RADIO and ELECTRONICS

ELECTRICITY — COMMUNICATIONS — SERVICE — SOUND

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Home-made High-quality Pick-up

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A New 3 in. Oscillo-scope

•

Radio in Civil Aviation —Part 2

JULY 1st, 1950 VOL. 5, NO. 5

1/10

Advance SIGNAL GENERATORS

TYPE B3

FREQUENCY RANGE: 100 Kc/s.-30 Mc/s. in 5 ranges.
CALIBRATION ACCURACY: ± 1%.
OUTPUT VOLTAGE: The output voltage is obtained from the end of a 75-ohm matched transmission line. Continuously variable from 1 μV to 100 mV.
OUTPUT IMPEDANCE: The output impedance is 75 ohms, normally matched into a 75-ohm terminating pad type TP.1 providing 37 ohms, 10 ohms, and a standard 10-ohm dummy aerial.
MODULATION: Internal modulation is provided at two levels, 10% and 30% at 400 c/s. External modulation requires 9 volts into an impedance of 10,000 ohms for 30% modulation.
R.F. LEAKAGE: Triple shielding of the oscillator has reduced the radiation from the instrument to a negligible amount.
POWER SUPPLY: 100-260 volts, 40-100 c/s., 14 watts.
DIMENSIONS: 12¼" x 13¼" x 10" deep.
WEIGHT: 26 lb.

TYPE E2

(Illustrated)
FREQUENCY RANGE: 100 Kc/s.-60 Mc/s. in 6 ranges.
CALIBRATION ACCURACY: ± 1%.
OUTPUT VOLTAGE: Approximately 1 volt is available at the full R.F. socket. The attenuators give a continuously variable output from 1 μV to 100 mV.
OUTPUT IMPEDANCE: The output impedance of the attenuator is 75 ohms. Normally this is matched with a 75-ohm terminating pad, type T.P.1, providing 37 ohms, 10 ohms, and a standard 10-ohm dummy aerial.
LEAKAGE: Negligible—less than 3 μV.
POWER SUPPLY: 110-210-230-250 volts, 40-100 c/s., 20 watts.
DIMENSIONS: 13" x 10½" x 7¾" deep overall.
WEIGHT: 15 lb.
FINISH: The case is finished in an attractive cream enamel, fitted with a leather carrying handle.

TYPE B4

A Wide Band Sub-Standard Instrument

FREQUENCY RANGE: Model A, 100 Kc/s.-70 Mc/s. in 6 bands. Model B, 30 Kc/s.-30 Mc/s. in 6 bands.
CALIBRATION ACCURACY: ± 1%. Directly calibrated.
OUTPUT VOLTAGE 1 μV-150 mV up to 30 Mc/s. 1 μV-100 mV above 30 Mc/s. Monitored by crystal voltmeter.
OUTPUT IMPEDANCE: 75 ohms, terminated by 75-ohm terminating pad type TP.1, providing impedance of 37 ohms, 10 ohms, and 10-ohm standard dummy aerial.

MODULATION: Internal 400 c/s., 0-50%. External, 100-10,000 c/s. ± 6 db., 0-80%.

AUDIO OUTPUT: 0-15 volts at approximately 400 c/s. into a load not less than 5,000 ohms.

R.F. LEAKAGE: Negligible—less than 1 μV.

POWER SUPPLY: 110-210-230-250 volts, 40-100 c/s. 22 watts.

DIMENSIONS: 13" x 12" x 6" deep.

WEIGHT: 25 lb.

IN THE NEXT ISSUE OF "RADIO AND ELECTRONICS" WE SHALL FEATURE DETAILS OF AUDIO AND V.H.F. SIGNAL GENERATORS

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RADIO and ELECTRONICS

Vol. 5, No. 5 July, 1st, 1950

OUR COVER:

This month we have a view of the aerial system for a 2000 mc/sec. radio link which provides 23 telephone circuits over a distance of 46 miles from Fraser's Mountain, Nova Scotia, to Charlottetown, Prince Edward Island. The radio link is used in preference to cables because of the ability of storms in Northumberland Strait to break submarine cables. Pulse-time multiplex modulation is used to put the 23 channels on the same R.F. carrier.

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Sound Reproduction and the Public

In these enlightened times it is the exception rather than the rule for exponents of new ideas to be pilloried for their pains. We have rather become sated with a multitude of wonders; so much so that the technical virtuosity inherent in the successful application of things like radar and television tends to become forgotten, or merely taken for granted. It is thus a little much to expect that the public should throw their caps in the air, metaphorically speaking, over such commonplace matters as the improvement in the quality of reproduced music. Perhaps the technical man does not really expect a great deal of favourable reaction from non-technical people these days, which is just as well, because in general, he will not get it. What does hurt, though is not so much a disinterested attitude, but actual opposition to technical improvements that the technician is quite certain he has made. He feels much as the early protagonists of outstanding medical and surgical advances must have felt when their brain-children were prevented from playing their part in the scheme of things through ignorance and intolerance.

The classic example in the field of sound reproduction is the public aversion to systems with a wide frequency range. But here, the fault has often been not with the public, but with the reformers. In America, some years ago, a great commercial "build-up" was given to such systems with the aid of the convenient tag "High-fidelity." The public reaction was not favourable, and to this day arguments are going on as to whether wide frequency range is acceptable to the non-technical listener *provided that all forms of distortion are reduced to a low enough level.* As yet, we do not know the answer to that one, because to obtain an answer is a long and costly business involving large-scale statistical studies which can be undertaken only by organizations which have the time and money to spend on such things. However, of recent years, we, the technicians, have made considerable strides towards laying that extremely substantial ghost distortion. And a particularly malignant spirit it is, capable of numerous manifestations. Just as we think one spectre has been exorcised, another one rears its head, and so the business goes on.

But there are signs that we are at last getting somewhere. Major advances in the design of main components like loudspeakers and gramophone pick-ups, together with parallel improvements in circuit design, have allowed us to record and reproduce music with a faithfulness unheard of only a few years ago; the radio set of today is a far cry from the first receivers that were made and sold in quantity shortly after the advent of broadcasting. The very fact that radio sets have ceased to be a nine days' wonder has helped to focus the listener's attention on *what* he hears, rather than on the previously marvellous fact that he heard anything at all! It seems to us, therefore, that the situation where improvements in the quality of reproduction are actually resisted is slowly disappearing. A little careful thought will probably convince many that this is so.

For example, the writer has always attempted to have in his home a receiver and record-player which gave as good results as were consistent with the depth of his pocket (never very capacious, let it be said) and which could reasonably be described as better than average. It has been distinctly noticeable over the last few years, since the developments in speakers, pick-ups and amplifiers, of which we spoke above, that people with an entirely non-technical background, on hearing the outfit for the first time, have commented favourably on it, without even having been asked to express an opinion. No doubt others have had the same experience, and this effect, slight though it may be, appears to be a reliable indication that the electrical reproduction of music has begun to reach a stage where it is comparatively easy to demonstrate a significant improvement over what might be described as the standard performance of the day. Nor is this the only thing. It is significant that the manufacturers of radio sets and radio-gramophones are actively searching for equipment and techniques which will enable them to improve the quality of their products, by both technical and aesthetic standards. This is a sure sign that there *is* a demand for better reproduction. The future is at least a little brighter than it used to be, when what the technician described as an advance was rejected on the grounds that it sounded, not better, but worse! That this is so can, we think, be directly attributed to the fact that we technical people now know more about the problems involved, than we used to, and should be an added incentive towards improving our technique and extending our knowledge still further.

An Easily Built 3 in. Oscilloscope for General Purpose Use

IT is some time now since the supply of cheap cathode ray tubes, ex war surplus was exhausted, and post-war C.R.T.s have been available for some time at a reasonable price. The article therefore describes a simple and inexpensive oscilloscope circuit suitable for a modern 3 in. tube. It uses only three valves, exclusive of the tube and two rectifiers, and is extremely compact. The power supply built in a separate unit makes it a simple matter to avoid magnetic hum without the use of a hard-to-come-by mu-metal C.R.T. shield.

INTRODUCTION

Some time ago, there were released from war surplus stocks a relatively large number of 3 in. cathode ray tubes, and a smaller number of 3 in. tubes. These were purchased at very low prices, and we have already published oscilloscope designs suitable for both these types of tube. However, anyone wanting to build himself an oscilloscope at the present time is at rather a disadvantage, since stocks of the cheap tubes are no longer available. It is necessary, then, to purchase a tube on the open market and, unfortunately, to pay something like the normal price for it. Luckily, though, there is at least one very useful C.R.T. on the market at less than £5, complete with its special socket. This tube, the Osram E-4102, has an effective screen diameter of 2¾ in.—slightly smaller than the more usual 3 in. tube—a length of only 7¼ in. overall. This latter is a great improvement from the point of view of portability, because the whole instrument can be made in a length of 9 in. or 2¼ in. less than the length of a 3AP1 itself. Of course, with such a short "throw" for the electron beam, the sensitivity is not as great as that of the 3AP1, but the E-4102 is not so insensitive as to cause difficulty, and it has other advantages besides its shortness. For example, it has all electrodes brought out to base pins, making it much more flexible in use than many other small tubes. It is possible, for instance, to use balanced deflection circuits, which cannot be done with a tube which has one of each pair of deflection plates tied to the final anode. Also, the cathode and heater are separately brought out, and this makes it possible to feed voltages to the cathode in order to produce special effects, such as blacking out the flyback of the saw-tooth sweep voltage. This is often more convenient than using the control grid for the same purpose.

In short, these tubes are excellent ones round which to build an oscilloscope circuit, particularly since they have a quite wide range of anode voltage over which it is stated that they will work satisfactorily. In designing the present instrument, we have taken a number of things into consideration, not least among them being cheapness and ease of construction. For instance, by using a special circuit trick we have enabled an E.H.T. voltage of 1100 to be obtained *without the use of a separate high-voltage* transformer. Only the one power transformer is used, supplying two output voltages, one for the amplifiers and time base circuit, and the other for the C.R.T. itself.

REVIEW OF FEATURES INCORPORATED

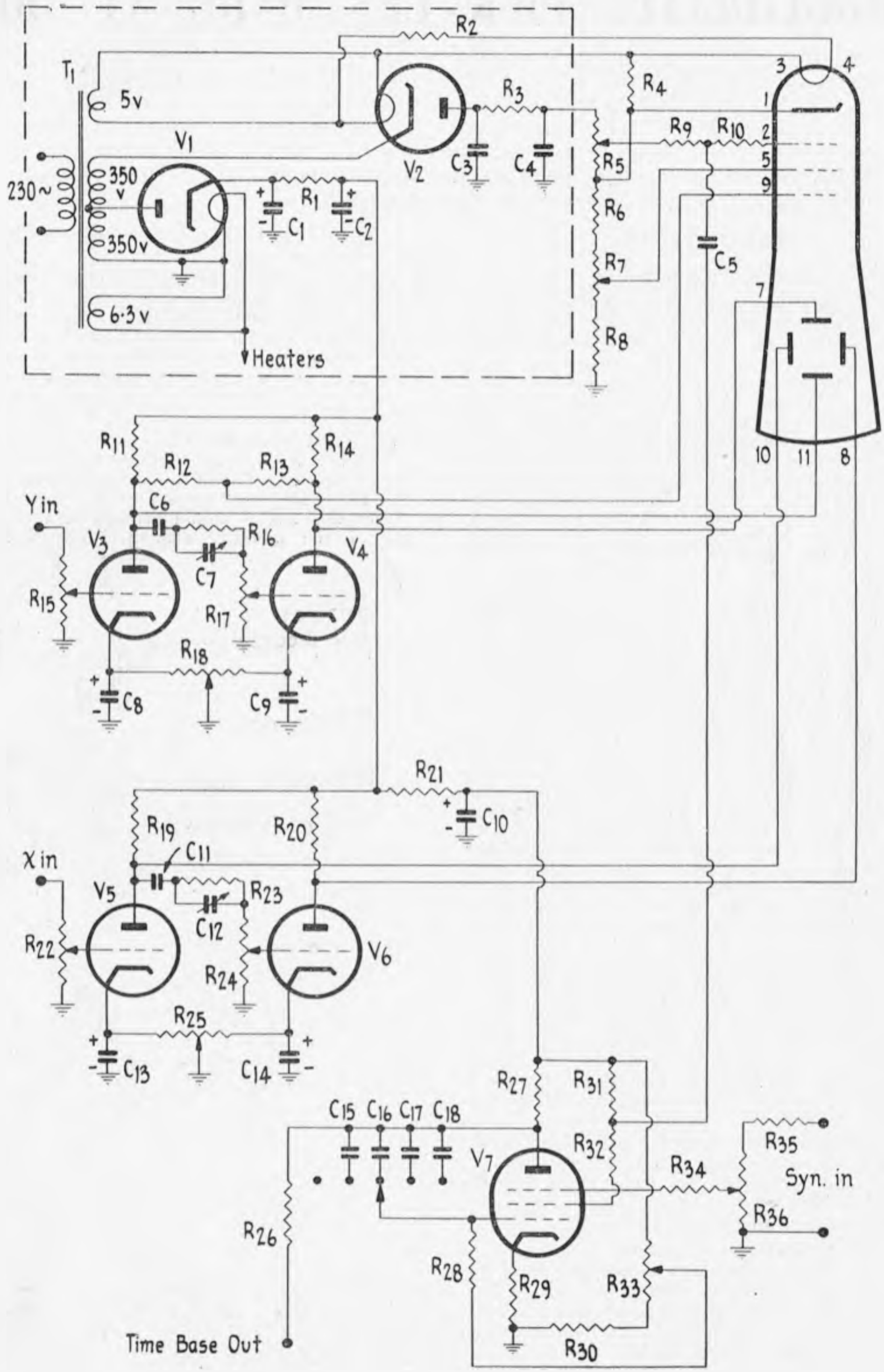
In describing an instrument like this one it is just as well to give a list of the circuit features embodied, because this is the quickest way of giving a generalized description. So here goes!

(1) Balanced deflection for both X and Y bases.
(2) Direct coupling from the amplifiers to the deflection plates.
(3) Only one double-triode used in the amplifier for each axis.
(4) Single-tube hard-valve time-base (not transitron).
(5) Provision for blacking out the flyback without using an extra valve.
(6) Simple balanced shift circuit operating on the amplifier valves, and requiring no ganged potentiometers or complex resistor networks.
(7) H.T. and E.H.T. voltage both derived from the same transformer, which is a standard receiving type.
(8) Excellent spot size due to the use of 1100 volts E.H.T. on the cathode ray tube.
(9) No blocking condensers between the input terminals and the deflecting plates (if desired) enabling the amplifiers to respond to D.C. changes if necessary. Blocking condensers can still be used when necessary.
(10) Frequency response of amplifiers limited to audio

(Continued on Page 26.)

COMPONENT LIST

V_1, V_2, 6X5.
V_3, V_4, ECC35.
V_5, V_6, ECC35.
V_7, 6AC7.
C.R.T., E4102.
T_1, Receiver power transformer.
R_1, R_{31}, 5k.
R_2, 1 ohm.
R_3, R_4, 10k.
R_5, R_9, R_{10}, R_{12}, R_{13}, R_{33}, 1 meg.
R_6, R_{16}, R_{25}, 10k. pot.
R_7, R_{17}, R_{21}, 100k. pot.
R_8, R_{27}, R_{32}, 100k.
R_{14}, R_{11}, R_{19}, R_{26}, 250k.
R_{15}, R_{22}, 500k. pot.
R_{18}, R_{23}, 3 meg.
R_{24}, R_{30}, R_{34}, 50k.
R_{20}, R_{28}, 500k.
R_{29}, 500 ohms.
R_{35}, 250k. pot.
R_{36}, 50k. pot.
C_1, C_{10}, 8 µf. electro.
C_2, 16 µf. 500v. electro.
C_3, C_1, 1 µf. 1000v.
C_5, 0.002 µf. 1500v.
C_4, C_{11}, C_{15}, 0.05 µf. 500v.
C_7, C_{12}, 3–30 µµf. Philips trimmer.
C_6, C_9, C_{13}, C_{14}, 25 µf. 25v. electro.
C_{16}, 0.001 µf. 500v.
C_{17}, 0.00025 µf. mica.
C_{18}, 0.0001 µf. mica.



T1
5v
V1
350 v
350v
230~
6·3 v
Heaters
V2
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
C1
C2
C3
C4
C5
1
2
3
4
5
7
8
9
10
11
Yin
R11
R12
R13
R14
R15
R16
R17
R18
C6
C7
C8
C9
V3
V4
R19
R20
R21
R22
R23
R24
R25
C10
C11
C12
C13
C14
Xin
V5
V6
C15 C16 C17 C18
V7
R26
R27
R28
R29
R30
R31
R32
R33
R34
R35
R36
Syn. in
Time Base Out

HIGH-FIDELITY PICK-UPS MADE AT HOME

IT IS well known that the best gramophone pick-ups, as well as being the most expensive, are of the simplest construction, have the lowest electrical output, and the lowest weight on the record. Not so generally known is the fact that the possessor of a pair of pliers, a vice, a file, and some patience, can in a few hours build himself a pick-up that will measure up to the performance of the best commercial units. As an experiment, a pick-up was made by hand in our own laboratory, and the results were so outstandingly good that the design is published here to give those who are experimentally inclined a starting point for their own work.

INTRODUCTION

The pick-up has always been looked upon with a certain amount of awe by those who like to build as much of their own equipment as possible. It seems to be tacitly agreed that while the amateur experimenter may profitably build his own receiver or high-quality amplifier, only those with a manufacturer's workshop facilities can attempt to make pick-ups with any prospect of success. Actually, quite a number of experimenters have in the past made their own pick-ups, with varying degrees of success, and in overseas publications there have been from time to time descriptions of designs that seemed to be specially suited to manufacture in the home workshop, with its limited facilities. However, one reason why amateurs never seem to have taken this aspect of constuction seriously is that the work is undoubtedly "fiddly," and the results supposedly unpredictable.

Things should be different now, though, because the principles underlying the pick-up are very much better understood now than they once were, and it has been found that the best pick-ups are those whose internal construction is the simplest and lightest, especially in the part attached to the moving needle-point. In fact, one has only to look at the contsruction of a high-class commercial pick-up to say (with reservations, of course) "Why, there's nothing in it!" Of course, this is not strictly true, because what does not appear to the eye is the time spent in developing the design and rendering it suitable for manufacture, not to mention the difficulties in making, on a large-scale basis, extremely small parts which must conform very accurately to standard dimensions and characteristics. Even so, an examination of some of the more popular types of good-quality pick-up revealed that their construction was fundamentally of so simple a character that we thought it should not be too difficult to design one which could be made fairly easily with tools likely to be found in any experimenter's workshop. After some initial work which gave decidedly negative results, through trying to copy a manufacturer's design, it was decided to branch off on a rather different line, from which the final results surprised no one more than ourselves by their excellence. The finished article which it should be possible to duplicate with ease, had the following desirable characteristics:—

(1) After pre-amplification and equalization for the recording characteristic, a response was achieved that is flat within plus or minus 1½ db. between 50 and 15,000 c/sec.

(2) Semi-permanent sapphire stylus.

(3) A weight on the stylus of ¾ ounce.

(4) Direct acoustic output almost inaudible at a distance of six feet from the turn-table.

(5) Excellent wave-form at all frequencies.

(6) Ability to play through the heaviest recorded passages without any sign of "hash."

(7) Ability to play satisfactorily records that were so worn as to be unusable even with good commercial pick-ups.

(8) Results audibly better than those from all except one type of commercial pick-up. The latter type is not available, being of American origin.

(9) Output voltage, approximately 1 millivolt.

(10) Output impedance 50 ohms approximately.

(11) Cost of materials, 14/-, approximately 10/6 of which is accounted for by a sapphire-tipped needle, whose tip is removed to make the stylus.

(12) If and when the stylus wears out, about half an hour's work would suffice to make a new armature complete, and even less if the original armature is to be used, and the new stylus cemented in place.

After this list, it would perhaps be useful to detail some of the desirable characteristics of high-quality

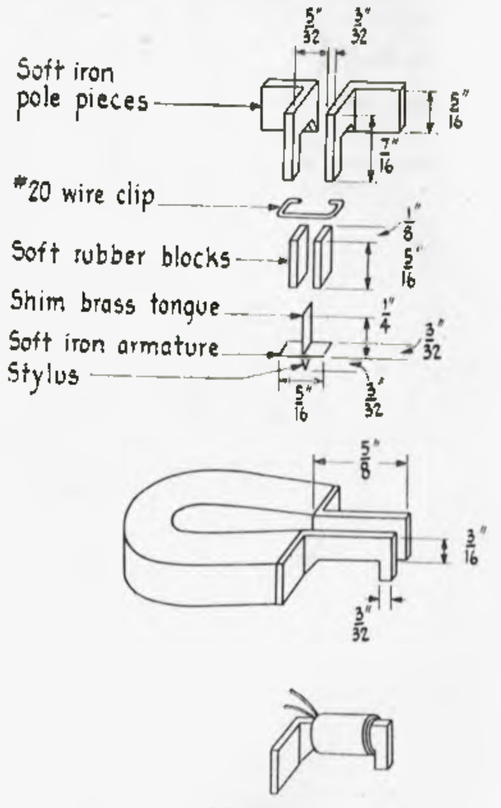


Fig. 1

An "exploded" view of the construction of the pick-up. The parts are not drawn to scale, but all important dimensions are given. The coil winding is described in the next.

pick-ups, and to see to what extent the present design fulfils the requirements.

SOME CONSIDERATIONS AFFECTING HIGH-QUALITY PICK-UPS

The problem of the high-quality pick-up is by no means a simple one, when it comes to putting into practice all the features that theory says are desirable, but many of these features are readily enough understood when put into ordinary language.

(1) The stylus point must be able to move as freely as possible in the direction at right-angles to the general direction of the record groove. In other words, the lateral compliance must be high. This is in order that the "waviness" of the groove, which constitutes the recorded sound, may be followed as easily as possible. When this happens, the motion of the stylus follows the shape of the waviness as exactly as possible, and other things being equal, a distortionless output results.

(2) There must be some kind of restoring force which ensures that in the absence of modulation of the groove, the stylus takes up a central position. Its excursions on either side of the mean position of the unmodulated groove will then be made equally easily, *i.e.*, no more force will be required to move the stylus a given distance on one side of the central position than is required to move it an equal distance on the other side.

(3) The construction of the moving part (*i.e.*, the stylus tip and the part which is made to vibrate through its agency) must be such that for vibration frequencies within and even beyond the audio frequency range, no mechanical resonances occur. If they do, there will exist a corresponding electrical resonance, which shows up as a greatly increased output at and around the frequency of the resonance. In short, a peak in the response.

(4) The output voltage of the pick-up must follow either a constant-velocity or a constant amplitude law over as wide a range of frequencies. In other words, whichever principle of operation the pick-up uses, its response must be flat.

(5) At all frequencies, it must produce as little waveform distortion as possible. This means that whatever the exact shape of the record groove's excursions, the stylus must be able to follow the groove exactly. In addition, there must be a linear relationship between the degree of mechanical movement and the voltage output, for if this is not so, the output wave-form will be distorted.

(6) It must be capable of playing very low frequencies without leaving the groove. Some pick-ups will not play at all a test cut of a frequency lower than 150 c/sec., either trying to, or actually jumping right out of the groove. In the past this occurred even with pick-ups which were supposed to be good in their class.

(7) The pick-up must be such that as little wear as possible is caused to the record.

(8) The pick-up must cause as little direct acoustic noise as possible—ideally, none at all. No pick-ups comply with this requirement absolutely, and it is interesting to note that other things being equal, the pick-up which makes the least amount of direct noise will be the best.

This list appears at first sight so formidable that to conform with all the desired characteristics might be deemed impossible. Luckily, however, it is found in practice that the more point (1) is complied with, the more nearly do the other desirable characteristics arise automatically. In other words, by attending to one or two points which seem to be fundamental, most of the remaining desiderata are achieved without striving for them. What, then, are the really important points?

THE MOST IMPORTANT FEATURES

Without doubt, the most important of the eight points above are numbers (1) to (3). If it so happened that the only forces on the stylus were lateral ones, there would be no other considerations worth worrying about once these three have been satisfied, but unfortunately, other forces come into play which can be regarded as departures of the system from the ideal, and which though exceedingly important, we will ignore for the moment, reserving them for special comment afterwards.

HIGH LATERAL COMPLIANCE

The importance of this should be immediately obvious if a little thought is given to the process of reproduction from a record. Basically this consists solely of transferring from the record the lateral excursions of the groove, and applying them to the stylus in such a way that the latter reproduces the movements of the recording stylus when it was making the record. If it is assumed that some means is available of creating electrical output voltages of wave-form exactly corresponding to the movements of the stylus, then that waveform will be a replica of the one fed to the recording head during the recording process, and we will have achieved the purpose with which we set out. It can thus be seen that the problem is above all a mechanical one, rather than an electrical one. This is brought out by the wording of (1) above. Again, it should be emphasized that if the recording process was a perfect one, then requirements (1) and (2) between them would constitute a complete specification of the requirements of the pick-up. Now let us see where we get to if we attempt to fulfil (1).

The early gramophones, which used acoustic reproduction, had a stylus in the form of the well-known "gramophone needle." When screwed into the chuck, lateral vibrations of the tip of the needle were transferred by a lever to the centre of a diaphragm, as often as not made of mica or some such stiff material. Unless the diaphragm was made very stiff, it was almost impossible to prevent it from showing mechanical resonances, which, of course, showed up as very nasty peaks in the acoustic response of the instrument. This was the main reason for making the whole moving system of needle, lever, and diaphragm so stiff. In other words its compliance was very low. Now if we have a moving system of this nature, the only way of making it follow the grooves of the record at all faithfully is to make it very heavy. A little thought will show why. With a very stiff moving system, the inertia of the "head" as a whole must be much greater than that of the moving parts. If it is not, the whole head will vibrate instead of just the centre of the diaphragm. This vibration of the whole tone-arm will make a great deal of mechanical noise, but will have no effect at all on the column of air inside the tone arm, and it is this column of air that has to be made to vibrate if any sound is to come out of the horn of the gramophone. In the case of the electric pick-up, the same considerations apply. If it is a magnetic one, the armature must vibrate relative to the structure of the head in order to produce electrical output, and any vibration of the head as a whole will do nothing but make a direct noise. If this were desirable, we would not need an amplifier and speaker at all! Thus, if the suspension of the stylus is stiff, then in order to prevent the head as a whole from vibrating, we will have to make the head very heavy. Old-fashioned tone-arms placed a

(Continued on Page 35.)

MEASURING POWER AT VERY HIGH FREQUENCIES

PART II

CALIBRATION OF THE LAMPS

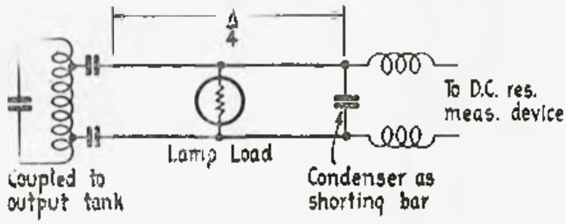
Before the lamps can be used for their intended purpose, they must be calibrated. To do this, some batteries, a potentiometer, a voltmeter, and a multi-range milliammeter are needed. A simple circuit is wired up, with the batteries, the potentiometer (connected as a rheostat) and one of the lamp units in series. It is a good plan also to include a key in the circuit, so that the fairly heavy drain on the batteries will occur only when measurements are being taken. The only remaining component is the voltmeter. This must be connected *across the lamp unit that is being calibrated,* and not across the battery, because the rheostat will vary both voltage applied to, and current drawn by, the lamp. In this way, we do not rely at all on a knowledge of the battery voltage under load, nor do we have to worry about the fact that the battery voltage will certainly drop from its open-circuit value when the load is connected.

The next thing to do is to prepare a table for the readings that are to be taken. In the first column, we put current readings, and in the second, voltage readings. There should also be room on the paper for two more columns, the first headed "Power," and the second, "Resistance." These two columns are calculated from the first two, after all readings have been taken. For a single 6.3-volt lamp, a fresh battery of this or a little more voltage should be used. The readings will be facilitated if accumulators can be used, since these will not change their voltage appreciably under load while the readings are being taken. Failing this, No. 6 dry cells are excellent, because of their large capacity. But if no suitable batteries are on hand, and some have to be bought specially for the calibration, the best ones to buy are several 9-volt bias batteries. If these are used, one will have to be prepared for them to be ruined in the process, and charged up against the construction of the calibrated lamps. For six in series, a rather high voltage would be needed, and so it is best to connect six lamps in series-parallel, when only about 20 volts will be needed. In our own case, this was done. If there is a partially run-down 45-volt B battery available, this can be pressed into service for the highest voltages, as long as it need not be used again for anything else afterwards! The calibration process is very simple and straight-forward, although one or two precautions are necessary. The chief one is to take the voltage and current readings as nearly simultaneously as possible. If the battery voltage did not change under load, this would not matter, but when dry cells are used, particularly under heavier loads than those for which they were really intended, the drop will be quite rapid, and if any delay is made in reading the meters, the results will be either too high or too low, according to which meter is read first. It is thus a good plan if possible to have two meter-readers, with one in control. This person has the key and the rheostat, and proceeds as follows: The key is pressed and held down. As quickly as possible, the rheostat is turned until the current meter reads a pre-determined figure. As soon as the pointer reaches the pre-determined spot, the controller calls out "Read!" whereupon the assistant reads the voltmeter as speedily as possible, saying "Right" as soon as he has made his reading. While the reading is going on (the assistant will need more time than the controller because the latter knows what mark he is going to adjust the current to, while the assistant does not know where his meter will read) the controller keeps on looking at his current meter, and if this has dropped while the assistant has been making his reading, he decides to discard the whole reading, and try again. At the higher currents, it is best to take a number of readings for each pre-determined current value, and strike an average; this will give a much more accurate result.

When the readings have been completed, the blank columns are filled in by calculation from the current and voltage, and the results are plotted on graph paper, preferably with resistance plotted horizontally, and power vertically. The calibration is now complete, and the lamp is ready for measuring R.F. power. To do this, however, the appropriate R.F. and D.C. circuit must be hooked up. This will be described next.

CONSTRUCTING THE MEASURING CIRCUIT

In our own case, the set-up was used primarily for power measurements on low-powered oscillators and frequency multipliers at ultra-high frequencies, and in particular in the 420 mc/sec. amateur band. However, the present description will serve whatever the frequency, as long as space is available for making a quarter-wave length of open-wire line, or something approaching it. The circuit can be seen in Fig. 4. The set-up consists of (a) a tuned circuit at the operating frequency, (b) a quarter-wave line at the same frequency, and (c) an ohm-meter capable of giving accurate readings of resistance within the range expected from the graph of the



The R.F. power measuring circuit for very high frequencies.

calibrated lamp. The quarter-wave line is constructed from heavy copper wire or thin rod, with a centre-to-centre spacing of about an inch. This close spacing helps to combat loss of power through radiation. The line is coupled to the tuned circuit by means of minute condensers. The higher the frequency, the smaller these can be, and at 420 mc/sec. they were no more than the capacity between the ends of the line and the insulated clips into which they were inserted. The insulation consisted of small pieces of cellophane tape, while the clips were contacts from an octal valve socket, soldered to the heavy copper "coil," at equal distances from the gap.

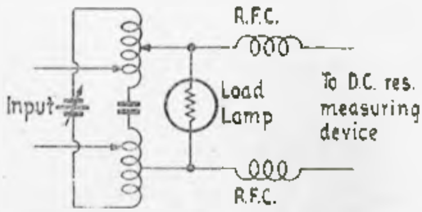
The tuned circuit consists of a cylinder cut from a 1 in. diameter piece of copper tubing, ¾ in. long. A gap 1/16 in. wide is cut in the piece of tube making it into a single-turn coil. The tuning condenser is a 3–30 $\mu\mu f$. Philips trimmer.

The whole thing is supported mechanically so that the "coil" can be coupled inductively to the output tank of the device whose power output is to be measured. First of all, enough coupling is used so that with the lamp tapped about half-way down the line, and the condenser adjusted to resonance, a glow can be seen in the lamp. Maximum power output can then be observed as maximum glow in the lamp. If the power is very small, and not enough to light the lamp, the ohm-meter can be connected across the end of the line remote from the tuned circuit; then, the change in resistance of the lamp can readily be seen long before it starts to show a glow, and maximum power output is represented by maximum resistance. After the initial tuning up of the load circuit, the lamp can be slid up and down the line, to find where it matches. Where the line matches the lamp impedance, a maximum will be found in power output, even though the coupling to the transmitter is not altered. The lamp is then permanently wired at this spot.

The circuit can be seen to excite the quarter-wave line without giving a parallel path for D.C. The large condenser at the far end of the line acts as a short-circuit to R.F., but blocks the D.C. Also, at the short-circuited end of a quarter-wave line, the R.F. impedance is zero, so that attaching the ohm-meter leads does not upset the R.F. operation of the circuit in any way. We thus have an R.F. load circuit, and a D.C. resistance-measuring circuit that are quite independent one of the other. In taking a measurement after the best spot has been found on the line for the lamp, the coupling to the transmitter is increased, and it will be found that the power output goes through a maximum as the optimum coupling is passed. The reading of the ohm-meter is the most sensitive indicator of maximum power output, and works even when the lamps are not glowing. However, in the best range for each lamp combination, a glow will be seen—in fact, about half brilliance is where the best measuring conditions obtain. Even so, the meter is far the best indicator of when the greatest output has been reached. At very high frequencies, the variable condenser of the tuned circuit may often be rather tricky to adjust exactly to resonance. If this is the case, there is no objection to setting the condenser somewhere near, and then using the condenser shorting bar as a fine adjustment. This gives a very smooth control, and makes quite adequate contact to the lines as long as the wires are wrapped round them two or three times.

USE AT LOWER FREQUENCIES

If it is desired to use this method of measurement at lower frequencies, where a quarter-wave line is too long for convenience, the circuit of Fig. 5 can be used in exactly the same way. Here we have only one tuned circuit. This represents the quarter-wave line, and the other one is not now necessary, because it is an easy matter to couple on the turns of the coil. In the V.H.F. case, the extra tuned circuit was used simply in order to get high-impedance coupling to the quarter-wave line, and thus avoid having to use the low-impedance end, where the resistance measuring circuit is attached, for coupling to the transmitter. The circuit is a balanced one, with a split-stator condenser. The coil is in two halves, connected together through a large condenser, of great enough capacity to have virtually no impedance at the operating frequency. About 0.001 or larger should be used, and the condenser should be a high-quality mica component. Thus, the condenser completes the R.F. circuit, as before, while separating the two halves in the D.C. sense, and allowing the ohm-meter to be connected at the centre of the tuned circuit, where there is no R.F. voltage, just as at the shorted end of a quarter-wave line. This time, the coupling may take the form of a link, tapped on to the coil, or feeding a two- or three-turn coupling coil, coupled at the centre in the usual way for balanced circuits. The lamp load is tapped across some of the coil in the usual way, and the circuit is adjusted resonance, and is also drawing rated power from the transmitter, as seen by the final plate current. The lamp must, of course, have been calibrated, and when all is in adjustment, the resistance is read, and applied to the exactly as a normal dummy load is, so that it is at graph to find the power output. In Fig. 5 are shown two R.F. chokes in the ohm-meter circuit. They should have as small a D.C. resistance as possible since they are in series with the measuring circuit, and tend to reduce the accuracy with which the load's resistance can be measured. However, it is only necessary to measure their resistance independently, and then to subtract this value from the measured resistance, to find the lamp resistance figure that must be applied to the graph.



Power measuring circuit for lower frequencies. The chokes R.F.C. must have a low resistance compared with that of the load lamp.

UNEQUAL CURRENT DISTRIBUTION

At V.H.F., it is not always possible to connect a number of lamps in series or series-parallel, because of the following effect. The whole thing may become so bulky, and the reactance of each individual lamp may be so high that when a number of them are connected in parallel or series, it is found that some lamps glow more brightly than others. Under these circumstances, it does not follow that the original premise about the D.C. resistance being a measure of the R.F. power through the load is still true. This is because of the non-linear nature of the resistance of the lamps. If the individual lamps are not equally brightly lit, showing that all are not passing the same current, it is highly likely that the D.C. resistance bears no simple relation to the power taken by the lamps, and the system of measurement breaks down. To guard against this when several lamps are used, it is advisable to use a series-parallel arrangement rather than a simple parallel or series one. It will be noted that this has been done in the six-lamp unit pictured in Fig. 3, and it is doubtful whether a greater number of these particular lamps would be practicable at the frequency used.

In order to avoid this trouble as far as possible, it is a better plan to use fewer more highly-rated lamps, and to see that these are of a type where the filaments are small and straight as possible. For slightly higher powers than we have been talking about, the straight-filament lamps used in motor-car trafficators would seem to have excellent possibilities in this application. They would be very easily connected in parallel without introducing much reactance, and are of a suitable length to connect straight across a line a little wider than 1½ in. spacing.

TREATMENT OF THE LAMPS

If any readers have been sufficiently impressed by this story to calibrate some lamps for this purpose, it should be pointed out that once made up and calibrated, they are measuring instruments, and not lamps any longer! That is to say, they should never be used simply as R.F. indicators, and should never be run in excess of full brilliance, as this will change their characteristics by evaporating some of their filaments, thereby making the calibration useless. If carefully used, however, their calibration should hold for quite a long time.

THE "RADIO AND ELECTRONICS" ABSTRACT SERVICE

AERIALS AND TRANSMISSION LINES

Construction details are given for several types of short-wave converters for use on the 75, 40, 20, and 10 metre amateur bands.

Radio and Television News (U.S.A.), March 1950, p. 38.

This paper reports the measured radiation characteristics of conical horns employing wave-guide excitation.

Proceedings of the I.R.E. (U.S.A.), March 1950, p. 249.

A shunt-excited flat-plate antenna is a structure comprised of a thin rectangular plate and a shunt feeding circuit formed by wire lying in the plane of the plate.

Proceedings of the I.R.E. (U.S.A.) March 1950, p. 280.

Methods are explained for coupling unbalanced to balanced lines and simple circuits are given for both fixed and adjustable impedance ratios.

QST (U.S.A.), April 1950, p. 20.

Here is a simple explanation of the action of dipole and reflector, stacked antennas, folded dipoles and of impedance calculations.

—*Radiotronics* (U.S.A.), February 1950, p. 15.

A treatise on "ghosts" such as may emerge from various types of television aerials—leading ghosts, trailing ghosts, etc., etc.

Radiotronics (U.S.A.) April 1950, p. 42.

AUDIO EQUIPMENT AND DESIGN

The exclusive use of magnetic tape in recording programmes provides an inexpensive solution to delayed broadcast problems.

—*Radio and Television News*, (U.S.A.), April 1950, p. 41.

"High fidelity." What does this term really mean? Here is a careful analysis of modern ideas in relation to the production of enjoyable music.

—*Radio and Television News*, (U.S.A.), April 1950, p. 52.

The fundamental aspects of magnetic tape recording, particularly for motion pictures, including a description of magnetic recording, reproducing and erasing head construction.

Audio Engineering, (U.S.A.), March 1950, p. 9

Steps to improve TV audio and attempts to improve the quality, a factor which has been somewhat neglected.

—*Audio Engineering*, (U.S.A.) March 1950, p. 14.

A few attractive designs are given for cabinets for audio systems.

—*Audio Engineering*, (U.S.A.), March 1950, p. 19.

The paper outlines briefly the advantages of disk as compared with other systems of recording.

Proceedings of the I.R.E., (U.S.A.), March 1950, p. 233.

CIRCUITS AND CIRCUIT ELEMENTS

Crystal controlled oscillators. Here is a review of crystal oscillators in relation to new types of crystals and tubes that are now on the market.

QST, (U.S.A.), March, p. 28.

ELECTRONIC DEVICES

A home-built electronic organ. Here are details of a musical novelty which appears not too involved to be within the realms of possibility.

Radio and Television News, (U.S.A.) March 1950, p. 43.

MATERIALS AND SUBSIDIARY TECHNIQUES

One of the main difficulties in the use of secondary-emission multiplier stages in thermionic valves is the instability of the secondary cathode. A study of the decay phenomena.

Proceedings of the I.E.E. (Eng.), Part III, March 1950, p. 55

MATHEMATICS

Articles written concerning dividing networks have failed to give the reader advice of how to wind inductances for these networks. The information is given here in digested form.

Radio and Television News, (U.S.A.) April 1950, p. 49.

Electron transit-time effects on the output and efficiency of some triodes having different geometrical structures have been studied and the results are given.

Wireless Engineer, (Eng.), February, 1950, p. 59.

Stresses in magnetic fields. A subject of interest to those to whom the elementary statements are inadequate.

Wireless Engineer, (Eng.), February, 1950, p. 35.

Practical calculation of magnetizing force. The design of much electrical machinery involves the evaluation of inductance from magnetic flux. This paper explains a geometrical method of calculating the magnetizing force in any practical case.

Proceedings of the I.E.E. (Eng.), March 1950, p. 37.

MEASUREMENTS AND TEST GEAR

The electronic switch. The oscilloscope is becoming one of the most important pieces of test equipment in present day servicing. Its versatility is greatly increased when used in conjunction with an electronic switch which is also a source of square wave frequency over a limited range.

Radio and Television News, (U.S.A.), April 1950, p. 39.

A radioactivity "sniffer." The bonus offered in U.S.A. by the Atomic Energy Commission for new uranium deposits has brought a demand for such instruments. A portable and convenient type is described.

Radio and Televison News, (U.S.A.), April, 1950, p. 47.

A TV linearity-pattern generator. This is an instrument designed to place horizontal and vertical lines on the screen of the CRT in the television receiver and serves as an accurate guide for setting the linearity of a receiver.

Radio and Television News, (U.S.A.), April 1950, p. 49.

Checking the response of an amplifier to a square-wave signal provides the fastest and easiest method of testing frequency response, phase-shift transient response, and similar characteristics of an amplifier. A wide-range square-wave clipper is described.

—*Radio and Television News*, (U.S.A), March 1950, p. 37.

INSTRUMENTS AND TEST GEAR

Due to its complex nature, impedance cannot be read directly on meters as can resistance, voltage, and current. The article describes a simple inexpensive "jig" or vacuum tube voltmeter accessory that requires no calibration.

—*Audio Engineering*, (U.S.A.), March 1950, p. 44.

MICROWAVE TECHNIQUES

The coaxial directional coupler of the Bethe-Hole type consists of two coaxial transmission lines crossed at an angle of 60 deg. and coupled by a single circular hole. The device should have perfect directivity at any wave-length.

—*Proceedings of the I.R.E.*, (U.S.A.), March 1950, p. 305.

PROPAGATION

The reflection of radio waves from a rough sea. When the sea is rough the reflected field will be a random fluctuating one, or at least will have a fluctuating component.

—*Proceedings of the I.R.E.*, (U.S.A.), March 1950, p. 301.

TRANSMITTING AND TRANSMITTERS

Several forms of multiplexing in which information from several sources is systematically combined and transmitted over a single channel have been described in literature. Recent advances make possible the sharing of a common channel without synchronization.

Proceedings of the I.R.E., (U.S.A.), March 1950, p. 270.

A controlled carrier modulation system is one that permits only enough carrier power at any instant to provide for distortionless detection at the receiver and it offers possibilities of lowered modulator power requirements.

QST, (U.S.A.), April 1950, p. 10.

(Concluded on page 48.)

For the Serviceman

The Columbus Models 66a and 6w

1. General Description.

This is a six valve two band receiver incorporating expanded short wave tuning. This model is notable for high sensitivity on both broadcast and short wave bands and, due to the use of a high-gain R.F. stage, signal-to-noise ratio is extremely good.

The short-wave band covers from 9,400 to 15,600 k.c. This range includes the three principal short wave bands at 19, 25, and 31 metres, which occupy three times the length of dial scale that would be taken up if the band spread principle were not incorporated. This results in greater ease of tuning and means that short wave stations that would normally be passed over, may be tuned in without difficulty.

A special oscillator circuit ensures that the oscillator frequency is unaffected by changes in A.V.C. voltage. This greatly reduces the effects of fading on short wave. To ensure constancy of calibration and alignment silvered-mica fixed condensers and high quality trimmers are used in all tuned circuits.

For Model 66A the valves used are as follows: (For Model 66W, see notes under circuit diagram.)

6K7G	R.F. Amplifier
6J8G	Converter
6B8G	I.F. Amplifier, Detector and A.V.C.
6J7G	Audio Amplifier
6V6G	Output
6X5G	Rectifier

2. Alignment Procedure.

This is fully covered in Service Bulletin No. 72. "Standard Line-up Procedure for Multiband Receivers," a copy of which is obtainable on application to the Engineering Department. The intermediate frequency is 455 k.c. and the line-up points are 1400 and 600 k.c. on broadcast and 15,000 k.c. on the short wave band.

3. Voltage Tests.

A.C.

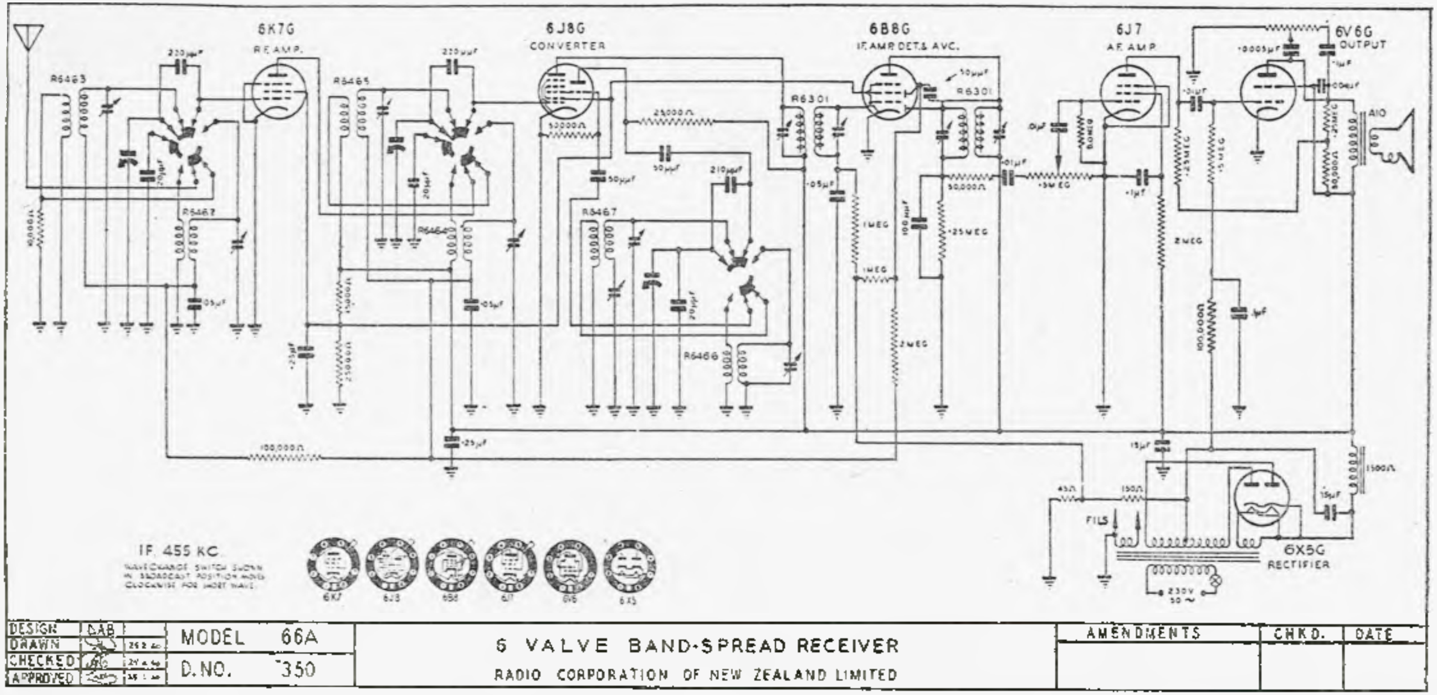
High voltage secondary of power transformer, from each rectifier plate to centre tap	335V.
Heater of Rectifier	6V.
All other Heaters	6V.
Dial Lamps	5V.

D.C. (Measured with a meter of 1000 ohms per volt sensitivity, between point indicated and chassis.)

First 15 mfd. electrolytic condenser	340V.
Second 15 mfd. electrolytic condenser	230V.
Screens of 6K7G, 6J8G and 6B8G	80V.
Plate of 6J7G	50V.
Cathode of 6J7G	0V.
Junction of 45 and 150 ohm resistors	3V.
Negative terminal of first 15 mfd. condenser	12.5V.

All measurements should be made with the receiver tuned to approximately 1000 k.c. and with o signal input.

MODELS 66A and 66W



Above Circuit applies to all Model 66A Serial Nos.: 50001 — 54800.
Tone Control Value: 0.5 meg.

Dial Scale: Model 66A OE8
Model 66W OE27

Pilot Light: 1 only Auto Type 6.3 v.

Wave Change Switch: 2H, 2XC, XE.

Output Transformer: Type A10.

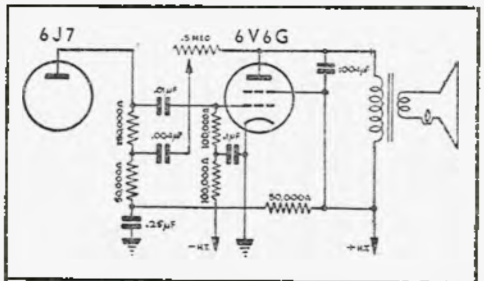
Condenser Gang: 66A Plessy E 3 Gang
66W R.C. Co. 317

Padder: Plessey 1760/4 (600 mmf)

Coils: Standard Coil Box

Power Transformer: Type T57

Note:—Model 66W uses 6SJ7 as audio amplifier and modification to tone and feedback circuits as shown in diagram on right.



MODIFICATION TO 66A TONE AND FEEDBACK CIRCUIT—

Serial Nos.: Model 66A, 67001—67324
Model 66W, All 66W's.

4. Resistance Tests.

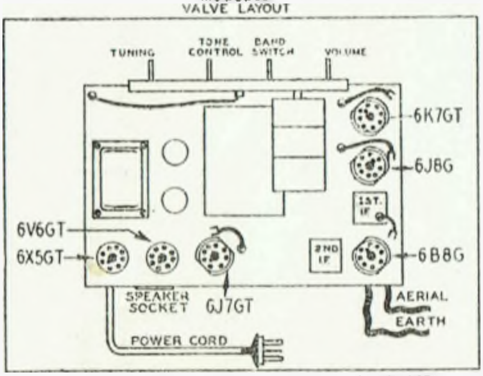
Where measured.	Approx. D.C. resistance in ohms.
Accross power trans. primary	45
Each rectifier plate to centre tap of power transformer secondary	300
Across speaker field	1500
Speaker transformer primary	500
I.F. transformer coils	7
B/C Aerial Primary	20
B/C Aerial Secondary	4
B/C R.F. Primary	70
B/C R.F. Secondary	4
B/C Osc. Primary	2
B/C Osc. Secondary	3
S/W Aerial, R.F. and Osc. Primary	0
S/W Aerial, R.F. and Osc. Secondary	0
Between positive terminal of first 15 mfd. electrolytic condenser and chassis	285
Between Cathode of 6J7 and chassis	0

5. Sensitivity Tests.

(Microvolts input to give standard output of 50 milliwatts.)

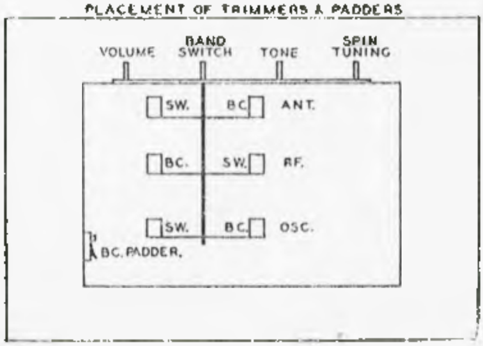
Frequency	Input to	Microvolts:
455 k.c.	Grid of 6B8G	4000
455 k.c.	Grid of 6J8G	75
1,400 k.c.	Aerial lead through standard dummy antenna	Under 1
1,000 k.c.	Aerial lead through standard dummy antenna	Under 1
600 k.c.	Aerial lead through standard dummy antenna	Under 1
15,200 k.c.	Aerial lead through standard dummy antenna	4.5
11,800 k.c.	Aerial lead through standard dummy antenna	6
9,600 k.c.	Aerial lead through standard dummy antenna	12

MODEL 66A
VALVE LAYOUT



With 66W, 6SJ7 is used in place of 6J7GT

MODEL 66A
PLACEMENT OF TRIMMERS & PADDERS



RADIO IN CIVIL AVIATION

(Continued from Previous Issue)

By W. S. JOYNER, A.M.I.E.E., A.M.N.Z.I.E.,

Chief Radio Engineer, Civil Aviation Branch, Air Department, Wellington

THE first article in this series outlined the general operational requirements of civil aviation in respect to telecommunications facilities and gave an historical review of the various war-time developments which were generally capable of forming the foundation of equipment for civil aviation purposes.

(i) INTRODUCTION

It will be recalled that the International Civil Aviation Organization (I.C.A.O.) allocated four main operational categories:

(i) Short Range Aids—up to 200 miles;
(ii) Long Range Aids—200 to 1,500 miles;
(iii) Aids to Blind Landing;
(iv) Aids to Air Traffic Control.

The present article will cover the Short Range Aids, will briefly review the reasons why certain highly successful wartime systems are not applicable to civil use and will give technical descriptions of systems in current use.

(ii) SHORT RANGE AIDS—HYPERBOLIC BLANKET COVER

The most popular wartime hyperbolic system was the British GEE, and many persons who had experience of this highly successful equipment find it difficult to understand why GEE has received such little attention for civil usage. The reasons are far from being entirely of a technical nature; but ignoring other factors, the technical objects are centred around the fact that regular, scheduled, aircraft traffic *must* follow "airways" or lanes between towns if they are to be flown with adequate margins of safety and with smooth traffic control particularly with respect to co-ordination and separation around the terminals. Any system which provides blanket cover with hyperbolic grid lines is not capable of being directly utilized for such "airway" flying. Systems must be used in which the pilot or co-pilot can select a required track and follow "Distance to go" and "Left-Right" indicators. Attempts have been made to produce track flying indicators from hyperbolic navigational grids, by balancing synthetically produced voltages representing the required track readings against those actually obtained in flight, but no satisfactory solution has been obtained.

Cathode ray tube display is also generally without favour for a civil short range aid, and while the weight of a wartime GEE aircraft set was far too great, developmental work and miniaturization could produce dial readings and lightweight equipment. A development of GEE, the GEE Track Guide, or the Australian Multi-track Radar Range shows considerable promise for airways use. One pair only of stations are placed astride each airway and tracks, with left-right indication if necessary can be provided along the centre of the designated airways.

No description of modern hyperbolic systems would be complete without a description of the British "Decca." As mentioned in the first article the system utilizes the fact that the locus of a point which moves such that it has a constant difference of range from two stations is an hyperbola. The Decca system measures this distance by using long waves, and assessing the phase difference between C.W. signals received from the synchronized ground stations. Ever since its operational inception as the British naval aid for the Normandy landings it has had striking success in the marine application and its direct meter presentation has facilitated its use. The order of accuracy is very high indeed, and over wide areas it is less than 100 yards, the average accuracy over the usable field being 1000 yards. The system has many ingenious features. For instance, it is almost impossible to receive simultaneously, but separately, two signals on the same frequency from two stations. The Decca system therefore uses frequencies at ground stations which are sub-multiples of a common

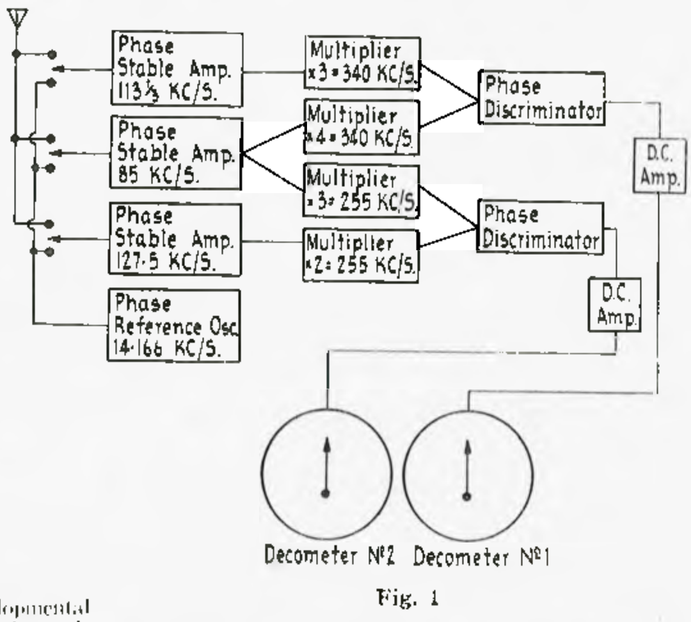


Fig. 1

frequency. The radio signals are separately received, and then multiplied by the requisite factors to bring them on to the common frequency; being C.W., the phase characteristics of the harmonic are identical with that of the received signal and the two phases may be compared. Fig. 1 illustrates this principle and indicates the order of frequencies used which is around 100 k/cs.

Irrespective of the length of the waves used it is obvious that phase readings must be repeated beyond the 360° and this factor of ambiguity was one which caused considerable delay for the application of Decca to aircraft navigation. Ships can usually position themselves to a very approximate point by virtue of the length of their voyages and the opportunities for stellar and solar navigation. Aircraft flying for hours cover the distance of days of ship transport, with nothing other than forecasted winds for dead reckoning, and this ambiguity could not be accepted. This problem has now been solved by essentially reversing the multiplying process of the normal readings, effectively increasing the wavelength and thus obtaining "coarse" fixes.

Fundamentally the system suffers from interference and other static difficulties associated with M/F but these have been largely overcome by very rigid frequency stabilization on the ground and the successful development of phase accurate receivers with an overall bandwidth of only 30 cycles.

For air traffic work the objections of any hyperbolic system apply. Decca originally produced one of the slightly different frequency. The aircraft receiver picks up the returned signal and measures the range as a time interval between its transmitted and received pulses.

Considerable dissension existed in the immediate post-war period as to the band of frequencies to be used for this function but it has now been decided to standardize upon the 1000 m/cs band in the United Kingdom and the U.S.A. for this equipment. Production valves are not yet available but developmental models are in use. In Australia the wartime frequency band of 200 m/cs is available for use and it is within this band that the Australian D.M.E. is being installed for its national airways. The I.C.A.O. standard equipment for use on international routes will be 1000 megacycles.

The greatest difficulty associated with D.M.E. in the U.S.A. as a modern aid is the provision of sufficient channels to enable all users to receive adequate service without interference from other aircraft, and the provision of automatic coding. A most complex system of

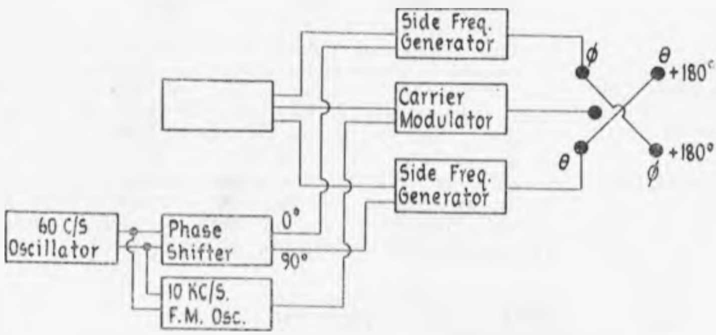


Fig. 2

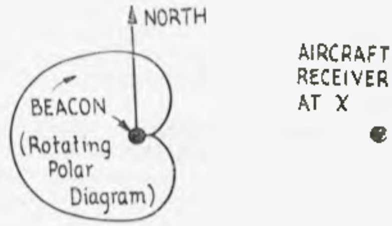


Fig. 3

simulated track devices mentioned above, but now appear to be abandoning this for a device in which the two Decometer readings automatically guide a pointer over a special map. By displaying the desired airway on the map the pilot can immediately see his positive relative to the airway and could read off his distance to go, etc. The unit is still in the development stage but has interesting possibilities.

The system is unique in that it has been developed and is being financed and produced solely by a commercial organization as a private venture. All other systems in use in the world have governmental backing in some form or another.

(iii) RANGE/BEARING SYSTEMS

Now it is possible to fix one's position on a map if one knows the range and bearing from two known points, and more readily if these parameters are from the same point. This is the basis of some types of modern aircraft navigational aids. Various methods are proposed for measuring bearing (ϕ); but most use pulse radar responders for range, and the equipment is known as Distance Measuring Equipment, D.M.E.

(iv) DISTANCE MEASURING EQUIPMENT, D.M.E.

So many wartime radar equipments used a simple transponder system for range measurement that the reader will no doubt be aware of the fundamentals of the system, but they are given here for completeness.

The aircraft equipment sends a pulse which is received by the receiver portion of a ground beacon. The output of this receiver drives and pulses the transmitter portion of the beacon which is usually on a "cross banding" between the radio frequencies of the outgoing and received pulses has been developed providing for 50 channels.

(v) BEARING INDICATION

At present the basis of civil aviation flying on airways pretty well throughout the world is the old four course medium frequency radio range. In the U.S.A. an almost identical development was carried out in the V.H.F. bands, although the beams provided were, mainly for operational reasons, two with visual indication and two with aural. Hence these ranges became known as "visual-aurals."

The limitation of bearing to four defined tracks or courses persisted, and an omni-directional range was only developed in the U.S.A. shortly after the close of hostilities. Since this has become the national standard for the U.S.A. and the I.C.A.O. standardized equipment for international routes it will be covered in some detail. The equipment is known as V.H.F. Omni-Range.

The system is based upon the use of a rotating horizontal-antenna directivity pattern. This pattern, which is a cardiod, is produced by an antenna array consisting of four elements mounted at the corners of a square and a fifth element mounted at the centre of the square. The centre element is fed with a 125 mc/s carrier amplitude modulated with a 10 k/cs frequency. The 10 k/cs frequency is itself modulated by a 60 cycle frequency. The other four elements are fed with energy as follows: Diagonally opposed pairs of elements are connected to a common feed point, but the feed lines to each aerial of the pair are such that one is radiating 180° out of phase with the other. The other diagonally opposed pair are similarly fed from a side-frequency generator but there is a 90° phase difference between the signals supplied to each pair. The side-frequencies used are 125 m/cs plus 60 c/s, and 125 m/cs minus 60 c/s, and at any given point in space one would receive a 60 c/s modulated 125 mc/s signal, the absolute phase of which depends upon the azimuth angle with respect to the beacon. The 60 c/s modulation of the 10 kc/s sub-carrier provides a reference phase by which the result can be produced as an indication related to a desired reference normally true or magnetic north. Figs. 2, 3, and 4 will assist in following the principle of operation of the system. In Fig. 4 it is assumed that the amplitude of the reference voltage passes through a maximum at the same instant as the rotating pattern passes through north. At the point X (due east) the variable phase voltage passes through a maximum 90° later than the reference-phase voltage. After the resolution of "sense" this is interpreted in the display in the aircraft as 90° from due north, *i.e.*, due east. The aircraft receiver is fitted with a two-channel output, one of which is fitted with a high pass filter thus passing the 10 kc/s sub-carrier, the phase of the 60 c/s modulation of that sub-carrier being used for reference and phase comparison with the 60 c/s modulation of the other channel.

Tremendous difficulty has been experienced with erroneous readings due to reflections from hills, trees, large buildings, etc. Horizontal polarization is much less susceptible to such errors and the accuracy of the system has largely resolved itself into the production of as pure a polarized radiation as possible. The performance of the present techniques in really mountainous country has yet to be fully ascertained and outside the U.S.A. the system is not being received with much enthusiasm for national, as distinct from international, use.

One other modern system for the assessment of bearing is considered to be of interest to the reader, and has already been mentioned above, namely the British GEE Track Guide, or the Australian Multi-track Radar Range.

This is essentially a miniature form of a hyperbolic navigation system using one pair of stations only. By making the distance separation of the order of 5 to 10 miles the hyperbolae are so nearly the radii of a circle that they can be regarded as such except for the immediate vicinity of the base line. Both equipments as now produced work in the 200 megacycles band and use a P.R.F. of 2,000 to 2,500 c/s with a pulse length of 1 microsec.

The discrimination of the system is such that discrete tracks are laid down, and the normal practice is to ensure that one of the tracks runs along the main runway and the two stations, Master and Slave, are placed astride the runway.

By means of integration circuits a D.C. voltage is produced proportional to the time difference between the two pulses and this voltage actuates a pointer moving on a scale graduated in "track" numbers. By setting up a voltage known to correspond to a specific time difference and comparing it on a centre zero meter a Left/Right indicator can be provided. In the experimental models used up to the present these two indications are combined in one meter with a horizontal pointer moving

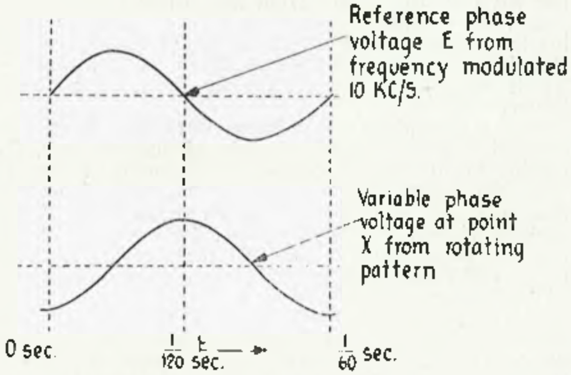


Fig.4

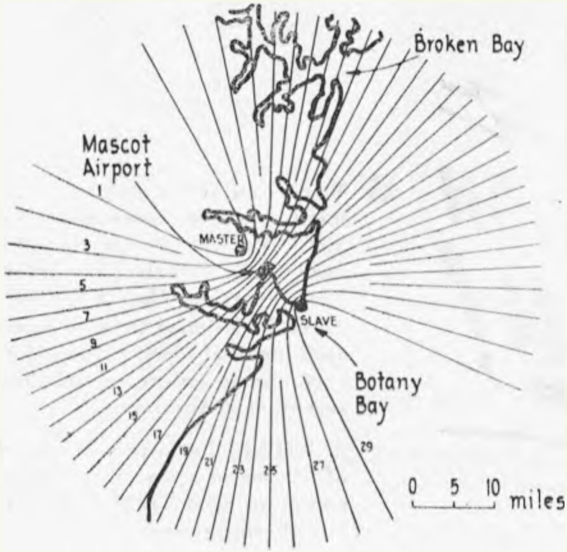
over the track scale and a vertical pointer giving Left/Right indication as in Fig. 6.

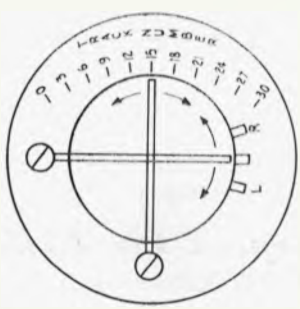
The major advantage of the system compared to any C.W. system is the complete freedom from topographical and site interference—the pulse that gets in first must be the direct pulse and although the reflects from the hills, etc., cause the received pulse to be increased in duration and amplitude the entire circuitry is based upon the leading edge.

The major disadvantage is that the tracks are only formed over part of the full 360°. In the vicinity of the extensions of the base line lateral variations cause little difference in the time difference of the receipt of the two pulses and the system is so insensitive as to be unusable over two sectors of approximately plus or minus 30°. It is possible, of course, to institute either another pair, or perhaps add only a third station, in order to extend the coverage although in general the orientation of the base line can be arranged to suit airways requirements.

(vi) SURVEY OF MODERN SYSTEMS

It has already been mentioned that the American V.H.F. Omni-Range is not universally popular in view of its associated technical difficulties. With 1000 m/cs D.M.E. it has been accepted as the aid for international routes but no other nation is committed to its used for its own national airways. One of the foremost air-minded countries in the world—Australia— has already commenced a programme of installing 200 m/cs D.M.E. plus wartime purchased V.H.F. "visual-aural" ranges (part (v) above), while France and the French North African Empire have contracted to install the British Decca. The situation in Britain and Europe generally is far from clear; GEE is available but by no means all European aircraft use it and Decca is fast gaining in popularity, although both systems, being entirely "receptive" by the aircraft, lack that transmission of intelligence from the aircraft to the ground which is likely to be necessary for air traffic control purposes within the next few years.





Left, Fig. 6

Above, Fig. 5

THE NEW ZEALAND ELECTRONICS INSTITUTE (Inc.) NEWSLETTER

The President of the New Zealand Electronics Institute (Incorporated) (Mr. J. W. Todd) submitted the following report for the year ended 31st May, 1950:

Meetings

(a) Annual meeting: The Annual General Meeting provided for under Section 17 was held in the Central Public Library, Mercer Street, Wellington, on Thursday, 2nd June, 1949.

(b) Council meetings: Four Council meetings were held during the year and in addition sub-committees, as appointed from the Council, met to implement various matters.

Membership

The current membership figure is tabulated below, and a complete list of members is also attached to this report.

	Overseas	Auckland	Christchurch	Dunedin	Wellington	Total
Members	–	1	2	–	6	9
Associate members	3	6	12	10	19	50
Associates	4	22	22	15	23	86
Students	1	10	3	6	26	46
Totals	8	39	39	31	74	191

In respect of the 66 unfinancial members, Council proposes to implement Section 8 (e) whereby members whose subscriptions are unpaid by the end of the two months following the close of the financial year will be required to lapse their membership.

Branches

The four branches, Auckland, Christchurch, Dunedin, and Wellington, have had a full programme of activities, details of which may be obtained from Branch Annual Reports. The major part of these activities consisted of talks on various electronic subjects, supplemented by operational displays of electronic equipment.

Finance

The draft financial statement reveals an excess of receipts over payments of £114 15s. Minor adjustments will appear in the audited statement of accounts to be presented to the Annual Meeting.

Membership Certificates

During the year membership certificates were printed, and arrangements are in hand for their completion and issuance to members entitled to receive them.

Educational

(1) Examinations: The next examinations will be held in September, 1950.

(2) Prize Award: The initial prize award of the Institute to the most successful candidate in the Radio Servicemen's Examination was this year granted to Mr. Phillip A. G. Howell, of Napier. The prize took the form of a text-book to the value of £2 2s., and congratulations are extended to Mr. Howell on his success in securing this award.

Your Council feels that by making prizes of this nature available to students it is fulfilling the objects of the Institute.

Constitution

Proposals have been received for an amendment of the rules respecting grades of members, and arrangements have been made for a special general meeting and postal ballot to determine this matter.

Journal: Council has considered the establishment of a journal, but in view of the present development stage of Institute affairs it has decided to defer this matter for further consideration at a more appropriate time. Arrangements have been made for *Radio and Electronics* to become the official organ of the Institute, and members have been kept fully informed of Institute activities during the past year by the insertion in *Radio and Electronics* of a monthly newsletter.

Common Seal

The Institute now has a Common Seal which, in accordance with Section 26, is in the custody of the Secretary. Acknowledgment is made of the assistance of Mr. Pollard in this regard.

Insignia

A design has been adopted and is now in course of preparation. When the insignia is available it will be reproduced on Institute stationery and documents. The thanks of the Institute is due to those members who submitted designs for consideration of your Council.

Thanks

The Council, on behalf of the Institute, extends its thanks to—

(1) Those firms who so generously made donations to the Institute funds;

(2) The management of *Radio and Electronics* for their co-operation in granting the Institute free space each month.

(3) The officers and individual members of Branches who gave of their time and knowledge to further Branch activities.

(4) The various speakers who, throughout the year, gave talks to Branch members on different subjects appertaining to electronic matters.

(5) Philips Electrical Industries of New Zealand Ltd. for donation to Institute Libraries of technical literature.

(6) All others who directly or indirectly contributed to the furtherance of the Institute objects.

General

Notwithstanding the difficulties experienced during the past year, considerable progress has been made, taking into account the fact that the Institute is a comparatively young organization and as such has to learn from actual experience. Rapidly changing conditions in the electronic industry will stimulate a demand for electronic knowledge, and if the Institute properly promotes and fulfils its objects it should be in a position to assist in supplying this demand and conducting examinations of a high standard. The examinations will elevate the status of the Institute and enhance its prestige and recognition by those engaged in the electronic industry. In addition the discussions and talks will greatly assist in contributing towards the promotion of the objects of the Institute.

* * *

WELLINGTON BRANCH ACTIVITIES: PRECIS OF ANNUAL REPORT

1. Branch Library: This Branch is pleased to report the formation of a library, and due to the generosity of Messrs. Philips Electrical Industries of N.Z. Ltd., Amalgamated Wireless (Australasia) Ltd., Spedding Ltd., and a number of our Branch members, the Branch Committee feel that the time is fast approaching when an announcement will be made regarding the availability of these books and magazines to Branch members.

2. Branch Laboratory: With the object of establishing a branch laboratory, the Committee is at present collecting material and data for the construction of a 3-inch oscilloscope. This is to be the first of a number of test instruments which are to be built for use in the laboratory, but until a permanent room has been obtained, it is proposed that individual instruments will be made available, on loan, to members, as they are completed. This policy is a long term one, and it is realized that a great deal of work has to be done before these plans can be put into effect.

3. Technical Advice: This Branch is pleased to record that a few of its members have availed themselves of the opportunity of applying to this Branch for solutions to technical problems.

4. Financial Membership: Of the total of 54 financial members associated with this Branch, there are: 6 Members, 17 Associate Members; 20 Associates; and 11 Students.

5. List of Papers presented during the year:

June, 1949: Annual General Meeting. Mr. L. W. Harrison, B.E., B.Sc., A.M.I.E.E., M.I.R.E., A.M.N.Z.I.E., M.N.Z.E.I., "A Visit to Mexico."

July, 1949: Mr. G. J. Wood, "Electronics as applied to Radiosonde Equipment."

August, 1949: Mr. R. E. Grainger, M.I.R.E. (Aust.), A.M.(Brit.)I.R.E., A.M.N.Z.E.I., "Disc Recording."

September, 1949: Mr. K. Williamson, M.Sc.: "Electron Miscroscope." Visit to Dominion Physical Laboratory.

October, 1949: Mr. W. D. Foster, B.Sc., A.M.(Brit).

(Continued on Page 48.)

The PHILIPS Experimenter

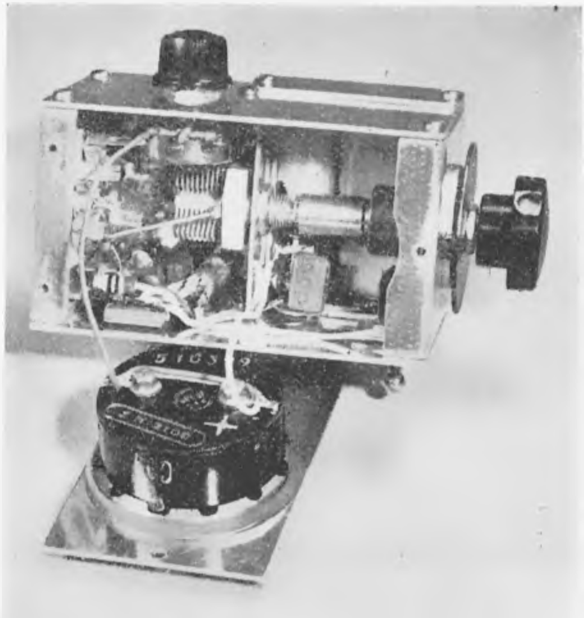
No. 33: A Sensitive Absorption Wave-Meter for All Bands

INTRODUCTION

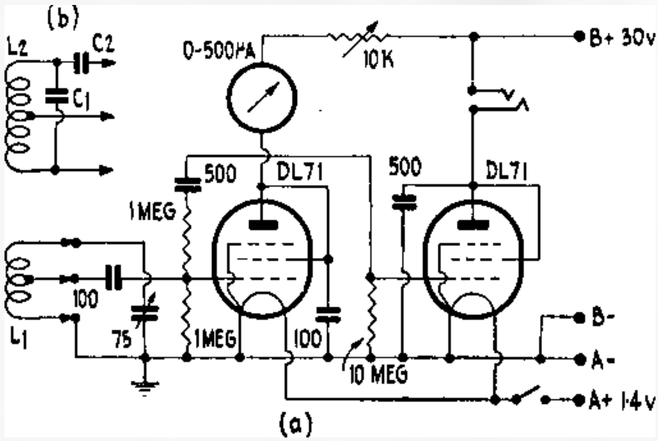
It is not always realized that in the amateur transmitting station, the possession of good receivers and transmitters is by no means the whole story. Auxiliary equipment can and does play a very important part in the successful operation of a station ,and a certain amount of it, namely frequency measuring equipment, is laid down in the regulations as being essential. It is perhaps a natural tendency to regard the crystal oscillator and the precision V.F.O. as being their own frequency standards, but such a view is not only rather short-sighted, but in many cases positively misleading. How many of the best of us have, for example, been transmitting gaily on some frequency in the vicinity of 10.5 mc/sec. under the mistaken impression that the output frequency was 7 or 14 mc/sec.? And supposing something goes wrong with the said crystal or V.F.O.? Who is to tell, without frequency measuring equipment that these things are working as they should? A simple, sensitive absorption wave-meter will resolve all these questions, and many others. It makes the setting up of a new transmitter delightfully easy, and one can be sure that the correct harmonic has been selected in the multiplier stage, without creating interference for some time before finding out the hard way. The wave-meter to be described in this month's issue of the Experimenter is small, self-contained, and easily built. Its sensitivity is such that even low-powered stages can be checked without bringing it nearer than within three feet of the tuned output circuit. By simple means, bandspread can be provided on all amateur bands, while general coverage from 3 to 148 mc/sec. can be had with only four coils.

THE CIRCUIT

The circuit uses two Philips sub-miniature valves, both type DL71. One is used as a grid leak detector, with the indicating meter in the plate circuit. This arrangement, with the grid of the detector valve tapped approximately half-way down the tuning coil, gives excellent sensitivity, and makes the indication very sharp by allowing the coil to retain a high Q even when loaded by the detector. On the 80-metre band, measurements showed that the actual working Q of the circuit was higher than 80, even with the detector functioning. This gives excellent discrimination, and sharp tuning, and there is every reason to believe that the meter's setting accuracy is better than one per cent. The second DL71 is used as an audio amplifier so that the unit can also be used as a monitor for 'phone transmissions. The extra valve was found desirable in that it enables the indicating meter to be set to full scale in the absence of a signal without disturbance to the setting when the phones are plugged in. It will be noticed that the zero-setting potentiometer acts as a simple rheostat in series with the H.T. feed to the detector valve. With the specified H.T. voltage of 30, the DL71 draws just over 500 μamps of plate current in the absence of a signal, and therefore with zero applied grid bias. When a signal arrives, it is rectified at the grid, which acquires a negative bias depending on the strength of the signal, and this bias causes a drop in plate current. Thus, in use, the series resistance is adjusted so that the indicating meter reads full-scale in the absence

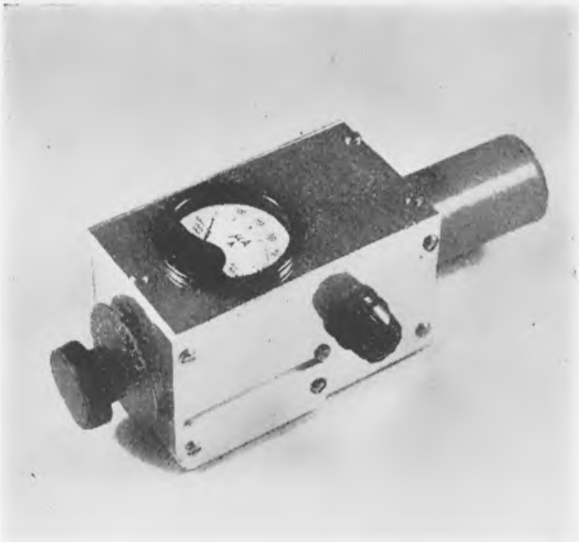


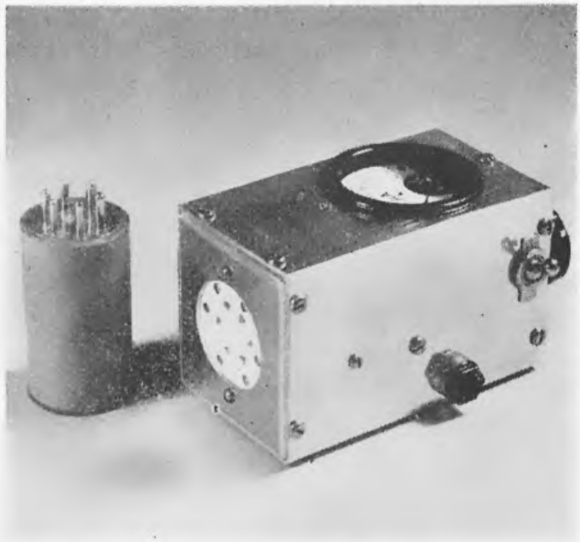
of a signal, whereupon a pronounced dip is obtained when a signal is tuned in. If the detector had been used also for audio output, the resistance of the headphones would



have prevented the initial setting of the meter from being carried out at all except when the B battery is very fresh. Also, plugging the phones in would have necessitated the re-adjustment of the zero-setting potentiometer. Using the separate valve for the phones obviates all this.

(Continued on Page 30.)





Two side views of the completed instrument, showing the placement of all controls, and the access hatch to the bat teries.

A 3 in. Oscilloscope

(Continued from Page 4.)

frequencies, enabling one stage of amplification for each axis to be dispensed with. Response is flat to over 10,000 c/sec., which is adequate for all normal work.

(11) Time base simplified by restricting the frequency range to fit in with that of the amplifiers. A wide range time-base cannot be fully utilized if the amplifiers' response is not wide also, so that the simplification does not degrade the performance.

(12) Separate power supply unit used so as to avoid magnetic distorbance of the C.R.T. spot, and the use of a mu-metal shield for the tube, which would otherwise be needed.

(13) Provision at the back of the scope unit for plugging in a self-contained unit which enables modulation patterns to be obtained without any physical connection to the transmitter, except perhaps in the case of low-powered equipment, where an R.F. coupling link may be necessary.

THE CIRCUIT

It may seem a little odd that all these features can be incorporated in an instrument which makes any pretence to simplicity, but such is undoubtedly the case. It may be said at the outset, however, that to provide all of them while using so few valves has been possible only because of two features of the design that were settled in the first instance. The first of these is the decision to use balanced direct coupling between deflecting plates and amplifier tubes. The second is the restriction of the amplifiers' frequency range to audio frequencies only. The latter, however, does not by any means prevent one from by-passing the amplifiers and applying high-frequency voltages, even R.F. ones, directly to the plates. It all works out something like this: If single-ended amplifiers were used, the performance of the C.R.T. itself would not be so good, owing to trapezium distortion, and it would not be possible to have as high an E.H.T. voltage on the tube, because direct connection could no longer be used, and the extra 300 to 400 volts that this gives would not be available unless a separate high voltage transformer were used.

Again, restricting the response of the amplifiers to A.F. only enables sufficient gain to be had from a single stage of amplification, whereas if a wider range had to be covered, it would be necessary to use two stages of amplification for each axis, and the individual valves would have had to be pentodes, probably with high-frequency compensation.

The power supply section of the circuit is quite interesting. It is made from a normal receiver transformer, of 350 volts a side, with one 6.3 and one 5v. L.T. winding. The 6.3 winding is used for the amplifier, time-base, and one of the rectifier tubes, while the 5v. winding is used for the remaining rectifier and for the C.R.T. heater. One side of the high voltage secondary is earthed, contrary to usual practice, and this give A.C. output voltages of 350 and 700. One 6X5 is used as a half-wave rectifier at the 350-volt tap, and arranged to give a positive output for the amplifiers and time-base oscillator. At the top end, the other 6X5 is used again as a half-wave rectifier, but this time with negative polarity, providing the bulk of the E.H.T. voltage—actually a little less than 800 volts at the output of the smoothing filter—the rest being picked up by returning the final anode of the C.R.T. to about +300v. on the positive supply, instead of to earth as is usually done. In both power supplies, the current drain is so small that is is feasible to use a resistance-capacity smoothing filter instead of the more ordinary L-C filter.

The voltage for the control grid, cathode, and first anode of the C.R.T. are obtained from the usual voltage divider between the negative high voltage supply and ground. In order to enable a black-out pulse to be applied to the grid of the C.R.T., some series resistance is included between the tap on the brilliance potentiometer and the grid itself. This enables the wave-form at the screen of the time-base valve to be fed to the grid without being short-circuited. A further resistor which is in the nature of a grid stopper, is placed in series with the C.R.T. grid and the feed condenser from the time-base screen circuit. Its purpose will be described later.

The amplifier circuits are identical. Each uses an ECC35 double triode in a paraphase arrangement. In this circuit there are only two small variations from the circuit as used in audio amplifiers. The first is that a small trimmer condenser is connected in parallel with the upper resistor of the voltage divider that reduces the output for the grid of the phase reversing section. The purpose of this condenser is to prevent the response from falling off below 10,000 c/sec., which it would otherwise do. The reason for this is that the sections of the ECC35 are high-mu triodes, with a large Miller effect capacity. This, as usual, causes a dropping off at frequencies above 10,000 c/sec., and especially so when two such stages follow each other, as in the paraphase circuit, where the second half obtains its input from the output of the first half. We therefore have two lots of Miller effect adding up in one side of the supposedly balanced amplifier, and only one lot in the other, so that the circuit tends to become badly unbalanced at high frequencies, unless something is done about it. The trimmer condenser, then, has the job of raising the frequency response at high frequencies of the second half of the paraphase amplifier, so that up to quite high frequencies, the responses of the two halves, though dropping off, remain balanced. The pre-set potentiometers in the grids of the second sections of the paraphase stages, and the balancing condensers, are used in balancing the paraphase stages.

The other point of difference between these stages and their ordinary audio frequency counterparts is the arrangement of the cathodes. Usually, the circuit uses a single common cathode resistor for both halves of the valve, but here we have a potentiometer so wired up that when it is adjusted, resistance is removed from one cathode, and placed in the other. The effect is, therefore, to reduce the bias on one section, and at the same time to increase that of the other. Because of this, the plate voltage of one section increases, while the plate voltage of the other decreases by an equal amount. Now since the plates of the amplifier valve are directly connected to the deflecting plates, these D.C. changes in the plate voltages will produce a constant deflection of the C.R.T. spot, so that the cathode potentiometer acts as a shift control. It can be argued that altering the bias on the amplifier valves will produce distortion of the signal that they are handling, and this is quite true, but owing to the way in which the system works, *this distortion does not matter, because it occurs only with that part of the signal which is off the screen, and not at all if the signal is not filling the screen.*

The reason for this convenient behaviour is that the

(To be Continued.)

Our Gossip Column

The radio and electrical trades will have a special interest in the elevation of Sir John Allum, Mayor of Auckland. An electrical engineer by profession he has had a long and active career in the city's business and civic life, having been elected to the council in 1920. He is director of the Allum Electrical Company, Ltd., which has offices in New Zealand's main centres. For long periods Sir John has been a power of strength to the business world of Auckland having held many high offices in representative associations, including those of manufacturers and employers respectively. In 1946 the honour of C.B.E. was conferred upon him. In addition to his many other activities, Sir John renders much useful service as a J.P. To Sir John and Lady Allum and their family, this journal offers its sincere congratulations on a well merited honour.

* * *

Reg Green has returned to New Zealand after an extensive trip to Sydney, Melbourne, and Brisbane.

* * *

Visitors to Wellington include Geo. Benson, Don Wishart, Bert Peoples, Ted Woods, and Jack Wimberley from Auckland. From Hawera, Noel Laird spent a few days in Wellington. Jack Wyness and Brig Mason have been North Island trippers recently.

Gil Smith has severed his connection with Electronic and General Industries and is now with S. Burnell Brown, Wellington.

* * *

Chris. Mathews has been visiting Christchurch, engaged in publicity matters for the South Island.

Noel Triggs, one time assistant Secretary of New Zealand Employers' Federation, and now as Motor Accessories, says he finds dealing with the public a pleasant change from industrial problems. Noel incidentally is moving the radio way, handling a well known car receiver.

* * *

Build a house around a washing machine says Buster Lewis when demonstrating a spin-dryer washer. Buster certainly looked the part when seen recently demonstrating this new equipment; knows all the answers, too; from the plumbing installation to blueing and drying. Watch your step, Buster, for if its as simple as you say there's plenty of washing coming along.

* * *

Played at Belmont, Wanganui.—H. W. Clarke (N.Z.) Ltd. won the Hodge-Cromwell Golf Trophy, beating Jack Hodge team by 2 games to 1. The winning team consisted of W. Clarke, H. Stephen, E. Paulin. Opponents were J. Hodge, A. V. Haworth, and B. Clarkson.

After the game the teams were the guests of Jack Hodge, Cromwell and Westinghouse dealer, and an enjoyable dinner at the Rutland rounded off a good day.

* * *

Keith Wyness, from Levin, recently tried his hand at the washing demonstration at H.M.V. Retailers. Good for the "blues," Keith.

* * *

Bill Neighbours had the time of his life in removing from Harris Street to more commodious premises at 22 Jessie Street. On taking possession, he found the top story still occupied by some "old timers" and Bill became quite a benevolent institution until he found more congenial surroundings for them. But this was not the end for other inhabitants made their appearance and Bill became ruthless to the extreme, for since they have no relation to their electronic counterparts the second lot went by way of fumigation. Ask Bill the story.

* * *

Recent overseas visitor to New Zealand was Mr. T. Crowe, of Ericcson Telephones Ltd., England. Ostensibly on holiday, Mr. Crowe, who is accompanied by his wife and daughter, could not avoid making several business contacts. Don Cooper, of Green and Cooper, Ltd., who covered some of the territory with this visitor says that like many others from Home, Mr. Crowe expressed a desire to return and see more of the countryside, and renew acquaintances made.

Philips Experimenter

(Continued from Page 25.)

In order to make the instrument self-contained, and compact enough to carry easily in one hand, the sub-miniature valves were chosen. These fit into a very small space, and better still, will work well from low voltage batteries of very small current capacity. The batteries used, and housed inside the case are one cell from a No. 712 3-volt torch battery, for the A supply, and a midget 30-volt hearing-aid B battery. These hearing-aid batteries will give excellent service when their rated maximum current is not exceeded. This rather limits their usefulness, but here, where the total drain of the two valves is approximately 1 ma., the life will be ample, especially seeing that the use will be intermittent. Unless the audio stage is being used, and this is only when the phones are plugged in, only the detector draws H.T. current, and this is limited to 500 μamps.

The small circuit (*b*) close to the main one shows the coil and condenser arrangements used for making band-spread coils for the amateur bands only. It is strongly recommended, however, that the general coverage coils be made too, because in these days, when so many of the bands are not in harmonic relationship, it is often necessary to operate a doubler or tripler on some frequency outside the amateur bands when multiplying to one of the higher ones. No attempt has been made to make the dial cover the "ham" bands exactly, since this hardly repays the labour involved. But it will be found that a very useful amount of spread has been obtained on all bands. An advantage is that fixed condensers have been used throughout for bandspreading, all adjustment taking place on the coils themselves. Once these have been adjusted and doped in position, there is then nothing which can get out of adjustment and spoil the calibration of the instrument.

CONSTRUCTION

There is nothing about an instrument of this nature which makes it essential to stick to the original lay-out of parts. However, a good deal of thought was put into making the arrangement of parts as handy as possible from the operating point of view, and we do not think that much improvement is possible. The aluminium box which houses the meter measures 4½ in. by 2½ in. by 2¾ in. It can thus be held easily in the left hand while the tuning knob is manipulated with the right. The coil, poking out the end can be inserted as near as one likes to the circuit from which the energy is to be picked up, though except for extremely low-powered stages, very loose coupling will suffice to give a readable indication. The photographs give a fair enough idea of the lay-out of the unit. The coil socket is mounted on one end, and the small vernier dial is on the other. Near the middle, inside, is a partial partition, on which the tuning condenser is mounted. On the left-hand side are the 'phone jack and the on/off switch, while on the right-hand side are the zero-adjusting potentiometer and a small removable panel through which the batteries are inserted. Connections are made to the batteries by means of brass contacts mounted on small pieces of insulating board. There are only two of these, for the positive terminals of the batteries. The negative connections are made by contact with the removable panel, which is held in place by self-tapping screws.

The valves and all their wiring except that of the tuned circuit, are placed on a small panel of bakelized sheet. This can be seen in the left-hand front corner of the box, mounted on edge. Along the top edge of the sheet are six solder lugs riveted in. These serve as tie-points for the parts, and also for the valve connections. The sub-miniature valves have no sockets—only wires emanating from the button base. These wires are flexible, and are intended to be used by soldering directly on to the appropriate points on the circuit. The valves are held reasonably firmly in place by the connecting wires, which are covered with fine spaghetti to prevent short-circuits, but it is desirable to fix them a little more firmly by passing a small rubber band round them and the insulating panel. The latter is held in place in the box by a single bolt. This is passed through the side of the box and a nut is screwed on to act as a spacer. Then, the panel is put in position, and a second nut is put on, holding the panel quite firmly.

COIL DATA

All coils are wound on $1\frac{1}{4}$ in. diameters formers made of polystyrene. These are very little more expensive than ordinary bakelite ones, and for this reason are worth investing in. Nine are needed altogether, four for the general-coverage coils, and five for the bandspread coils, which are made for all bands from 80m. to 6m. inclusive. For all coils except the smallest in the general-coverage range, 20 gauge enamelled wire is used. All coils, bandspread or otherwise, are tapped at the centre. It should be realized that to get the exact ranges specified in the table below, a certain amount of juggling will be needed, but with the turns as specified, no more than an alteration in spacing of the turns should be needed to bring them right. In the case of the lowest coil in the general-coverage range, there is no room for any more turns, so that if a little more inductance turns out to be necessary, a good idea is to take an iron slug, removed from a broadcast coil or I.F. transformer, and to thread a hole in the bottom of the former to take the brass adjusting and mounting piece that is attached to the core. Then the core can be screwed into the hole, and its position adjusted until the lowest frequency just hits the maximum capacity point on the tuning condenser. It is worth while going to a little trouble to see that there are no gaps in the coverage, even though this might take a little time to do.

GENERAL-COVERAGE COILS

Band.	No. of Turns.	Spacing or Winding Length.
3–7.5 mc/sec.	45	Spaced one wire diameter.
7.5–20 mc/sec.	15	Length = $\frac{5}{8}$ in.
20–55 mc/sec.	$4\frac{1}{2}$	Close-wound.
55–148 mc/sec.	Hairpin from 16-gauge copper wire	$1\frac{3}{4}$ in. long, $\frac{1}{2}$ in. wide.

BANDSPREAD COILS

Band.	No. of Turns.	Spacing or Winding Length.
3.5–4 mc/sec.	35	Close wound.
7–7.5 mc/sec.	16	Length = 1 in.
14–15 mc/sec.	$9\frac{1}{2}$	Length = $\frac{5}{8}$ in.
28–30 mc/sec.	$4\frac{1}{2}$	Length = $\frac{3}{4}$ in.
50–60 mc/sec.	$2\frac{1}{2}$	Spaced one wire diameter.

BANDSPREAD CONDENSERS

Note.—These are wired inside the coil formers.

Band.	Series $\mu\mu$f.	Parallel $\mu\mu$f.
3.5–4 mc/sec.	50	50
7–7.5 mc/sec.	50	50
14–15 mc/sec.	15	30
28–30 mc/sec.	15	30
50–60 mc/sec.	15	15

A point worth mentioning is that except for the large coils which require the whole available winding space, all coils are started exactly $\frac{3}{4}$ in. from the bottom of the coil former. If this is not adhered to, it will be found that the above tables are inaccurate owing to lead lengths altering the inductance.

CONSTRUCTING THE COILS

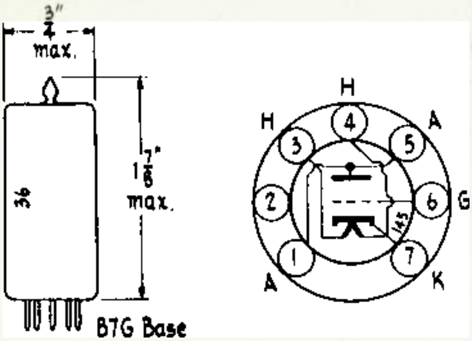
The coils are wound in the ordinary way, but have all been covered to improve their stability and ageing qualities. It so happens that $1\frac{1}{2}$ in. diameter bakelized paper tubing just fits nicely over the coils after they have been wound. When the coils have been finally adjusted, they should be finished off with a coating of poly dope, which will fix them firmly in place. No worth-while frequency change will be noticed either on doping, or on covering with the tubing. The latter is glued on to the end flange of the coil form with cellulose cement, and at the pin end of the former, a thin ring of the same paper tube is forced into the gap between the paper tube and the polystyrene former, and glued in place. The coils can then be reckoned as permanently holding their inductance values, thereby stabilizing the calibration of the wavemeter.

CALIBRATION

A job like this is worth constructing calibration curves for, and if it is as well-made as the original, it will pay to go to some trouble to borrow an accurately calibrated oscillator in order to draw the graphs. Although the accuracy of an absorption meter cannot compare with that of a good heterodyne meter, the two have quite different spheres of application, and within its limitations, the instrument we have described can be called a precision device.

TUBE DATA: TYPES 6C4, 6T8, and 6X4

Type 6C4—H.F. Power Triode



As oscillator or power amplifier, type 6C4 will operate efficiently at frequencies up to 150 mc/s.

RATINGS

Heater voltage	6.3 volts
Heater current	0.45 amp.
Anode voltage	300 volts max.
Anode dissipation	1.0 watt max.
Diode current	5.0mA max.

OPERATING CHARACTERISTICS

Anode voltage	100	250	volts
Anode current	11.8	10.5	mA
Grid voltage	0	—8.5	volts
Anode impedance	6,250	7,700	ohms
Mutual conductance	3.1	2.2	mA/V
Amplification factor	19	17	

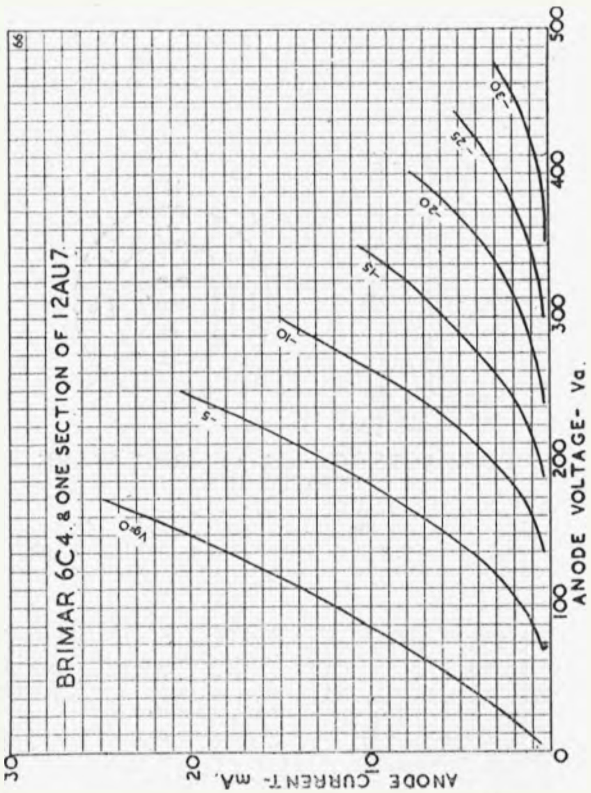
Class C Telegraphy

Anode voltage	300 volts
Anode current	25 mA
Grid voltage	—27 volts
Grid current (D.C.)	7.0 mA
Input power	0.35 watt
Output power	5.5 watts*

*Approximately 2.5 watts at 150 mc/s.

INTER-ELECTRODE CAPACITANCES

	with shield	without shield	
Input	1.8	1.8	pF
Output	2.5	1.3	pF
Grid to anode	1.4	1.6	pF



OPERATION AS RESISTANCE COUPLED AMPLIFIER

Kindly refer to type 6AT6 for operating details.

Type 6T8—Triple Diode Triode

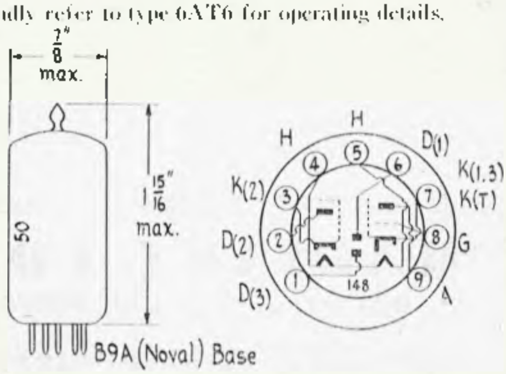
The 6T8 is particularly suitable for use in discriminator circuits and for delayed A.V.C. applications. For discriminator use Diodes 2 and 3 should be employed.

RATINGS

Heater voltage	6.3 volts
Heater current	0.45 amp.
Anode voltage	300 volts max.
Anode dissipation	1.0 watt max.
Diode current	5.0mA max.

OPERATING CHARACTERISTICS

Anode voltage	100	250	volts
Anode current	0.8	1.0	mA
Grid voltage	—1	—3.	volts
Anode impedance	54,000	58,000	ohms
Mutual conductance	1.3	1.2	mA/V
Amplification factor	70	70	



INTER-ELECTRODE CAPACITANCES*

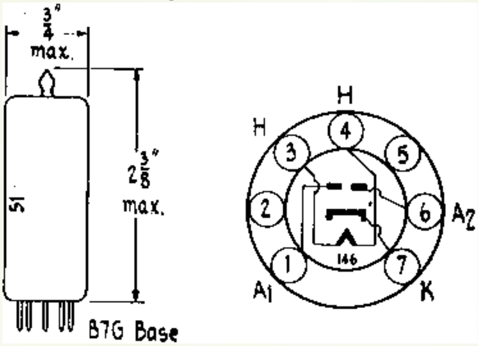
Triode input	1.5 pF
Triode output	1.1 pF
Grid to anode	2.4 pF
Grid to each diode	0.03 pF max.
Diode (D1 or D3) input	3.8 pF
Diode (D2) input	2.2 pF

*Measured with no external shield.

Type 6X4—Full-wave Rectifier

RATINGS

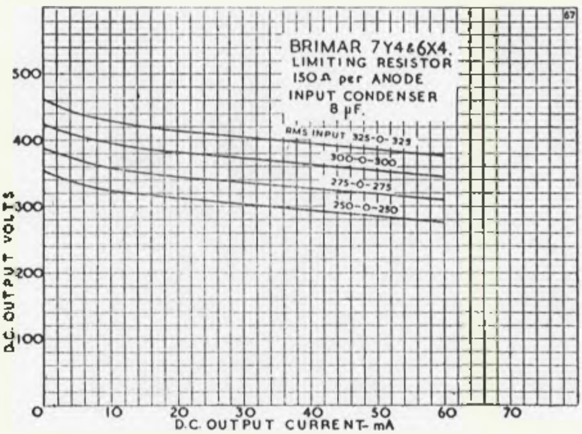
Heater voltage	6.3 volts
Heater current	0.6 amp.
Peak inverse voltage	1,250 volts max.
Peak Current (each anode)	210 mA max.
Peak heater-cathode potential	450 volts max.

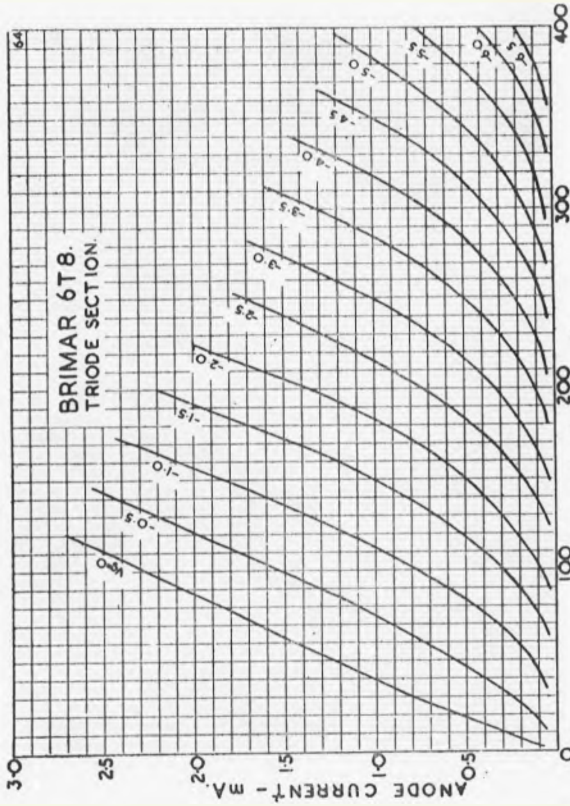


CHARACTERISTICS AS FULL-WAVE RECTIFIER

CONDENSER INPUT

R.M.S. input per anode	325 volts max.
Supply impedance per anode	150 ohms min.
Rectified current	70 mA max.





Home-made Pick-ups

(Continued from Page 7.)

weight of any thing up to four ounces on the point of the needle. They had to because the compliance at the needle point was so small.

At this time it is difficult to see why, but the first electric pick-ups that were made corresponded remarkably well to the acoustic sound-box. That is to say, the needle-point compliance was very slight, and the weight was great, for exactly the same reasons as in the sound-box. In the pick-up it is just as necessary to have no appreciable resonances within the audible range as it is with the sound-box, but the early pick-ups were fairly heavily built, and the armatures to which the needle chuck were connected were quite heavy. Also, in order to increase the electrical output, long armatures were used amplifying mechanically the movement of the stylus tip before transferring the movement into electrical energy. This type of construction automatically produced an armature-needle system with a resonant frequency within the audio range. At the time of which we are speaking, it was not considered feasible to raise the resonant frequency to a very high figure by stiffening and lightening the armature. This was brought about mainly by the necessity for using a large and robust needle chuck. This being the case, the only way of making the resonance unobjectionable was to damp the armature very heavily. This was usually done by means of rubber blocks, mounted at the upper end of the armature. These blocks acted both to produce the restoring force required by (2) above, and to damp out the resonance of the moving system. The result of all this was again a device with very little lateral compliance, and therefore with considerable weight, and electric pick-ups of the day were very often as heavy as their acoustic counterparts. Of course, the fidelity obtainable with the earliest electric gramophones was able to lose that of the acoustic gramophones, so that at first there was not the same incentive to produce pick-ups with much better characteristics.

However, before long it was realized that with the improvements that were occurring in amplifiers owing to the intensive development of electronic circuitry, not to mention the introduction of the electro-magnetic speaker, the pick-up was the weakest link in the reproducing chain and that if it could be improved the results obtained would be very much better. Even so, the run-of-the-mill magnetic pick-up that was available for retail purchase remained very much the same article until the years just before World War II. In fact, even today the general-purpose magnetic pick-up follows much the same formula, and compared with the performance of the best types, it is just not in the swim.

An obvious step in attempting to improve the magnetic pick-up is to make the moving system much smaller and lighter. If this can be done, there is every chance of raising the mechanical resonance to a very high frequency. For instance, if it can by some means be induced to go up to 20,000 c/sec. or higher, it clearly does not matter very much how sharp it is, particularly if the highest recorded frequency is considerably lower than this. If we assume that this can be done, then damping of the movement is unimportant, and we need supply only enough damping to act as a restoring force. The needle point is then very easy to push from side to side, and the weight of the head can be made much less. This causes far less wear on the record, and the pick-up begins to assume characteristics that can almost be called high-fidelity without bringing a blush to the cheek of the maker! At any rate, it was along these lines that magnetic pick-ups developed. Quite early in the piece, someone had a very bright idea that for a time represented the ultimate in performance. It was to dispense with the needle chuck proper, and therefore with its weight, to dispense with the armature as a separate part, and dispense with its weight, and more important with its contribution to lowering the resonant frequency of the system. This left only the needle itself. The rest of the pick-up remained much as before, in that a magnet and a coil were provided, but the needle was made the armature by inserting it in a block of live rubber, or in some sort of self-gripping socket, and placing it directly in the field of the magnet. In this way, the weight of the moving system was reduced to that of the needle itself, and the resonant frequency was made high because of the extreme stiffness of the relatively short, thick, stiff needle. This was the needle-armature type of pick-up, which was to some extent in advance of its time. Unfortunately, it did not become as popular as it deserved, because its output voltage was so much less than that of the "brute force" types that held the field. In fairness it should be said that amplifiers were still not what they are today, and extra amplification to provide for a low-output pick-up was costly, and low-output devices in general were difficult to apply on account of hum troubles. These days, however, it is a comparatively simple matter to cope successfully with an output of 1 millivolt or so, and because valves are cheap, it is not unduly costly to do so.

At the moment nothing is being said about crystal pick-ups, because their development is a subject on its own, and because in many things the same considerations apply to both types. So far, then, we have seen that small size, low weight, and high resonant frequency are three very necessary features of the moving part of a high-quality pick-up. They enable the needle-point compliance to be made high, and the needle point to follow the record groove much more faithfully than the heavyweight pick-up and, in addition, bring the advantage of less wear on the record.

Modern developments have been almost entirely in this direction, irrespective of what basic type of pick-up is being considered. After all, whether the transference of mechanical to electrical energy takes the form of an iron armature, a moving coil, or a piezo-electric crystal, the considerations we have been describing still apply, and the choice between the three types (there are others, of course) depends largely on other considerations.

THE REMAINING FACTORS

Although it is true that if the main conditions outlined in the last section are complied with, the frequency response and wave-form of the pick-up will automatically be good as well, there are other considerations that apply quite forcefully. For instance, the "magnetic" type of movement, which relies on the modification of a magnetic field by a moving armature for giving its output voltage, suffers from a fundamental disadvantage. It is that the relation between the deformation of the field, and the E.M.F. produced, is not strictly a linear one. This is especially so when the field is a strong one, strongly affected by the armature. This being the case, it seems that the magnetic pick-up must produce some distortion even if the moving system is perfect in its capacity as a groove-follower. However, this defect can be brought to negligibly small proportions by using only a weak magnetic field, and a very small armature so that here again we have a reason why a low-output pick-up is more likely to be a good one than a "steam-roller" which produces several volts. This magnetic distortion is one argument in favour of the moving coil type of pick-up, in which the magnetic field is stationary, and an E.M.F. is produced by "waving" a small coil back and forth in the field. Here the principle is that of the alternator, and there is complete linearity between the mechanical movement and electrical output, as long as certain easily-met conditions are observed.

At the present time, there are a number of light-weight pick-ups on the market, all of which give excellent results. Prices vary, as does performance, but there is no reason why for a very few pounds one cannot have the benefit of record reproduction that could not have been approached except by professional gear only a few years ago. But before we go on to discuss one of the most important developments in the pick-up field it would be as well to say a little more about points (4) to (8) above.

The flatness of the response curve is of major importance, but is one of the things that looks after itself if the other things are right. If there are no resonances within the required frequency range, or near it, and if the needle-point compliance is low, then the response will be very flat over a wide range.

Referring now to (7), a light-weight pick-up with a high compliance will automatically play easily through the heaviest bits of recorded music, and in particular will play tones as low as 50 c/sec. and lower without any signs of distress.

The question of needle wear on the record is a very complex one, depending on many factors, including the material of which the stylus tip is made, but perhaps the most potent wear-reducing factor is light weight, which is the prime necessity, other factors coming in only after this has been looked after.

A FAMOUS PICK-UP

Several commercial pick-ups have been given a great deal of publicity, both technical and otherwise, and have become more or less famous. Let it be said at once that these pick-ups all fully deserve their success and their fine reputation. In addition, considering their excellent performance, their price is astonishingly low. But there is one pick-up, not available in this country, which seems to be noticeably better than all the others. This is due to a novel type of armature, in which the stylus has a considerable *vertical* compliance in addition to a high lateral compliance such as we have been recommending. The point is, why does the provision of vertical movement for the stylus improve matters, and in what way? Briefly, the provision of vertical movement is a method of allowing for the fact that the stylus tip and the record groove are never of the same shape. It is almost impossible to arrange for the stylus to fit the groove perfectly, even if there were only one type of record to be played. As it is, there are several different shapes used for the cutting styli which make the groove, and as many different groove shapes, and a single needle has to follow every type of groove. Also, there is something called the "pinch" effect, which causes the tip of the stylus to ride up on to the side of the groove, thereby causing a considerable vertical force on the needle. If the latter has no provision for vertical movement, then any vibrations occurring in a vertical direction are transferred directly to the pick-up head, which then "talks" in the same way as one which is too light for the stiffness of the needle laterally.

It is a significant fact that the only pick-ups which give almost no direct noise, or "talk," are those which have some vertical compliance, allowing the suspension of the stylus to take up this movement, without transferring it to the head as a whole.

However, the direct noise, though a nuisance, can be coped with by enclosing the turntable and pick-up in a suitable box, and so need not itself be troublesome. A more important feature of pick-ups without vertical movement, and with considerable "talk" is that they are not always capable of playing heavily-recorded passages without introducing a certain amount of high-frequency "hash" into the electrical output, which is far more serious. As stated above, an armature with plenty of lateral compliance gives a light pick-up which is much better at playing heavily recorded passages than a heavy-weight one, but for the very best results it seems essential that vertical compliance be added as well. *It is the provision of high compliance in both lateral and vertical directions* which has enabled us to make, very simply, a pick-up which gives results that by ear, are almost indistinguishable from those of the famous American pick-up that we have been describing.

CONSTRUCTION OF THE R. AND E. PICK-UP

The construction of the pick-up is made quite clear by the diagrams included in Fig. 1. The magnet is a small Alnico one purchased from a hardware firm. It bears the brand "Eclipse," which is the trade-mark of a British magnet manufacturer of long standing. It comes complete with a soft-iron keeper, which is not used, but which should be left on the magnet until it is actually in use. The pole-pieces are made from pieces of very soft iron. Iron for the purpose is best obtained from an old P. and T. relay, in which it is used as the core material. It is exceedingly soft, and can easily be shaped with a file, as was done in our own case. The two main bends (one in each pole-piece) were already in existence, and the width of the piece of iron was such that the rather complex shape could be obtained simply by filing down, and without any building up at all. The diagram shows one the pole-pieces with its coil wound on it. The coil is wound directly on to the iron, a single layer of cellophane tape being use as insulation. Each coil consists of four layers of very fine enamelled wire (40 to 42 gauge) with enough turns put on to fill the available space. After each layer, a single layer of cellophane tape is added, and the next layer put on over it. There are four layers in all, and the D.C. resistance of each coil is in the region of 15 ohms. It should be pointed out that the construction of the coil is not at all critical, and wide variation is permissible. If anyone is more patient with very fine wire than we are, there is no reason why an even finer gauge should not be used. For instance, if 48 gauge were used, it would be possible to put on several times as many turns as we have on the original, with a proportional increase in output voltage. Since the original had an output of less than 1 millivolt, there is room for an increase!

The pole-pieces, with their coils wound, are held to the pole faces of the magnet with a suitable bonding material, since it is not possible to machine the pole faces of the magnet, or insert screws to hold the pole pieces. In the first instance, while the glue is setting, the strong attraction of the magnet poles will hold the pole-pieces firmly in place. The adhesive used in our own version was "Adfast," which is a rubber-based cement capable of sticking almost anything to anything else. It may be obtained from a hardware store. It is very tacky stuff, rather like "Bostik" which would also probably be suitable. It takes at least 48 hours to dry properly, so that after the pole-pieces and their coils have been made, they can be left to stick to the magnet poles while one wrestles with the problems of making the armature.

MAKING THE ARMATURE

The armature is simply cut out from a piece of very thin soft iron with a pair of scissors, and its edges are cleaned up with a file, by holding it in a pair of long-nosed pliers. Next, the exact centre of the armature is marked with a scriber ,and a small hole (1/32 in. diameter) is drilled at the marked point. This hole forms a seating for the stylus. The material used for the armature should not be thicker than 1/64 in. at the outside, and preferably should be thinner.

Unfortunately, we could not find a glue which would be 100 per cent. satisfactory in bonding the metal of the armature to the rubber damping blocks, and so had to resort to using the thin shim-brass tongue, soldered to the armature. This is the most ticklish job in the whole thing, and has to be done with as little solder as possible. First of all, the armature must be tinned with solder on the side to which the tongue is to be attached. It is perhaps easiest to do this tinning before the armature is cut out, since this gives a larger piece to work with. When tinned, the surplus solder is wiped off while the iron is still hot, just as a plumber "wipes" a joint. This leaves a very thin, but sufficient coating of solder on the iron. The hole for the stylus can then be drilled, and will not tend to become filled with solder when the brass tongue is being attached. Make sure that the brass tongue is soldered accurately at right-angles to the armature, and that as little solder as possible remains in the corners. If any does stay there, it will prevent the armature from bedding firmly down on the rubber mounting blocks, and if this occurs, the brass tongue, which is slightly springy, will be acting as the restoring spring instead of the rubber, and the characteristics of the pick-up will not be the same as those of the original. To remove the surplus solder, the armature is gripped carefully in a pair of long-nosed pliers, and a *small* file is used gently until the junctions between the brass and the iron, on both sides, are sharp right angles. If this is carefuly done it will take some time, but will be well worth the trouble.

After this, all that remains is to fit the stylus to the armature, cut the rubber blocks, and put the whole thing together, using the 20 gauge copper wire clip to prevent the drag of the record on the stylus from pulling the rubber blocks and the armature from between the pole pieces.

MAKING THE RUBBER BLOCKS AND ASSEMBLING THE PICK-UP

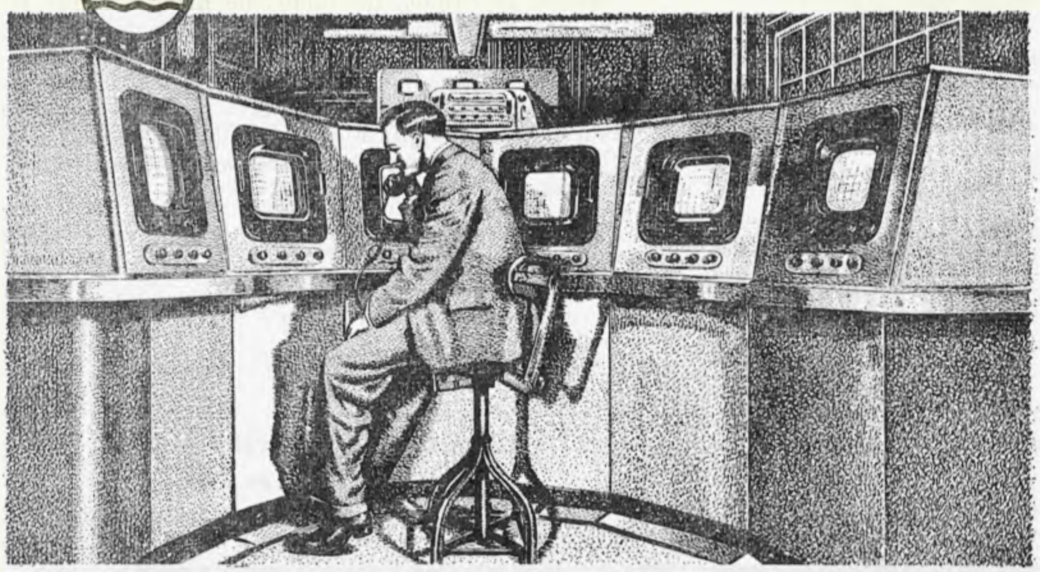
The rubber blocks are very easily made by cutting them from a live rubber band. The band used is of the size which has a cross-section of approximately 1/16 in. square, and two short lengths are cut, preferably with a pair of scissors, holding the rubber stretched while the cuts are made. This helps to ensure that the cut is square on the end. It is worth going to considerable trouble to see that the cut faces are at right-angles with the length of the piece, because it is on the cut ends tht the armature rests. Our method of putting the pieces together was as follows. The two rubber blocks were held together between the finger and thumb of the left hand, and the brass tongue attached to the armature was inserted between the two blocks, which were pressed tightly up against the armature. The whole is then slid carefully between the pole-pieces which should be close enough together to give a slight squeeze to the rubber blocks. The assembly is pushed from the armature end up into the pole-pieces until the armature is approximately 1/32 in. from the bottom square faces of the pole pieces. The whole thing will stay like this indefinitely as long as no attempt is made yet to play a record with it. Next the wire clip is made from copper wire, and placed round the pole pieces, being squeezed slightly with the pliers to make it stay in position. This clip prevents the rubber, with the armature from being dragged from between the poles by the forward pull of the record groove.

When everything is in position, the rubber blocks are sealed together on the back and front faces, where the joins appear, by flowing some ordinary rubber solution on, such as is used for mending bicycle tyres. With a pin, some of the rubber solution is induced to flow up between the ends of the rubber blocks and the armature, helping to make a firm seating for the latter.

FITTING THE STYLUS

It is recommended that the last job should be that of fitting the stylus to the underneath of the armature. The seating hole has already been made, so that the first thing is to prepare the stylus. This is obtained by purchasing a sapphire-tipped gramophone needle. The one we used was not one of the miniature type, but was a large, bent-shank needle intended for use in a normal-sized pick-up chuck. This is the most costly part of the job, and also the most fiddly part. The thin lower part of the needle is cut off, giving a straight bit, not very thick, with the stylus mounted at the end. It is held very carefully in a pair of pliers, and a smile file is used to file away as much of the aluminium shank as possible, leaving the stylus, set on its little nylon shank, which in turn sits in the aluminium main shank. The whole thing, filed down, should not be longer than 3/32 in. at the outside. The most difficult part of the operation is not to lose the work! We recommend working on a clean table, covered by a clean sheet of white paper, so that if the stylus is dropped from the pliers, it can easily be found again. One cannot afford to lose too many needle-tips at about half a guinea a time!

When the filing down has been completed, with care to see that the filed face is at right-angles to the length of the needle, the tip is fitted to the armature by the very simple process of sitting it in the hole, and flowing round it some cellulose cement of the kind sold for building model aeroplanes. Do not use "Octopus" cellulose glue, because this tends to become brittle. The model aeroplane cement is very quick-drying, and does not become so brittle. Do not be afraid to use plenty of this glue.



In fact a small pyramid can be built up with it—it does not shrink very much on drying—as long as care is taken not to get any on the sapphire tip of the stylus. It would be difficult to remove without the stylus coming off the armature. Note that the stylus does not need to be a push-fit into the hole in the armature, which merely acts as a seating, the actual holding being done by the glue.

Sapphire styli, if not chipped through dropping on the record, will last for some thousands of playings, so that it will be found quite practical to use them, and fit a new one without dismantling the pick-up after the first is worn out.

In our next issue, we will present some photographs of the original pick-up, and a suitable pre-amplifier circuit for use with it. Since the output is very low, special precautions need to be taken against hum, and so the application of the pick-up will be worth treating in a separate article. In the meantime, builders can go ahead and see what they can make of the construction. So far, we have not had room to give details of how the head is to be mounted to an arm, but this will be made clear in the subsequent article.

WIRING OF THE TWO COILS

It is necessary to wire the two coils in series, of course, but care must be taken to ensure that their outputs add, instead of cancelling out, otherwise the output would be much lower than it should be, and that is low enough! The best plan is to wind the two coils in the same direction on the pole-pieces. Then, if the inner end of one winding is wired to the outer end of the other, the connections will be correct. In any case it is easy to test whether the connections are correctly made by trying the

(Continued on Page 48.)

The Editor's Opinion . . .

The Garrard Automatic Record Changer Type 65A/D16 With Interchangeable Pick-up Head

We have been supplied with a Garrard automatic record changer, and three interchangeable pick-up heads by Fisher and Paykel, Ltd., the New Zealand agents for Messrs. Garrard Engineering and Manufacturing Co., Ltd., and it is thought that the following test report will be of considerable interest to manufacturers and others who may be interested in the production of radio gramophones. The sample with which we were supplied for the purpose of the tests about to be described was a new one, and we broke the sealing on the carton ourselves. It can thus be taken that the results described were typical of the product, as manufactured in quantity, since no pre-selection for the purposes of the test was made. The tests were both electrical and by listening. In making them, the automatic changer was operated in the normal manner, with both 10- and 12-inch records, separately, and mixed, and the mechanism was found to be most reliable in every way.

ELECTRICAL TESTS

If it is assumed, as can be done in this instance, that the mechanical part of a record changer is of satisfactory design and performance, the most important question a prospective user will want to ask himself is "does the quality of reproduction that this unit gives conform with the standard of the equipment with which it is to be used?" It was with this question in mind, therefore, that the electrical and listening tests were performed on the sample unit. The work done was as follows:—

(1) Frequency response runs were taken on the three pick-up heads. For this purpose, the H.M.V. constant frequency record ED1189 was used, giving frequencies from 50 to 20,000 c/sec.

(2) The wave-form of the pick-ups' outputs was examined on the same oscilloscope that was used to indicate the response.

(3) A representative selection of good gramophone records was played, using the pick-ups in turn, through high-quality reproducing equipment, and the results were compared among themselves, and also against other commercial pick-ups claiming high-quality characteristics.

FREQUENCY RESPONSE

High-fidelity Pick-up

The curve obtained in our test was found to be in excellent agreement with that published by the makers in their descriptive list. The latter was somewhat difficult to read on account of its small size, but the main features of the published curve were reproduced by the experimental one. This head was found to have a response flat within plus or minus one decibel from 110 c/sec to 7500 c/sec. A very slight resonant peak was apparent at approximately 7000 c/sec., but its rise was only 1 db. above the response at the reference level at 1000 c/sec. This is so slight as to be negligible as far as any audible effect is concerned. The response was 3 db. down at 9,000 c/sec., and 7 db. down at 10,000 c/sec. This is slightly quicker roll-off than is shown in the published curve, but at this frequency it can hardly be regarded as a disadvantage, particularly since many users prefer to insert a low-pass filter cutting off in the region of 9,000 to 10,000 c/sec. in order to improve the results from slightly worn records without losing a significant amount of high-frequency response.

There was noted a slight rise in response below 100 c/sec. It should be mentioned that this is after the 6 db. per octave low-frequency drop in the record output has been allowed for, so that with a normal pre-amplifier such as should always be used with a pick-up of this type, the slight rise mentioned would appear. It is presumably due to arm resonance, but it amounted only to 3 db. at 50 c/sec., so that it could by no stretch of the imagination be termed troublesome. It might even be considered a slight advantage, since the exact theoretically required measure of compensation is not easily obtained, and a small rise on the part of the pick-up itself makes satisfactory compensation somewhat easier to achieve.

Miniature Magnetic Pick-up

Unlike the high-fidelity head, which has a built-in sapphire stylus, the miniature magnetic head employs miniature needles. Either miniature steel needles, such as the "Silent Stylus" or small-shank sapphire-tipped needles can be used. There is no chuck proper, the needle being held in place by the elliptical shape of the holder, in conjunction with the drag of the record on the needle-point.

As was to be expected, the performance of this head did not quite come up to that of the previous one. However, its response also agreed very well with the maker's published curve. The most notable exception was the manner in which the high-frequency response held up. The published curve does not extend beyond 8000 c/sec., but the head tested showed a drop of only 3 db. at 10,000 c/sec. from the response at the reference level of 1000 c/sec. With this head, the resonance of the moving system was shown to be at 45000 c/sec. Here, again, though, the amplitude of the resonant peak was only 2 db., and it is again doubtful whether any audible effect would be noticeable on its account.

The response of this head was found to be flat within 1 db. between 140 and 3,400 c/sec., and within 2 db. between 120 and 7,500 c/sec.

Standard Magnetic Pick-up

This head is larger and heavier than the other two, as might be expected, and has the normal type of chuck and set-screw to enable it to take standard needles. Its performance, too, was noticeably inferior to that of the two high-quality units. It should hardly be criticized on this score, however, because it is intended rather as an inexpensive, robust reproducer for general purpose use, making no pretence toward high-fidelity. Here again, though, the maker's response curve was found to be very accurate, and while the performance was by no means as impressive as those of the other two heads, it does not appear to us that this should be given undue weight, since this pick-up appears to have been designed as a high-output unit, requiring little or no bass compensation, and with a purposely restricted frequency response.

Actually, the response is very regular for a pick-up of this type, and it was rather surprising to find that although the upper resonance was amply in evidence, its amplitude had been kept to within 2db. of the response at 1000 c/sec. The low frequency resonance is made use of to eliminate the need for bass compensation circuits, and the results of listening tests showed that this had been done quite successfully. This head has a response that is flat within 3 db. between 200 and 4,800 c/sec.

DISTORTION

The oscilloscope showed that the high-fidelity and miniature magnetic heads were excellent from the point of view of lack of distortion. Admittedly, observation of a wave-form on the oscilloscope is a crude method of observation, but there is little doubt that it is more sensitive than the ear. Both these heads played through the test records without any signs of distress, at all frequencies, and both made only a slight amount of direct mechanical noise. As was to be expected, the high-fidelity head was quieter than the miniature magnetic, and, in fact, could be heard only with difficulty with the amplifier turned off.

One point upon which the changer mechanism could be criticized was that when the arm of the automatic stop mechanism started to bear on the pick-up suspension, a slight amount of distortion was observable on both the better heads. It would appear that the stop mechanism was exerting a little too much side pressure on the arm, and that this pressure should be relieved by a slight adjustment of the mechanism.

LISTENING TESTS

In listening to the three heads, playing the same recordings through the same associated equipment, the difference between them was audible. The best results were obtained from the high-fidelity head. This played through the most heavily recorded passages without chatter. The attack and transient response sounded excellent, while the freedom from bad resonances resulted in even, clean high-frequency response.

Although the response curve of the miniature head is little inferior to that of the high-fidelity one, the listening tests showed the latter to advantage. On good records, the miniature gave almost indistinguishable results, but it was noticed that the high-fidelity one gave better performance on partially worn records. The standard head was noticeably inferior to the other two pick-ups, but it is considered that within its own class, the standard head is a good one.

In short, Messrs. Garrard have produced in these three heads a series of pick-ups that should meet almost all requirements, from the cheaper more robust type of head, to the more delicate but greatly superior high-fidelity head. The miniature magnetic forms a very useful bridge between these two types, with characteristics that do not fall much short of those of the high-fidelity model.

The "Tannoy" 12 in. Dual Concentric Loudspeaker System

(Continued on Page 44.)

This speaker is a smaller brother to the larger 15 in. dual unit that was reviewed in these pages some time

ago, and, as its title suggests is rather more than the usual contraction "speaker" suggests. It is, in reality, a system of two speakers, combined both electrically and mechanically in such a way that each complements the other, with the desirable object of covering the audio frequency range smoothly and without noticeable transition from the lowest to the highest frequencies. An integral part of the arrangement is the cross-over network, whose job it is to see that only the appropriate portions of the frequency range are fed to the two speakers.

The advantages of thus dividing up the spectrum, and allotting the lower portion to a speaker specially designed for it, and doing the same thing with the higher part as well, are by now appreciated by almost everyone interested in faithful sound reproduction. Briefly, they are concerned mostly with the reduction of distortion occurring in the speaker itself, and with the extension of the useful frequency range. The latter is possible largely because of the former effect, and between them, the dual loudspeaker, complete with cross-over network, has become one of the chief tools of the engineer interested in high-fidelity sound reproduction.

In the "Tannoy" dual speakers, the above principle has been extended in practice to combining the separate driving units into one assembly, no larger than a single 12 in. speaker of the ordinary kind. This scheme has several advantages over the conventional method of using two entirely separate driver units, which must, of necessity, be mounted some distance from each other. The scheme used is to make the voice coil of the low-frequency speaker of large diameter, so that it becomes possible to hollow out the central pole piece. This is done in such a way as to form a short exponential horn, at the back end of which is placed the high-frequency driver unit. Then the paper cone of the low frequency speaker is made with an exponential flare which in cross-section carries on the flare of the small central horn. In other words, the low-frequency cone acts as a continuation of the high-frequency horn, and acts simultaneously in this capacity and in its more conventional one of low-frequency radiator.

It should not be inferred that the system just described is applied only in the "Tannoy" units, because certain American speaker systems use the same principle. However, it has been applied with outstanding success both in the small "Tannoy" speaker system under review, and in its larger brother. It is a noticeable feature of the new speaker that the bass response is particularly smooth and clean. Unlike many speakers which at first hearing impress one with their low-frequency response, further listening does not lead to the impression that it is "synthetic." In such speakers, a roll of drums, for instance, will certainly make a low-pitched sound, but not necessarily one which can be recognized as that belonging to any particular type of drum. With this speaker, there is no doubt that the tympani, or orchestral kettle-drums are what they are, even when playing in their lowest register. In addition, it was impossible, however carefully one listened, to distinguished by ear that often faint, but distressing "garbling" of the higher-pitched instruments, such as the flute and piccolo. Whatever seemed to be going on at lower frequencies, these instruments were reproduced with life-like clarity. After all, the proof of the pudding is in the listening as far as speakers are concerned, and no one who can listen carefully needs the assistance of intermodulation measuring equipment to tell that intermodulation is taking place. The flute, already mentioned, constitutes an excellent test for this, especially when the lower pitched sections of the orchestra are playing at some strength at the same time. It is perhaps natural that this should be so, when it is remembered that the flute produces the closest approximation to a pure tone, of all the instruments. It is because of this that any distortion of its reproduction is easy to recognize. It is not until one has heard instruments like the cymbals and triangle through a speaker of this quality that one realizes just how good well-made modern recordings are! Which brings up another rather important point. It is important when assessing the performance of any high-quality speaker to take this into account, but more so than usual with the "Tannoy." We refer to the necessity for removing as far as possible, all sources of distortion in the ancilliary equipment. If a speaker of this quality is to be used with any satisfaction at all, it is essential to reduce amplifier distortion to an absolute minimum. The reason is, of course, that if a speaker reproduces very faithfully what is put into it, without adding its own contribution to the distortion, then what does exist is very forcibly brought to the attention of the listener.

In short, these speakers are something quite out of the ordinary as far as performance is concerned, and are worthy of the best possible auxiliary equipment. For what they do, the price is very reasonable, and they should find a ready market among quality enthusiasts.

The New Zealand agents are Green and Cooper, Ltd., whose advertisement will be found elsewhere in this issue.

N.Z. Electronics Institute

(Continued from Page 23.)

I.R.E., M.N.Z.E.I., "Some Aspects of Modern High Quality Audio Equipment."

November, 1949: Mr. K. B. Gilby, B.E., A.M.I.E.E., A.M.N.Z.E.I., "Some Aspects of Modern Vacuum Tube Voltmeters."

December, 1949: Visit to the Automatic Exchange and Carrier Room.

March, 1950: Mr. W. D. Foster, B.Sc., A.M.(Brit.) I.R.E., M.N.Z.E.I., "Further Aspects of Modern High Quality Audio Equipment."

May, 1950: Mr A. Ryland, "Remote Control Equipment of Radio Transmitters."

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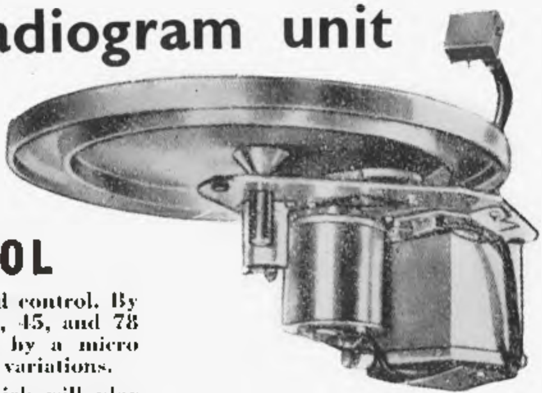

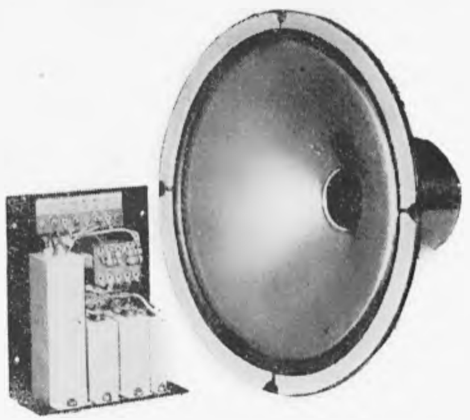

Abstract Service

(Continued from Page 13.)

Key clicks and receiver band-widths. How to adjust your transmitter keying.

QST, (U.S.A.), April 1950, p. 34.

A 2-metre station for the novice. This is described in three parts, full construction instructions being given.

QST, (U.S.A.), Feb., March, and April, 1950.

TELEVISION

An effective "sync" lock-in circuit. A new circuit for television receivers developed and available in kit form for taking care of the horizontal control.

Radio and Television News, (U.S.A.), March, 1950, p. 44.

Television servicing. The ability to recognize trouble by the type of pattern is an asset in servicing video receivers. This is for those who seek to learn the methods of television servicing in advance of practice.

Radio and Television News, (U.S.A.), March 1950, p. 49.

Television trouble-shooting without instruments. The procedure outlined describes a method whereby a great number of circuit faults can be found without instruments.

Radio and Television News, (U.S.A.), March 1950, p. 61.

MISCELLANEOUS

A theoretical and experimental study of the series-connected magnetic amplifier.

Proceedings of the I.E.E. (Eng.), Part I, March 1950, p. 85.

Incandescent light flicker causes trouble to the amateur using light powered transmitters. A recommended solution is given.

QST, (U.S.A.), March 1950, p. 18.

Welding aluminium with a blowtorch. This method for amateurs may be most useful.

QST, (U.S.A.), March 1950, p. 22.

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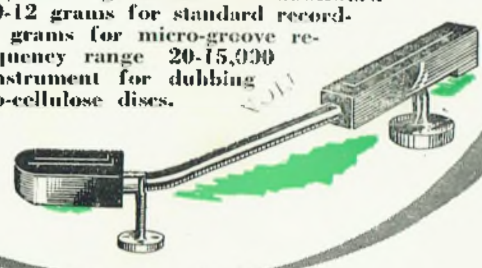

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