator. Then, this having been fixed, the curve tells us the maximum grid swing that can be put on the modulator while still retaining linear modulation. If this is wider than the maximum allowable frequency swing, then all is well. It is also possible to read from the curve the peak-to-peak A.F. input voltage required to give any desired deviation. This in turn enables the amount of audio gain needed to be estimated, since it will already be known what output voltage can be expected from the microphone it is intended to use.

These are only two examples of the usefulness of the audio frequency meter, but will serve to show what sort of thing can be done with its aid. Another useful purpose to which it can be put is the dajusting of a variable oscillator to known small frequency differences from a particular value, as, for instance, when one wishes to take selectivity curves, particularly on a very selective I.F. amplifier, such as one with a crystal filter. To do this, is very difficult with an ordinary signal generator, if not impossible, since the dial cannot be read to within a few thousand cycles, let alone a few hundred. With the aid of a frequency meter, however, and a detector and fixed oscillator, it is quite easy. The fixed oscillator is set to the desired frequency by zero-beating with the signal generator. Then, to take a reading at, say, 1000 c/sec. off resonance, one oscillator or the other (it does not matter which) is detuned until the A.F. frequency meter, attached to the output of the detector, reads an A.F. beat frequency of 1000 c/sec. In this way, very close adjustments of the frequency of an R.F. oscillator can easily be made.

CIRCUIT AND PRINCIPLE OF THE FREQUENCY METER

Having described some of the things that can be done with such a meter, let us go on to examine the principles underlying its operation. For the moment, we will dispose of the first three stages by saying simply that they are A.F. amplifiers, or rather two cathode followers with an amplifier stage between them. The reason for this particular set-up will be described later. Anyway, the 6J7 takes the audio signal and amplifies it, at fixed gain, until in its plate circuit there is an audio voltage of considerable magnitude—about 100 volts peak. The waveform will most likely be somewhat distorted, but we need not worry about this, because in the next stage we are about to distort it even more, and on purpose, too! Now the 6V6 is likewise a resistance-capacity coupled amplifier stage, and as can be seen by a glance at the diagram, is run at zero basis. Ordinarily, the 6V6, when used as an output valve, has to be biased to about—18 volts, and for distortionless output, the input signal is kept to a peak voltage a little smaller than this, or less, when full output power is not wanted. Here, however, the output from the driving stage is of the order of 100 volts peak, as mentioned above. As a result, the 6V6 is driven to cut-off and beyond for a large portion of the negative-going half-cycle, and during the positive half-cycle, is driven into grid current. The result is an output waveform, something like that shown as the output on Fig. 1. Since the corners are almost square, and both sides, top and bottom, are almost straight lines, this is called a square-wave, to distinguish it readily from an undistorted sine-wave. The method described here is one of the standard methods of producing square waves, which are an essential part of the circuitry of television and radar. When the valve is operated in this way, it is really amplifying only during the steep sides of the square wave, for at all other times it is either cut off, or passing heavy and constant current.

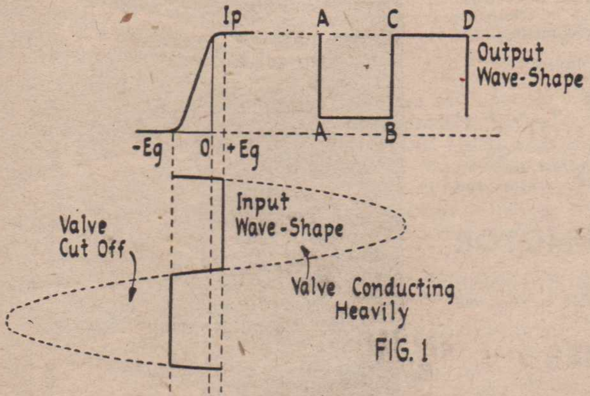


FIG. 1

It may not be immediately obvious why the bottom of the output waveform is flat, because this occurs during the heavily-conducting part of the cycle. The reason is to be found in the characteristic curves of the pentode or beam tetrode, and in the use of the large grid stopper resistor. The first point is illustrated in Fig. 2, which shows the characteristics of the 6V6, together with the load line for the 500-ohm plate load resistor. This shows that when the grid is sufficiently negative to cut the valve off, the plate voltage rises to the voltage of the H.T. line, and as long as the grid voltage is at cut-off or beyond, the plate voltage has this value. This explains readily enough why the positive half-cycle of the output voltage has the flat top, but it is not quite so easy to see why the same thing applies to the negative half cycle. First of all, if we look at the valve curves, it is seen that for an appreciable part of their length, all the grid voltage curves coincide, i.e., at very low plate voltages,

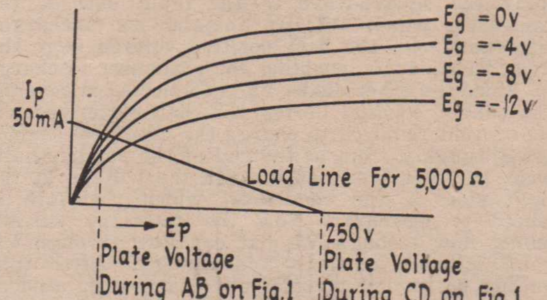


FIG. 2

Thus, if the valve has a resistive load, and the grid is driven up to cathode potential, or even a little more positive, the plate will fall to the voltage represented by the point where the load line cuts the curve for Grid Volts = 0. At this point, the curves for positive grid voltages, were they given would lie very close to this one, indicating that even if the grid is driven positive, very little more change in plate current can occur, and therefore, very little further change in plate voltage. This action is assisted by the grid stopper, which sees to it that however positive the input voltage may be, the actual grid voltage never goes more than a small fraction of a volt positive. Thus, as soon as the grid starts to draw current, there is a large voltage drop in the stopper resistor, and this, together with the small resistance between grid and cathode once the grid is conducting, forms a voltage divider which does not allow the grid to go more than very slightly positive. In addition, because the valve amplifies considerably during the short periods in which the input voltage is crossing the valve's characteristic, the time that these periods last is very short indeed; so short are they, that the "on" and "off" periods are very nearly equal, and for all practical purposes are so.

Now, whatever the frequency that is fed into the input terminal, the same sort of waveform comes out at the plate of the 6V6. The only difference between the output at one frequency, and that at another, being the number of times per second that the waveform occurs. The circuit thus far, therefore, acts as a square-wave generator, producing square-cornered waves of the same amplitude and shape, irrespective of frequency, and differing only in that frequency. The 6V6 can indeed be likened to a switch, connected with a battery and a resistor (the load resistor) and operated at regular intervals, in such a way that the switch is open and closed for equal periods of time. The only difference between the 6V6 and the switch is that the former manages to perform the switching at very rapid rates, such as could never be obtained by a switch.

The next essential part of the circuit is the pair of diodes, together with the 0-1 ma. meter. This is known as a counter circuit, and produces a meter reading that depends directly on the number of switching cycles in a given time, or, in other words, on the frequency of the square-wave fed to it by the 6V6. It works in the following way.

In order to simplify the explanation, the essential part of the counting circuit has been re-drawn in Fig. 3. This shows an input condenser, C, the two diodes, and the meter. Suppose that we suddenly apply the square-wave to the input side of the condenser, which we can imagine as uncharged beforehand. On the first positive voltage step, the diode V1 conducts, enabling the condenser to charge up. Since the other diode, V2 is connected in reverse, this cannot conduct during this half-cycle, because the current required to charge the condenser cannot flow through it. But, at the end of the positive half-cycle, there is a sudden drop in the voltage at the input side of the condenser, which therefore is caused to discharge. Now the discharge current cannot flow through V1, but can flow through V2, which it does, until it is discharged. After this, another positive step comes and charges the condenser again through V1, and so on. The net result is that a pulsating, but uni-directional current flows through each diode, one working every positive half-cycle, and the other every negative one. It will be noted that we have assumed that at each voltage step, the condenser has time to charge or discharge completely before the next step occurs. This is important, and is one of the things that has to be looked after in designing the circuit values.

When a condenser is charged to a fixed voltage, the number of electrons, or in other words the total quantity of electricity flowing depends (a) on the capacity of the condenser, and (b) on the voltage to which it is charged. Further, if the charging is done several times a second, the quantity of electricity passing each second will depend on both these things, and on a third also, namely, the number of times a second the charging takes place. But the quantity of electricity passing per second is the same thing as the current in the circuit, so it is possible to write a very simple equation connecting the voltage, the current passing through the charging diode, the capacity of the condenser, and the frequency. This equation is:—

$$i = C.V.f. \quad . . . (1)$$

where i is the current in amps., C the capacity in farads, V the input in volts, and f, the frequency in cycles per second.

This equation is the theoretical basis on which the frequency meter rests as a measuring instrument, for all we have to do in order to convert the circuit of Fig. 3 into a frequency meter is to put a D.C. meter in series with either of the diodes, and suitably calibrate it. Either diode will do, because since the condenser is completely charged and completely discharged before every reversal, the current through the diodes must be equal. In practice, we are also interested in knowing what sort of current we can expect from a given circuit, so that we shall know how sensitive a meter movement we must use. Also, we must have some means of ensuring that whatever the frequency fed into the squaring circuit, the condenser will have time to become fully charged and discharged before the half-cycle of square-wave finishes. If this is not done, all the current will not have flowed into or out of the condenser, and the meter reading will no longer be proportional to the frequency. Another practical consideration of some importance is that of knowing how high a frequency the circuits can handle, and what, if anything, causes the circuit to have an upper or lower frequency limit, beyond which it does not work properly. All these points will be discussed in the next section.

PRACTICAL CONSIDERATIONS

The answer to the first question is given partly by equation (1), above. For instance, we know that if we take a 6V6 and give it a plate load resistor of 5000 ohms, it will give a square-wave output of approximately 125 volts if the H.T. voltage is 150. Secondly, we can put in a likely value for the capacity, C, say 0.01 uf. Then all we have left is the current, and the frequency. If we fix the current at 1 ma., a convenient value, and substitute in the equation the values shown, we find that the frequency that would give the 1ma. from a 125 volt square-wave, through a condenser of 0.01 uf. is 800 c/sec. This means that with the circuit constants shown, a condenser C of 0.01 uf. would give a full-scale reading of 800 c/sec. Similarly, if the capacity is divided by 10, making it 0.001 uf., the range of the meter would be 0 to 8000 c/sec. And, other things being equal, a 0.0001 uf. condenser

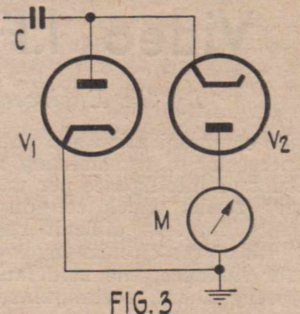


FIG. 3

would give a range of 0 to 80 kc/sec.

Theoretically, it can be seen from Equation (1) that the meter current does not depend on the value of the load resistance R, but in practice, the value of this resistor does have an important effect, because if it is made too large, it limits the highest frequency that can be measured, since it makes the condenser take too long to charge completely. It is a matter of common knowledge that if a condenser C charges through a resistance R, the time taken for it to charge to 67 per cent. of the applied voltage is measured by the product RC, and is given in seconds if the R is in megohms and C in microfarads. But we want the condenser to charge completely before the square-wave half-cycle is completed, so that for any value of the condenser and the resistor there is an upper limit to the frequency that can be measured before the current ceases to be a linear indication of the frequency.

Continued on Page 32

The "R. & E." Amateur Television Project

(From Page 8)

corresponding part of the frame circuit. This is unfortunate, because the two parts of the circuit do exactly the same thing, the only difference being that the line time-base does it at many times the rate of the frame time-base. But as we will see later, doing things at high speed requires more bandwidth, and for that reason an extra amplifying valve has to be used, and also the circuit has had to be altered from a triode amplifier to a pentode amplifier. However, we will go into those aspects when we come to discuss the circuits in detail.

V5 is an oscillator, working at approximately 15,000 c/sec. This is 300 times the frame frequency of 50 c/sec., so that we must get 300 line deflections for every frame deflection. In other words, the C.R.T. spot executes 300 horizontal sweeps in the time taken for the vertical deflecting voltage to take the spot from the top of the picture to the bottom. The picture must, therefore, be a 300-line one. This frequency, and therefore, number of lines, has not been chosen haphazard, but with a purpose which will be detailed later. At the moment, it will be sufficient to say that 300 lines are enough to give a picture of excellent quality, not so good as the British standard of 405 lines, nor yet the American one of 525 lines, but still enough to give a really good picture that will certainly be well worth looking at. V6 is another EN31, in an almost identical circuit to that of V3, except for the frequency and gives the same sort of saw-tooth output. V7 and V8 are amplifier and phase inverter respectively, which again provide a push-pull deflecting voltage for the X plates of the C.R.T.

The remaining valves, V4 and V10, are concerned solely with the production of the blackout voltage for the C.R.T. grid, and their functions will be described later in greater detail.

It so happens that at the cathodes of the saw-tooth generator valves, a positive pulse occurs, and this pulse corresponds exactly in duration with the flyback of the saw-tooths in each case. But to black the spot out, a negative pulse is needed. We therefore insert a pulse amplifier, one for the line blackout pulse, and the other for the frame pulse. Then the two pulses are added together in a cathode-follower adding circuit, and the output of this stage is sent to the grid of the C.R.T., blacking out each flyback as it occurs.

(To be continued.)

Video I.F. Amplifier Design

By the Engineering Department, Aerovox Corporation

In modern radio communication and pulse ranging equipment, the necessity of transmitting and receiving a large amount of intelligence per unit time, or of handling wave forms which contain high frequency components, imposes difficult requirements upon the bandwidth of the circuits involved. In the radar system, for instance, the modulation of the transmitter by very short, rectangular pulses of energy, results in the R.F. output occupying a broad band or **spectrum** of frequencies. The width in megacycles of the band required for the transmission of such rectangular pulse signals is expressed, to a rough approximation, by:

(1)

$$\text{Bandwidth (mc.)} = \frac{2}{\text{Pulse length (Microseconds)}}$$

Thus, a radar transmitter being modulated by .5 microsecond pulses would occupy a band (exclusive of minor side bands) of 2 divided .5 or 4 megacycles. In television, the transmission of high-definition picture information consisting of several

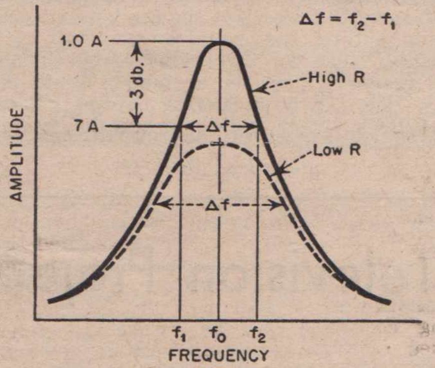


FIG. 1

million elements per second, as well as synchronizing pulses and sound, requires the allocation of a 6 megacycle channel for each transmitter in operation.

In any such broad bandwidth system, if the receiver is to recover as much of the transmitted signal as possible, it must be capable of simultaneously accepting the entire band of frequencies transmitted and amplifying each equally. In the superheterodyne type of receiver, the satisfaction of this requirement greatly affects the design of the I.F. amplifier, since it is this channel of the receiver which determines the overall selectivity to a large extent. Fortunately, the design of broad-band or "video" intermediate-frequency amplifiers has been greatly simplified by war-time research work. As a result, the design of high gain amplifiers capable of essentially "flat" band-pass characteristics as wide as 10 megacycles is relatively uncomplicated.

The bandwidth of an I.F. amplifier is taken as the frequency difference between points 3 db. down from maximum amplitude on each side of the response curve and is symbolized by $\triangle$f. See Fig. 1. In the simplest form of amplifier stage, which is the single-tuned circuit shown in Fig. 2, the bandwidth in megacycles is given by:

(2)

$$\text{Bandwidth } (\triangle f) = \frac{1}{2\pi RC}$$

R=the total resistance shunting the tuned coil in megohms.

C=the total capacitance shunting the coil in uuf.

As this relation shows, the bandwidth of the single-tuned stage is inversely proportional to both the shunt capacity and the shunt resistance. In practice it is the resistance which is varied to control the shape of the response curve. The addition of "loading resistors" across the tuned circuits, common in television and other video I.F. circuits, broadens the response as is illustrated by the dotted curve in Fig. 1. Loading the resonant circuit lowers the circuit Q and thus reduces the maximum response or gain as is shown. The bandwidth at the new 3db. point has been increased but the peak response has been sacrificed proportionately in favour of bandwidth. This demonstrates the important fact that the gain-bandwidth product of such an amplifier is constant. This means that a stage giving a gain of 10 over a bandwidth of one megacycle may also be made to deliver a gain of five at a two megacycle band-pass, or any other combination whose gain-bandwidth product (G × B) is equal to ten. The gain-bandwidth product, which is the accepted "figure of merit" of an amplifier stage, depends on the transconductance (gm) of the tube type used and the **total** distributed shunt capacity in the following manner:

TUBE TYPE	Trans-conductance (Micromhos)	Tube Capacity +5 mmf.	Gain-Bandwidth Product (Megacycles)
6AC7	9000	21	68.7
6AU6	5200	15.5	53.6
6BA6	4400	15.5	45.3
6AG5	5000	13.3	59.5
6AK5	5000	11.4	69.4

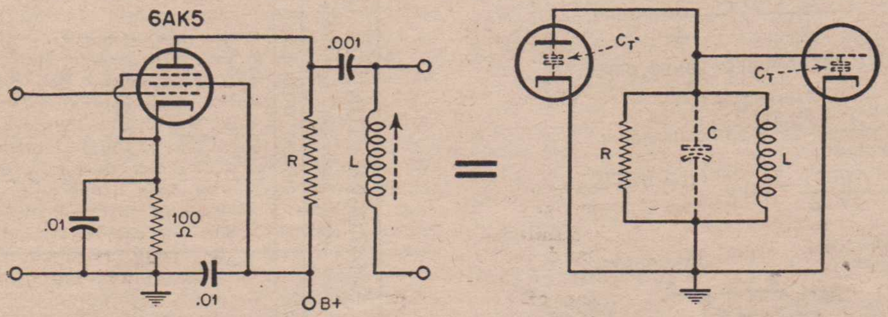
TABLE I

Since the gain-bandwidth product is inversely proportional to C, which includes the distributed wiring capacity as well as the tube interelectrode capacitances appearing across L, it is very important in circuit lay-out to reduce stray capacity to a minimum. In practical circuits using modern tubes, the total C may be limited to 10 uuf. Table 1 shows the G × B products for some frequently used tubes, allowing 5 uuf. for distributed circuit capacity.

Unfortunately, when single-tuned amplifier stages resonated to the same frequency (synchronously tuned) are cascaded, the overall band-pass does not remain that of the individual stages, but is reduced radically with the number of stages. Four stages, each four megacycles broad at the 3 db. point, when cascaded would thus have an overall band-pass of only 1.75 megacycles. This is evident from the fact that if the voltage gain at the centre frequency (fo) is 10, the gain at the 3 db. point is only 7.07. Upon amplification by a second identical stage, the gain at fo is 10 × 10 or 100, while the gain at the former 3 db. points is now only 7.07 × 7.07 or 50, which is 6 db. down in voltage. The band-width at the 3 db. points has been reduced to 64 per cent. of that for the single stage. Further amplification by similar stages would result in the overall band-width being reduced to 51 per cent. for a third stage, 44 per cent. for a fourth stage, 39 per cent. for the fifth, etc.

frequency is aligned to the mid-point of this slope, the small portion of the **vestigal** lower side-band which is under the response curve is compensated for by the omission of a similar area from the lower 1.25 mc/sec. of the upper side-band. Therefore, the response to the lower video frequencies is made nearly equal to the higher ones, although derived partially from both upper and (vestigal) lower transmitted side-bands.

Considerable improvement over the performance of synchronous single-tuned amplifiers may be obtained by the use of multiple-tuned circuits. In a double-tuned, transformer-coupled stage such as is shown in Fig. 4, the coefficient of coupling (k) and



TYPICAL SINGLE-TUNED STAGE A.C. EQUIVALENT

FIG. 2

$$G \times B\ (\text{mc.}) = \frac{9m}{2\pi C} \qquad (3)$$

In addition to the undesirable feature of rapidly decreasing pass-band for multiple stages, the synchronously single-tuned system does not satisfy the requirements of the television video I.F. since it is incapable of producing the flat-topped response curve required for picture reproduction. The shape of the video I.F. response which is accepted as the standard in television practice is shown in Fig. 3. An essentially "flat" band-pass of nearly 4 megacycles is required for high-definition picture reproduction on large-screen cathode ray tubes, although

the primary and secondary circuit Q's may be adjusted so that the response curve is essentially flat topped. Such maximally flat or "transitional" coupling occurs when the circuit Q's and the coefficient of coupling are related as shown in Fig. 4. The term "transitional coupling" is derived from the fact that the coupling is adjusted to the point of **transition** between the single and double-humped response curve. It will be recalled that, as the coupling coefficient of the tuned transformer is increased from a very small value, the curve of

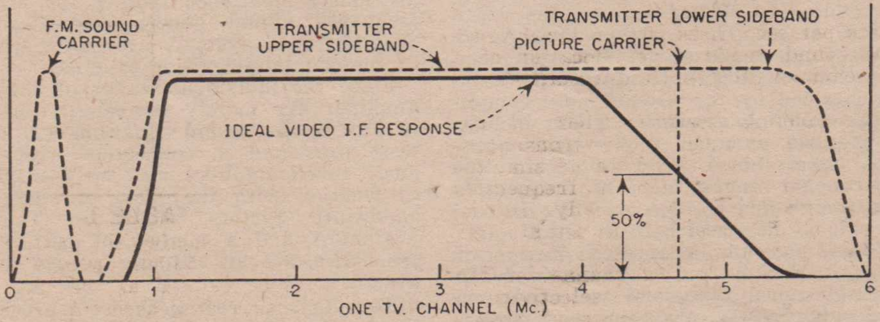


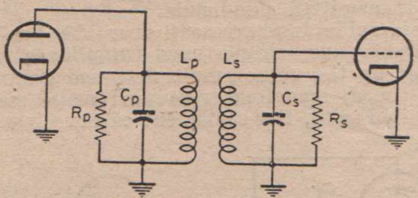
FIG. 3

sets using small tubes may get along with much less. The gradual, nearly linear, decrease in the response at the picture-carrier end of the curve is intended to compensate for the presence in the transmitted signal of the first 1.25 mc/sec. of the lower side-band. (The rest is suppressed at the transmitter). When the picture-carrier I.F.

secondary current versus frequency changes from a small sharp peak when the circuits are under-coupled, to a broad double-peaked response when the circuits are over-coupled. (Dotted lines, Fig. 4). The coefficient of coupling of the inter-stage transformer may be determined by measuring the capacity values necessary to resonate the primary to a given frequency when the secondary is alternately open- and short-circuited. (Co and Cs respectively). Knowing the ratio of these capacities; At the value of k corresponding to critical coupling, the transfer of energy to the secondary is maximum and the curve is flattopped.

(4)

Coefficient of coupling (k)=(sq. rt.) $1 - \frac{Co}{Cs}$



EQUIVALENT DOUBLE-TUNED CIRCUIT

When: $Q_p = Q_s$

$$K = \frac{1}{\sqrt{Q_p Q_s}} \text{ for transitional coupling}$$

$$\Delta f = \frac{\sqrt{2}}{2\pi RC} \quad \text{where.} \quad C = \sqrt{C_p C_s} \quad R = \sqrt{R_p R_s}$$

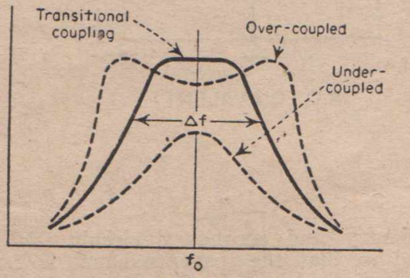


FIG. 4

The response characteristic obtained in this manner is more nearly that required by the television video I.F. Furthermore, because of the more uniform response over the pass-band, the overall bandwidth does not decrease as rapidly when identical stages are cascaded as in the case of synchronous single-tuned stages. When two double-tuned, transitionally-coupled amplifier stages are cascaded, the output bandwidth is reduced to 80 per cent. of the width of an individual stage. The corresponding figure for synchronous single-tuned stages is 64 per cent.

Further improvement in gain-bandwidth performance may be obtained by the use of more complicated interstage coupling networks. These include, double-tuned stagger damped, triple-tuned transformer-coupled, single-tuned inverse-feedback and complex filter-coupled stages. Most of these types are difficult to design and troublesome to construct and align, so will be discussed here in detail.

One type of band-pass amplifyer which does retain the simplicity of design and alignment of the synchronous single-tuned type, and yet overcomes most of its disadvantages, exists in the stagger-tuned amplifier. Wallman* and others have shown that if the successive stages of a simple single-tuned amplifier are adjusted to slightly different frequencies (staggered) throughout the desired pass-band, the composite response curve may be made flat-topped and the gain high. Furthermore, the design work requires only high school maths and a few simple tables, the construction done with common tools and the alignment may be accomplished in a few minutes with the aid of a spot-frequency signal generator and an output meter. The double-tuned and other more complex types previously mentioned require the use of a swept-frequency signal generator and an oscilloscope. Stagger-tuned systems are being used extensively in commercial television practice.

*Wallman, Henry. MIT Radiation Lab. Report No. 524.

• STAGGER-TUNING TABLE •

Δf = Required overall bandwidth, f_o = Center frequency, $d = \frac{\Delta f}{f_o}$

NUMBER OF CIRCUITS	CIRCUIT FREQUENCY	CIRCUIT BANDWIDTH
Staggered - pair	$f_1 = f_o + .35\,\Delta f$ $f_2 = f_o - .35\,\Delta f$	$.71\,d\,(f_1)$ $.71\,d\,(f_2)$
Staggered - triple	$f_1 = f_o$ $f_2 = f_o + .43\,\Delta f$ $f_3 = f_o - .43\,\Delta f$	Δf $.5\,d\,(f_2)$ $.5\,d\,(f_3)$
Staggered - quadruple	$f_1 = f_o + .46\,\Delta f$ $f_2 = f_o - .46\,\Delta f$ $f_3 = f_o + .19\,\Delta f$ $f_4 = f_o - .19\,\Delta f$	$.38\,d\,(f_1)$ $.38\,d\,(f_2)$ $.92\,d\,(f_3)$ $.92\,d\,(f_4)$
Staggered - quintuple	$f_1 = f_o$ $f_2 = f_o + .29\,\Delta f$ $f_3 = f_o - .29\,\Delta f$ $f_4 = f_o + .48\,\Delta f$ $f_5 = f_o - .48\,\Delta f$	Δf $.81\,d\,(f_2)$ $.81\,d\,(f_3)$ $.31\,d\,(f_4)$ $.31\,d\,(f_5)$

After Wallman

TABLE II

Since the individual stages of the stagger-tuned amplifier are merely the single-tuned type shown in Fig. 2, the design equations (2) and (3) which were presented in connection with the synchronously tuned amplifier may be used. These, used in conjunction with the table of stagger-tuning and bandwidth factors shown in Table II (after Wallman) and a method of cutting the coils to resonance, are all that are needed to complete the design.

To illustrate the method of procedure, suppose that a video I.F. amplifier using 6AK5 pentodes is to have a uniform gain of 75 db. over a bandwidth of 4 mc/sec. centred at 24 mc/sec. Referring to Table I it is seen that the 6AK5 has a gm of 5000 micromhos and the total interstage capacity may be limited to 11 uuf. The gain-bandwidth product (Eq. 3) then becomes 5000/6.28 x 11 or 72.4 megacycles.

(Continued on Page 32)

HAM ACTIVITIES

CONDITIONS on all bands have noticeably improved and 1951 has got off to a good start so let us hope we may continue to enjoy this state of affairs. Amongst many other things, quite apart from Amateur Radio, I know we all wish for better things in this year—in particular, the international situation.

Conducted by
J. A. HAMPEL, VK5BJ

Naturally, we all share that wish, but it has become necessary to reiterate the warning made by the W.I.A. some time ago—DO NOT initiate, or allow yourself to be dragged into a conversation on present world affairs over the air.

So many "Hams" are currently "blowing their tops" on the band regarding this subject, forgetting that such discussions are definitely against the regulations. Whatever your political views, please do not air them via amateur radio. There is a time and place for everything, and right at this moment we cannot afford to introduce prejudice which could mean a loss of frequencies. If you must talk about the subject, do it with a foot on the rail, or a similar more suitable place.

Similarly one's own common sense should guide him in all those touchy situations that sometimes get by on the air. For instance, do not do as one chap did—run down the Advisory Committee over the air after receiving a friendly note. Remember it took a deal of study for the majority to gain the necessary ticket, but it only takes one word on the air to lose that same ticket.

Results of the 1950 Remembrance Day Contest will be found separately in these notes. After a casual glance at the scores the result is indeed very poor. Of the 2,824 stations who could take part, only 317 logs were returned. Allowing for a percentage who are inactive, the final figure illustrates the apathy displayed by a large majority who could have made a material difference to their State's total by submitting even a small log in excess of six contacts.

VK "Hams" must take the proverbial bun when it comes to anything like Contests or Field Days. When one reads what the W's and G's can do in these matters, it should make us blush a deep red! Doubtless there will be the usual number who will criticise the scoring system of this recent contest as was done the year before, yet every time the Contest Committee asks for suggestions, no one comes forward. Still it goes on; but, it is a pity that the ones who do the grumbling do not get the chance to do some work on a committee themselves.

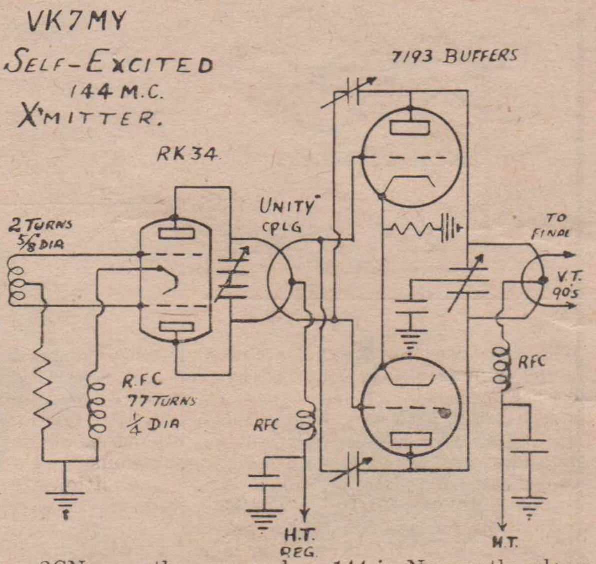
The result should be interesting! ONCE AGAIN I would ask you for notes of activity in your division or town, etc. Let us have news from field days, clubs and so on, as there is plenty of room for it. GOING UP!

THE V.H.F. MAN'S PAGE.

With VHF Field Days and several break-throughs the high frequency boys have had a good run of luck. Some VK2 Stations are reported as working into KH6, so things are looking up for some States. 5BC is still the most consistent 6 metre station in VK5; apparently Hughue has abandoned 40 and 20 for good! 5UL has returned to 6 and can be counted as one reason for 5BJ not appearing on 6 in an already VHF-minded suburb. Two metre gear is well under way with only 2OT's return to Broken Hill delaying the urge to finish off the transmitter and start the automatic transmissions with Max.

Further to the remarks regarding 7MY last month, other details of the rig are: The transmitter is a self-excited job using an RK34 which drives a pair of 7193's. These 7193's give enough output to produce sixty mils of grid current to the VT90 Micropups in the final. At the moment, the final is running Class B until a larger modulation transformer is wound up. A Station of this type is certainly an ambitious venture; even a blower has been installed to keep those AMPS of filament current down at room temperature.

A circuit of 7MY's rig is published herewith. The circuit may not be received too favourably by some due to the type of oscillator used in these days of almost exclusively crystal-controlled sigs on 144 mc.



2CN recently appeared on 144 in Newcastle where there are very few stations active. Bert is using a pair of 7193's in a unity coupled oscillator as per the A.R.R.L. Handbook. The receiver is a simple super-regen. Many stations are still trying to find the band after being lured to the VHF bands with the advent of summer.

2OT is the leading VHF man at Broken Hill. Max has a 50 ft. steel tower with a 3 element beam on six metres and a 4 element one on two metres. For six metres he uses a 6J6 regenerative crystal oscillator and a 832 final. The receiver is the R.F. and I.F. sections of a SCR522 feeding into the usual receiver a, B28. A SCR522 is used on two metres as a transmitter, whilst a re-vamped 522 receiver takes care of the incoming signals. This now uses a 6J6 push-pull R.F. stage, p.p.6J6 mixer and a similar type of regenerative oscillator as used in the transmitter.

Well gang, what about some news at your end? The address already appears elsewhere in the notes.

(Continued on Page 27)

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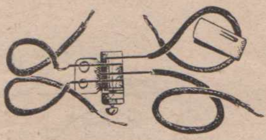

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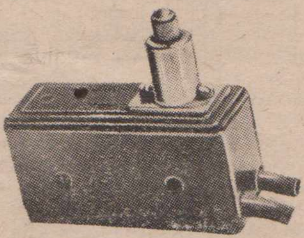

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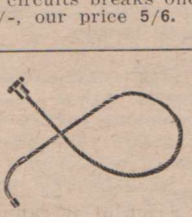

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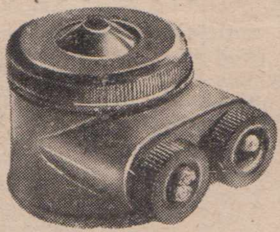

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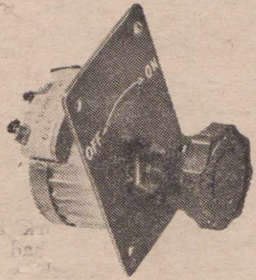

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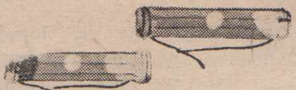

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50	Assorted	15/-
100	Assorted	27/6
500	Assorted	£6/5/-

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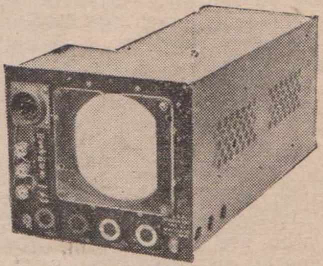

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HAM ACTIVITIES

(Continued from page 25)

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HH2X — P.O. Box 103, PORT-AU-PRINCE.
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ZS3X — Box 85, WINDHOEK, S.W. AFRICA.
YV5EH — Cristo a Cordova 93, CARACAS, VENEZUELA.
OA8A — Don Stark, Box 2492, LIMA, PERU.
KV4AU — Bourne Field Housing, ST. THOMAS, VIRGIN IS.
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OK1PC — Praha 8, SMETANOVA 9, CZECHOSLAVAKIA.

1950 REMEMBRANCE DAY CONTEST.

Via VK5WI comes the following information:—The winner was VK7 again, then VK6 followed by VK5. Their scores were 155, 151, and 78 respectively. VK2, VK4 and last, VK3, followed with their scores being 38, 30 and 20.

Response was very poor and doubtless some means of making the contest more attractive will be sought for 1951.

AROUND THE SHACKS

The first unrationed-petrol-Christmas for a long time was apparently the reason for the large number of stations heard working portable. 3ALM was worked while he was at Torquay, on the coast near Geelong, using a ATR2B transceiver which uses an 807 in the final and a similar tube to modulate it. Although his antenna was an unknown length of wire about ten feet off the ground, Lloyd was getting seven's and eight's from all round .—.—.

Max, 2OT, of Broken Hill, operated portable from many varied locations. Undoubtedly his best spot for getting out was from Port Noarlunga, a VK5 seaside resort about 20 miles south of Adelaide. His rig was a 6C4 crystal oscillator driving a 6V6 to nine watts input powered by a genemotor supply. The receiver was a 6K8 converter feeding into the car set. The whole set-up was relay controlled from the dash, the transmitting gear being stowed in the boot .—.—.

5NB went portable on Torke Peninsula in his home State using a Type III employing series screen modulation and a Windom antenna. Ted was lucky to have the A.C. laid on where he chose to operate, or perhaps things were arranged the other way round .—.—.

Another Type III user was 3NZ, portable at Canadian Bay with Bill, 3ATW, heard on the mike a lot of the time. The battery volts must have been down however, as they were using only 4 watts input when worked .—.—.

3JO was another who went portable in Victoria but little is known of the gear which was operated from the Eildon Weir .—.—.

2WT seems to work everything there is, but when you consider the V beam coupled to the 807's, it's no small wonder .—.—.

5CH provides news from the south eastern parts of VK5 this month: 5KU is active on 40 in the early mornings working the choice c.w. DX. Of course, this sort of thing comes easy when Erg has to get up early in the small wee hours to pacify a QRM'ing newly-arrived harmonic .—.—.

John, 5FD will not be heard around for a time as a recent change to a new QTH also means a dearth of A.C. power .—.—.

At last 5MS is content. At one time Stewart had a reputation for trying a different antenna weekly; now, however, a new 3 element rotary beam tops a new tower so there will be less antenna activity in the future .—.—.

Noticed in "QST" that W9EH has up a 36 element rotary beam for ten metres! The whole array and turning mechanism only weighs 2,500 lbs. .—.—.

Those who want to QSL to VK1FE should note that he is ex-4FE. Similarly, VK1PG is ex-2PG and their home addresses are to be used for VK1 QSL's. .—.—.

3ZV has returned to 40 after a long absence. Arthur runs 85 watts to an 803 with HY25's as modulators. The receiver is an AR88 .—.—.

5EN has been heard operating from Arwakurra using only 4 watts. Next portable step will be to put the rig on 20 and 10 then Ernie proposes to be signing mobile on 40 and 2 from his new car .—.—.

3MZ has been doing the rounds of the VK5 shacks. By the time you read these notes Reg will be back signing "The Voice of Preston" once again. Most of the VK3 visitors thought the heat a little above the usual Melbourne weather — ask Reg .—.—.

The NBFM in use at 3APF sounds very clear, perhaps a little narrower than in usual practice. Peter uses an 807 in the final and a reliable dipole antenna .—.—.

3AMC is not heard on the air very often owing to work taking up a great deal of John's time. John had to find time around the festive season though, so he could exploit his call and sing VK3 "A Merry Christmas." One time when irregular use of phonetics could be overlooked .—.—.

5CA went aroving around South Australia on a tour of the State, managing to see only one ham in that time—Bob, 5OD, at Pt. Pirie. Time did not permit looking up a lot of those who Brian had promised to contact .—.—.

Someone will probably write to me before long complaining that there is a definite leaning towards the VK5 aspect. I shall be only too pleased to answer that the reason is because no one forwards any notes from their own district. Shortly, a period of inactivity at 5BJ will mean no "on-the-air" news as is gleaned at present and news, no matter how briefly set out, will be very welcome. Each month 5CH and 5VM go to the trouble of setting out pages of notes, but a lot of it cannot be used otherwise all the news would be VK5.

Human nature seems to guide us all to want to know what the other fellow is doing, so if you can take pen and paper to write a few lines on the activity in your district, remember the address is Box 1589M, G.P.O., Adelaide, S.A.

THE N.B.F.M. EXCITER

(Continued from Page 16)

In order to measure the frequency with a good frequency meter such as the surplus BC211 wavemeters, or the LM series, all that is needed is to pick up the signal from the oscillator in the wavemeter, and to read each frequency in the usual way by zero-beating, and then reading the dial. If an A.F. direct-reading meter is used, such as is described elsewhere in this issue, a little auxiliary equipment will be needed. It will be a fixed-frequency oscillator of some sort, and a diode detector followed by some audio amplification to bring the audio beat note up to approximately 1 volt amplitude. The auxiliary oscillator, and the output from the F.M. unit are both fed into the diode detector, and one or other of them is adjusted to zero beat. It is preferable to do this with the full 18 volts bias applied to the modulator valve. Then, as the frequency is varied by altering the battery voltage on the grid of the modulator, the shift in frequency of the modulated oscillator will show up as an audio beat note, whose frequency will be indicated directly on the frequency meter. Then to plot the curve, these readings are plotted against the D.C. grid voltage as before. It will be found that the best bias voltage (i.e., at the centre of the most linear portion of the curve) will be 7.5, or thereabouts, and that at about 5 volts and 10 volts, the graph starts to show signs of curvature, flattening out well before cut-off and zero bias are reached respectively.

AMOUNT OF FREQUENCY DEVIATION

In performing the original development work on this circuit, it was found that with the modulator tube's gridplate capacity alone, the frequency swing for linear deviation was not wide enough, and for this reason a simple modification was made which is shown on the circuit. The condenser C, of 15 uuf, was added to the grid-plate capacity. Doing this amounts to making a valve with an abnormally large grid-plate capacity, for as far as the signal is concerned, it cannot tell whether the capacity it encounters is inside the tube or external to it. The result in practice is that instead of having to write 3.4 uuf. in the formula for the grid-plate capacity, we write 18.4, with a large consequent increase in the Miller effect capacity. Not only does the input capacity become very much greater, but so also does the variation of it, produced by applying signal to the modulator. As a result, a much larger linear frequency deviation is obtained.

USE OF A REGULATED POWER SUPPLY

It will no doubt have been noticed that the H.T. supply for the modulator and oscillator is specified as 225v., regulated. This is not really essential as far as the oscillator itself is concerned, but is a "must" for the modulator valve. This valve's gain will vary widely with changes of H.T. voltage, so that H.T. drift, caused by changes in line voltage will cause the centre frequency to change. The regulated power supply obviates this, and it should be remembered that any direct means of producing F.M., whether narrow or wide, will suffer in the same way if the modulator's power supply is not regulated. Accordingly, the power supply should contain a VR150 and a VR105 in series, to supply the 225v.

ADJUSTMENT FOR USE

In this country, the band available for N.B.F.M. on 80 metres is from 3500 to 3800 kc/sec. This is fortunate in one way, because if the band were a little wider, it would be necessary to bring the tuning control for the modulator plate circuit out to the front panel. In practice, however, it is recommended that a spot frequency be chosen within the band and all N.B.F.M. working done on this frequency. This will enable the modulator tuned circuit to be peaked up exactly for this frequency, thereby obtaining optimum results there, with little effect occurring if the operator wishes to QSY a few kc. on either side of this spot. The easiest way to set up the modulator tuning is to first set the oscillator to the desired carrier frequency, and then couple a sensitive absorption wavemeter as loosely as possible to the plate circuit of the modulator. Then, the tuning is peaked up for maximum output from the plate circuit of the modulator. Before this is done, however, the resistor R will have been adjusted to the value which gives the best operating point for the modulator. In the absence of a performance curve, obtained as described above, it will be sufficient to set the cathode voltage of the modulator tube to exactly 7.5 volts.

Once the modulator plate circuit has been tuned up, there is nothing to do but connect up the mike, and go on the air!

A SUITABLE RECEIVING ATTACHMENT

In an early issue it is hoped to describe a small unit which can be attached to any receiver to give distortionless reception of narrow-band F.M. signals. This unit, it is expected, will be fed from the 455 kc/sec. I.F. channel of the receiver, and will give enough audio output to be fed back into the set again at the grid of the first audio amplifier. It is hoped to make use of the diode counter-circuit type of discriminator, since this has no critical adjustments, and once the circuit is designed, will stay in alignment for ever, because there are not tuned circuits attached to the discriminator to get out of line and spoil the proper operation of the F.M. detector. With this, and the present unit, amateurs should have all the "gen" to enable them to transmit and receive N.B.F.M. signals of high quality, at relatively low cost, and without critical adjustments of any sort.

✣ ✣ ✣

SHORT WAVE REVIEW

Conducted by L. J. Keast
7 Fitzgerald Rd., Ermington, N.S.W.
Phone: WL 1101

NOTES FROM MY DIARY

THE DOCTOR COMES TO TOWN.

Regular readers of my pages over the last ten years or so will remember one of the best and most reliable of Dx-ers—Doctor Keith Gaden. I had a call from him a couple of weeks ago and during our hour's chat, I did my best to get him interested in the old Hobby again. Another thing, I hold him I wish he would settle down in N.S.W. instead of Banana Land. Imagine my delight to get an air-mail from Brisbane that he was going to reside in Manilla, N.S.W. For the benefit of those unfamiliar with N.S.W., it is on the Western Line between Orange and Parkes, about 280 miles from Sydney.

Keith, at one time, was one of the most prolific correspondents and many a Dx-er was put right on his mystery station by the Doctor.

THOSE SUN SPOTS.

Doubtless many listeners to Dx have moaned about poor reception at times and most likely have been blaming their receiver or perhaps figuring that at the first opportunity they will try and alter their aerial system.

But don't worry—sun spots was the cause last month. Even the overseas News Service to the newspapers was interrupted for hours on end.

THE CANADIAN BROADCASTING INTERNATIONAL SERVICE.

INCREASED SERVICE TO LISTENERS
— in —
AUSTRALIA, NEW ZEALAND
and the SOUTH PACIFIC.

CHOL—11.72 mc. 25.60 met:
Wednesdays and Sundays, 6.40 p.m.—7.45 p.m.
CKLO—9.63 mc. 31.15 met:
Wednesdays and Sundays, 6.40 p.m.—7.45 p.m.

OUR CANADIAN COUSINS.

The Sunday night service from Canada to Australia from 6.40-7.45 on Sundays will continue, and in addition the same station will broadcast on Wednesdays at the same hour.

CREDIT LINE.

Unfortunately during the changeover, recognition of reporters' notes has been frozen out, but believe me, I am conscious of the help given by "Sweden Calling," "Radio Australia," "London Calling" (Eastern and Western editions), "Radio & Television," Arthur Cushen, Rex Gillett and Roger Legge.

THE MONTH'S LOGGINGS

CANADA

CKNC, Montreal, 17.82 mc. 16.84 met: Mondays, 12.45-1.15 a.m., Swedish; 1.30-2.00 a.m., Finnish.

CKCX, Montreal, 15.19 mc. 19.75 met: 9.50-10.40 a.m., Portuguese; 10.40-11.45 a.m., Spanish; Mondays, 1.30-2.00 a.m. Finnish.

CKRA, Montreal, 11.76 mc. 25.51 met: 9.50-10.40 a.m., Portuguese; 1040-11.45 a.m., Spanish; 11.45-Noon, French; Noon-12.45 p.m., English; 12.30-12.45 p.m., Dutch (Sats.); 12.45-1.35 p.m., Spanish.

CKLO, Montreal, 9.63 mc. 31.15 met: Noon-12.45 p.m., English; 12,30-12.45 p.m., Dutch (Sat. only); 12.45-1.35 p.m., Spanish; 2.30-3.00 p.m., Northern Messenger (Mondays only to Northwest Territories and Arctic Regions).

CKOB, Montreal, 6.09 mc. 49.26 met: 2.20-3.00 p.m., Northern Messenger (Mondays only to Northwest Territories and Arctic Regions).

To Australia and New Zealand

CKLX, Montreal, 11.72 mc. 25.60 met.: Commentaries from the U.N. (Except Sundays and Mondays), 1.50-2.20 p.m.

CHOL, Montreal, 11.72 mc. 25.60 met: Commentaries from the U.N. (Except Sundays and Mondays.) English programme for listeners in the South West Pacific area. 6.40-8.30 Sundays.

CKLO, Montreal, 9.63 mc. 31.15 met: English programme for listeners in the South West Pacific Area. 6.40-8.30 Sundays.

OCEANIA

New Zealand

ZL-3, Wellington, 11.78 mc. 25.46 met: 4.00-6.45 a.m., 5.00-8.30 p.m.

ZL-10, Wellington, 15.22 mc. 19.72 met: 7.00 a.m.-4.45 p.m.

ZL-4, Wellington, 15.28 mc. 19.64 met: 4.00 a.m.-8.30 p.m. (9.30 p.m. Saturdays). Arthur Cushen reports: On first Tuesday of each month at 7.20 p.m. Dx Broadcast tips are given by Cleve Costello, Wellington.

MISCELLANEOUS

Morocco

Radio International, Tangier, 6.11 mc. 49.10 met: Rex Gillett reports this station as follows: daily, 10.00 p.m.-2.00 a.m. and 4.00-10.00 a.m., with musical programme in French, Spanish, English and Arabic. English 9.00-9.30 a.m.

Malta

"Your Forces Broadcasting Station, Middle East," 6.01 mc. 49.83 met: 3.00-6.00 p.m.; 3.00-8.00 a.m. **7.22 mc. 41.55 met:** 2.00-4.15 p.m.; 7.30-11.30 p.m.; 2.00-8.00 a.m. **11.895 mc. 25.22 met:** 2.00-4.15 p.m.; 7.30-11.30 p.m.; 2.00-3.00 a.m.

15.125 mc. 19.83 met: 2.00-4.15 p.m.; 7.30-11.30 a.m. Above information was airmailed by "Sweden Calling."

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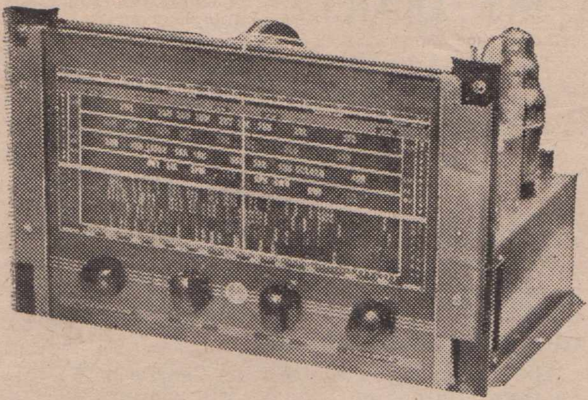

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CLASSIC RADIO

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HABERFIELD.
PHONE UA2145.

Short Wave Review

(Continued from Page 29)

EUROPE

Czechoslovakia

OLR3A, Prague, 9.55 mc. 31.41 met: 5.15-5.45 a.m., 6.30-6.45 a.m., 8.15-8.30 a.m. Now in English at 6.30 a.m.

OLR4A, Prague, 11.84 mc. 25.34 met: 9.45-10.30 p.m. Reported by Rex Gillett as being heard in English broadcast closing at 10.45 p.m.

OLR2A, Prague, 6.01 mc. 49.52 met: 8.15-8.30 a.m., 9.00-9.45 a.m.

Greece

Radio Athens, 6.175 mc. 48.58 met: Opens at 1.00 a.m.

France

Radio Paris, 21.74 mc. 13.80 met: Heard indistinctly around 10.15 p.m. Badly interfered with by GVT, 21.75 mc. 13.79 met: in BBC Far Eastern Service to China and Japan.

Radio Paris, 17.85 mc. 16.81 met: Much better signal here at 10.00 p.m. Close with "Marseillaise" at 10.00 p.m.

Portugal

Emissora Nacional, Lisbon, 15.40 mc. 19.47 met: Reported by "Sweden Calling" as on air in mornings.

Emmisora Nacional, Lisbon, 15.365 mc. 19.53 met: Programme to Far East from 1.30-2.02 a.m.

Emmisora Nacional, Lisbon, 15.39 mc. 19.49 met: Heard 3.00-3.45 a.m.

Hungary

Radio Budapest, 6.247 mc. 48.07 met: News in English at 7.00 a.m. and 9.10 a.m.

Radio Budapest, 9.83 mc. 30.52 met: News in English at 7.00 a.m. and 9.10 a.m.

Radio Budapest, 11.91 mc. 25.18 met: News in English at 7.00 a.m. and 9.10 a.m.

Italy

Radio Italiana, Rome, 21.57 mc. 13.91 met: English, 9.00-9.30 p.m.

Radio Italiana, Rome, 17.80 mc. 16.85 met: English, 9.00-9.30 p.m.

Radio Italiana, Rome, 15.12 mc. . met: Special Pacific Service with News at 6.15 p.m. Reports asked for.

Poland

Radio Polskie, Warsaw, 6.115 mc. 49.06 met: 3.45-4.15 a.m. (English).

Radio Polskie Warsaw, 6.22 mc. 48.23 met: 3.30-4.00 a.m. and 5.00-5.25 a.m. (English).

Radio Polskie, Warsaw, 7.205 mc. 41.66 met: 7.00-7.30 a.m. (English).

Radio Polskie, Warsaw, 9.57 mc. 31.35 met: Midnight-12.30 a.m. (English).

Spain

EAJ-3, Valencia, 7.037 mc. 42.64 met: English Programme Wednesday & Saturdays at 5.40 a.m.

SCANDINAVIA

Finland

OIX-4, Pori, 15.19 mc. 19.75 met: Heard at 9.00 p.m.

Norway

LKJ, Tromso, 9.54 mc. 31.45 met: 9.00-10.00 p.m. relays Home Service.

THE EAST

Indo-China

Radio France Asie, Saigon, 9.524 mc. 31.50 met: Gives special programme on this frequency around breakfast time. English at 8.30 and 10.30 a.m.

Radio France Asie, Saigon, 6.115 mc. 49.06 met: Reported by "Sweden Calling" as opening at 8.10 a.m. with signal piano notes and "Marseillaise".

Radio France Asie, 11.83 mc. 25.36 met: Programme in English, 7.15 p.m.-8.15 p.m.

Radio France Asie, 11.775 mc. 25.47 met: Programme in English at 11.00 p.m.

CEYLON COMMERCIAL SERVICE

Radio Ceylon, Colombo, 15.12 mc. 19.83 met: Heard from 1.10 a.m.—gives request records at 2.00 a.m.

Radio Ceylon, Colombo, 11.98 mc. 25.04 met: 9.30 p.m.-2.45 a.m.

Formosa

"The Voice of Free China", Taipeh: 11.725 mc. 29.59 met: News in English at 9.30 p.m. followed by French (Rex Gillett).

India

VUD-5, DELHI: 7.27 mc. 41.24 met: English for Europe 5.00-6.00 a.m.

VUD-5, DELHI: 9.575 mc. 31.35 met: English for Europe 5.00-6.00 a.m.

Korea

HLKA, Seoul: 7.933 mc. 37.83 met: Can be identified by "This is HLKA" which is announced every 30 minutes. Programme is in Korean.

Pakistan

Radio Pakistan, Karachi, 5.98 mc. 50.17 met: 4.30-4.45 a.m. (News in English).

Radio Pakistan, Karachi, 7.263 mc. 41.32 met: 11.30 p.m.-12.15 a.m., 2.00-3.00 a.m.

Radio Pakistan, Karachi, 9.645 mc. 31.11 met: Noon-2.00 p.m., 12.15-1.45 a.m., 2.00-3.00 a.m.

Radio Pakistan, Karachi, 11.75 mc. 25.55 met: 10.30-11.15 p.m., 11.30 p.m.-1.45 a.m.

Radio Pakistan, Karachi, 11.885 mc. 25.24 met: 4.30-6.30 p.m., 10.00-11.15 p.m., 2.00-4.30 a.m., 5.00-5.45 a.m.

Radio Pakistan, Karachi, 15.27 mc. 19.661 met: 4.10-6.30 p.m.

Radio Pakistan, Karachi, 15.335 mc. 19.55 met: 11.45 a.m.-2.00 p.m.

Radio Pakistan, Karachi, 17.77 mc. 16.81 met: News at 10.00 p.m.

AFRICA

Anglo-Egyptian Sudan

Anglo-Egyptian Sudan, Khartoum, 9.746 mc. 30.781 met: Daily, in Arabic from 2.15-2.45 p.m.; daily (except Saturdays), 2.30-4.00 a.m., 5.00-5.30 a.m.; Saturdays, 2.30-3.30 a.m., 5.00-5.30 a.m.; Fridays, 6.00-7.30 p.m.; Saturdays, midnight-1.00 a.m.; Saturdays, in English, 3.30-4.00 a.m.

Turkey

TAS, Ankara, 7.285 mc. 41.19 met: Heard in English 7.00-7.45 a.m.

TAT, Ankara, 9.515 mc. 31.45 met: English from 7.00-7.45 a.m.

TAP, Ankara, 9.465 mc. 31.7 met: English from 7.00-7.45 a.m.

VIDEO I.F. AMPLIFIER DESIGN

(Continued from Page 24.)

If this stage "figure of merit" is divided by the required overall bandwidth of the amplifier, the result (18.1 or about 25 db.) is the mean stage gain available using 6KA5s. Therefore, three stages, properly staggered should be capable of providing the specified 75 db. gain. Table II gives the value of frequency and bandwidth to which each of the four coupling networks associated with the three stages must be adjusted to form a flat staggered-quadruple. In this example, the factor d, which is equal to the bandwidth divided by the centre frequency, is 4/24 = .166. Using this figure in Table II indicates the four circuits should be stagger-tuned to: 24.76, 23.24, 25.84, and 22.16 megacycles with the bandwidths adjusted to, 3.77, 3.56, 1.63, and 1.39 megacycles, respectively. Knowing the required banwidths and the value of total C per stage, the values of the needed loading resistors may easily be found from the equation for the bandwidth of a single-tuned stage (Eq. 2). Solving for R in this equation yields values of 3845, 4060, 8900, and 10,400 ohms, in the order of decreasing bandwidth. In practice, the next higher standard values of resistance may be used, since other tube and circuit resistances are in parallel with the loading resistors and lower the total effective value somewhat. The inductances required to resonate with 11 uuf. distributed circuit capacitance at the above stagger-frequencies may be determined by the use of a reactance calculator, a "Q Meter" where available, or by empirical formulas. Since additional capacitance is very detrimental to the gain-bandwidth product of the stage, the coils should be self-resonant with the circuit capacity or tuned with high quality powered-iron slugs.

When resistors and inductors corresponding to the values determined for R and L are inserted in typical single-tuned stages such as that shown in Fig. 2, and these stages are connected in cascade, the resulting stagger-tuned amplifier is non-critical to adjust and will compare favourably with more complex types in performance. The overall gain-bandwidth produce is better than a synchronously tuned amplifier of the same number of stages by a factor greater than two. Alignment is accomplished by connecting a standard AM signal generator to the input of the amplifier and an amplitude indicating device such as a voltmeter to the output.

The signal generator may then be set to the recommended stagger frequencies in succession and the individual stage corresponding to that frequency peaked for maximum output response. Due to the isolating action of the tubes, there is virtually no interaction between stages while tuning. This is in sharp contrast to the procedure with double-tuned or triple-tuned circuits. In this case, a swept-frequency signal source and an oscilloscope must usually be connected to the input and output (respectively) of each stage in succession and the coupled circuits tuned and retuned until the desired response is observed on the 'scope. If adjacent-channel and sound carrier frequency "traps" such as are found in most television video I.F. amplifiers are incorporated in the single-tuned system, some slight tuning interaction may be noted.

AUDIO FREQUENCY METER

(Continued from Page 21.)

In practice, it is found that the time constant of the load resistor and the condensor C must be approximately equal to one-fifth of the time of one half-cycle of the square-wave input. If this fact is taken into consideration at the same time as the equation which predicts the meter current, it is found that there is a maximum meter current, irrespective of frequency, up to which the indications are linear with respect to frequency. Now as long as this maximum current is well above the full-scale current of the meter used, then we shall have no trouble from this source of inaccuracy, and the overall accuracy of the meter will depend solely on the accuracy of the indicating meter and the stability with which the square-wave voltage is generated. For those who may wish to use other meters than a 0-1 ma. movement the formula giving the maximum allowable meter current is:—

$$i < \frac{V}{9.2R}$$

where i is in amps, V in volts, and R in ohms.

(To be continued).

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