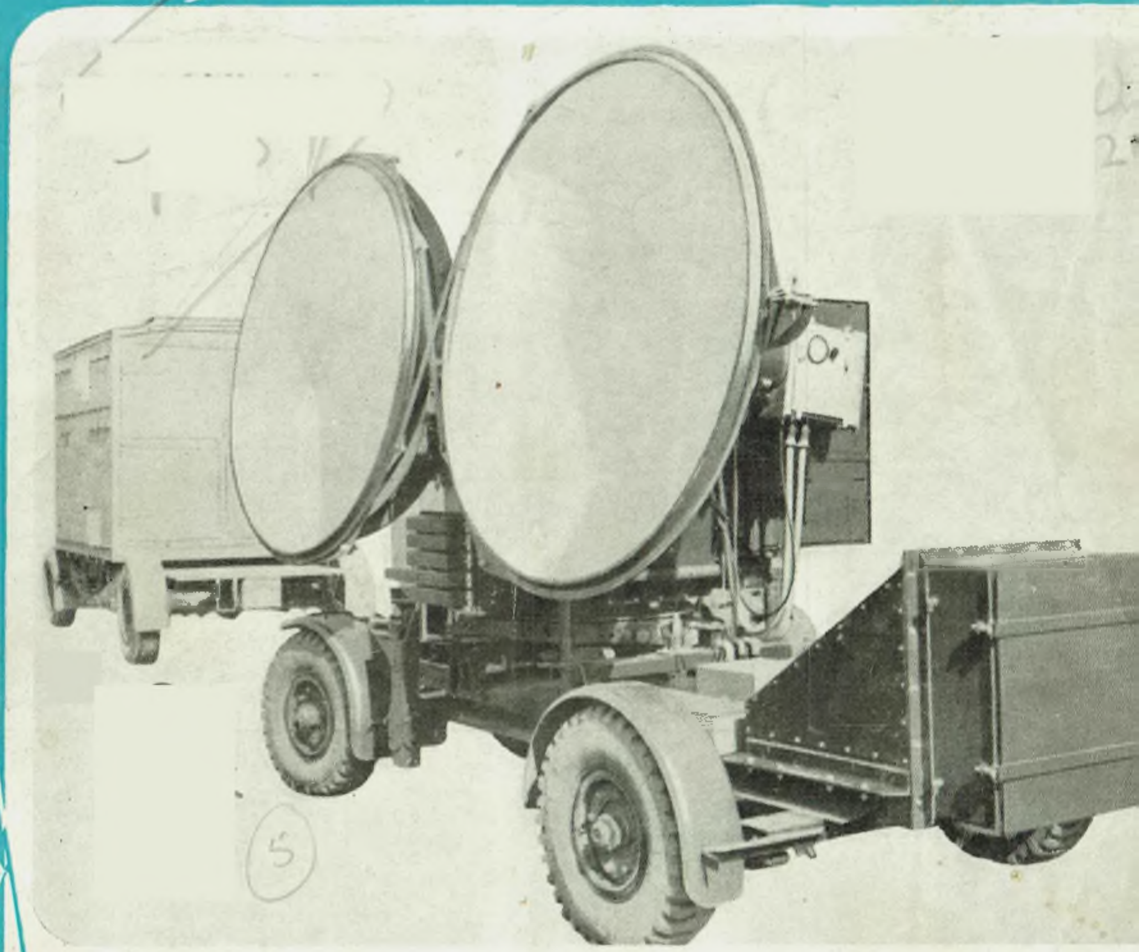
# RADIO and ELECTRONICS



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**AUGUST 1st, 1946**

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1'6

# RADIO and ELECTRONICS

Vol. 1 No. 5 August 1st, 1946

Contents Page



OUR COVER this month shows a B.T.H. mobile experimental micro-wave height-finding radar equipment. The trailer in the foreground carries the transmitter, aerials, and turning gear. One of the two large parabolic reflectors is used for transmitting and the other for receiving. The "dishes" can be rotated both in elevation and bearing by remote control from the vehicle in the background, which houses the receiving and display equipment. The equipment was developed in England as early as 1941.

CORRESPONDENCE

All correspondence, contributions, and enquiries referring to advertising space and rates should be addressed to:—

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A five, and also a six-valve, dual-wave receiver.

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# Television—When?

The art of picture transmission had been brought to a high degree of excellence before the recent war, and it is certain that considerable improvement will ultimately become possible as a result of war-time development in all branches of electronics. The use of unattended automatic relay stations has overcome to a large extent the difficulty of providing adequate television coverage over broken country, so that, from the technical standpoint there is very little reason why television broadcasts could not be successfully carried out in the more thickly-populated areas of this country.

How soon, then, can New Zealand expect its own television service? Some will argue that since we were not far behind the rest of the world in the introduction of sound broadcasting, someone will see to it that television, too, will not be long wanting. But things are very different now from what they were two decades ago. Amateur enthusiasm gave us our first broadcasting, but can hardly be expected to provide a television service, however limited.

It is the National Broadcasting Service to which we must look for a move in this direction, but so far, this body has given no sign of any impending developments, and rightly so, for although television has reached the stage where it gives acceptable results, no international standards have been laid down. The television signal is quite complex, and may be varied in many fundamental ways without sensibly affecting the quality of the image, but as a result, receivers built for operation on one type of signal will not necessarily operate on a signal having different specifications. On this score alone, any authority cannot be blamed for wishing to delay the advent of television until an international standard signal has been defined, for however delighted the interested public might be to see a service instituted at an early date, the same public would be somewhat displeased, to say the least, if afterwards an international agreement rendered their receivers useless.

But the weightiest objection is that of the expense, not so much of acquiring the equipment, though this is costly enough, but of providing programme material. One American authority has estimated that, to give a three-hour programme daily from a single station, costs three million dollars a year. The reason for this may not be immediately obvious, but becomes so when it is realised that, apart from such items as sports broadcasts, all televised material must undergo as much rehearsal as a full-scale stage presentation, all for a single performance from which there is no direct revenue.

From time to time, complaints are voiced through the press that radio license fees in this country are much too high. In our opinion, this is not so, but be that as it may, there is no doubt that, either a considerable increase in the general license fee, or a substantial special fee would have to be imposed if the National Broadcasting Service were to implement even a limited television service. Many listeners who do not want television, or who, from their geographical position could not expect immediate service, would strongly oppose the first course, which would certainly not be without its injustices, whilst the number of people willing to pay a heavy fee and install expensive receiving equipment would be unlikely to yield a great enough revenue to support the venture, even with generous subsidies from the main broadcasting funds.

At the moment, then, and probably for some years to come, finance will be the chief obstacle that television has to face. There seems to be a public impression that television is "just round the corner," and that old sets will serve until combination television and broadcast receivers are on the market. Nothing could be farther from the truth.

It will be some years yet before such a view can reasonably be held, and the National Broadcasting Service would be doing a service to the public and the radio industry if it were to make an official pronouncement to that effect.


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# RADAR—JAPANESE STYLE

**" . . . Our radars were frequently attacked and destroyed by the Allies. . . ."—Senior Japanese Naval Radar Officer, South-East Asia Command, Rabaul Area.**

Behind in the world race for technical superiority, the Japanese failed to realise the supreme importance of comprehensive radar coverage until too late. When they did realise its tactical advantages, they were on the defensive—a defensive from which they never recovered.

The early warning radar nets established by the Japanese were inadequate to provide more than a barely average warning efficiency. The author was in the unique position of being able to follow the Japanese effort to provide radar coverage in the Solomons-New Britain area right to the end of the war, when he was able to interrogate the Japanese technical officers on the effectiveness, not only of their defence warning, but also of the effectiveness of the Allied effort to bring counter-measures to bear and destroy their stations.

So this story really commences as the dark days of 1942 came to an end, when the American armed forces were amassing vast quantities of equipment on Guadalcanal prior to their very successful attempts to recapture the Solomon Islands.

Ineffectual as it was, the warning provided by the enemy radar soon became an increasing hindrance to the mounting intensity of the Allied bombing. A counter-measures organisation was speedily swung into action to deal with the tricky problem of locating and destroying these enemy "eyes."

A Catalina aircraft was fitted out with a modified set of airborne search radar. Essentially simple, the equipment consisted, at this stage, of a receiver capable of covering the frequencies then used by radars, fed into a display unit. The "Cat," painted black, would set out on all-night patrols over enemy territory, stooging around until the operator was able to pick up enemy pulses on his screen. These would look like railings, and by counting the number on the screen and measuring their width a wealth of information was available. Once picked up, the enemy radar would be tracked and plotted on several bearings and the intersections pin-pointed. First thing next morning the area would be photographed, the film developed, and later that same morning the area bombed.

Station after station was put out of action in this outwardly simple but hazardous manner. Soon the Japanese were driven to extraordinary measures of protection—even to the extent of digging 60 feet into the side of a hill and then burrowing a tunnel over 80 feet vertically up to the crest, where they mounted the aerial array energised by transmission lines run through this tunnel. Thus it was almost impossible to destroy the equipment itself. The only way was by an improbable direct hit on the small target presented by the array itself.

However, the Japanese losses were twofold. Losing valuable technical equipment is serious enough, but far more serious was the irretrievable loss of personnel able to man and operate salvaged and reconditioned units. Radar equipment is complicated in design to an advanced degree. Constant care in servicing and an efficient supply organisation to keep up a steady flow of parts are both vitally necessary for smooth and efficient operation.

The Japanese, indoctrinated with the idea of supremacy in all military matters, seemed careless with their supply organisation. On the first signs of adverse operating conditions, the whole net began to crumble. Operators were killed and none was available to take their place. Supplies petered out. They were up against it—badly. One mistake that cost them dearly was the short-sighted policy of training only their radar officers to service and maintain radar sets. For reasons of security, the enlisted personnel were "untrained" to a remarkable degree. They knew nothing other than how to adjust the viewing screen and how to interpret what they saw on it. The effect of this system was devastating. Before long, the number of technical officers was hopelessly insufficient. In one area continuously being "pasted," seven units, spread over an 80-mile zone, were serviced by four officers. A difficult task, as most of the units were inaccessible to all except the most agile of mountain goats.

Things went from bad to worse. Bombing became heavier and heavier. Supply ships were a thing of the past. Tension mounted, and relations between the army and the navy grew strained. It was not very long before the army turned on the navy and accused them of not bringing in vital supplies. The navy retaliated to the effect that, if the army would not keep losing islands so quickly, they could do something about it. It was during this bickering that radar came into its own. The warring factions soon realised how important were those few minutes of warning which radar was able to give. The navy, short of commodities held in plentiful stock by the army, quickly appreciated the "barter" value of their radars. They promptly threatened to cut the army off the warning net unless certain supplies were immediately forthcoming. They got away with it once or twice, but the army soon tired of giving in and virtually severed relations. True to its threat, the navy discontinued supplying warning and the army was forced to place look-outs near navy shore establishments. The ships had long since come to rest at the bottom of Rabaul's beautiful harbour. Whenever naval personnel made for the nearest "foxhole," the "spy" would pass the news back to his unit. Thus, for several long months the Japanese survived. Isolated, alone, they waited for the Allies to attack their strongest of bases: an attack which, by virtue of atomic bomb, never eventuated.

## JAPANESE EQUIPMENT.

Contrary to expectations, Japanese equipment proved to be good. It was solid and well built, but definitely not modern in design. Their radar equipment in Rabaul was obsolete, inasmuch as the superbly-designed British and American equipment had advanced as far ahead again in technical achievement. Ranges and bearing accuracies were those associated with British equipment in use in 1940.

Japanese research establishments had developed experimentally units with far greater range, and had produced several microwave units for gun direction, and even for torpedo aiming on their large submarines. However, this modern equipment, for all its collective good, might well never have been conceived, for Japanese production was bottle-necked by a low standard of technical employee in the many factories turning out electronic equipment. Valves were largely copies of American and Continental valves in use well before 1939. Their inability to change factories over to the manufacture of more modern and more sensitive valves was most marked. The efforts of Japan's many brilliant scientists bore very little fruit, and the outposts of the "South-East Asian Empire" were equipped with outdated units.

Typical of radars used in the field is the Model One Mark One. This was turned into the hands of the navy in 1941. Designed by acedesigner, Naval Captain Ito, the units were destined to become a mainstay for their ground-based air-warning system. Operating on a frequency of 100 mc/sec., the transmitter had a power of 5kw. and radiated from a 4-stack 5-bay array. A 10 microsecond pulse with a recurring frequency of either 1000 c/sec. or 500 c/sec. was locked to a receiver time base of either 1 or 2 milliseconds' duration. This latter gave a choice of two ranges—0-150 or 300 kilometres.

A common aerial was used for both transmission and reception. This was achieved by the use of "spark gap" switching, a system in wide use by the Allies. Briefly, this consists of the insertion of spark gaps in what could be described as an R.F. transformer device, with wavelength adjusted so that a spark gap in one "leg" will strike and present a short circuit to R.F. at the input of the system. Then, by coupling both transmitter and receiver into the unit, alternate use can be made of the same aerial. As the transmitter pulses, the R.F. strikes the spark gap and cuts off the receiver input. When the transmitter is quiescent, the aerial feeder is routed through to the receiver.

Bearings on aircraft were obtained by a pair of selsyn units, one of which was connected to a bearing indicator near the operator, and the other coupled mechanically to the turning motor at the array itself. Although low in power (and 5kw. is a very low radar power, Allied equipment of a similar nature being rated at 150 to 250kw.), the very efficient aerial system enabled a "useful" range of 70 miles to be reached.

Airborne radar was not neglected by Japanese scientists, but once again their field units were out-dated. Large flying boats of the well-known "Emily" type were fitted with a simple form of search radar, but, due to poor servicing and a lack of confidence brought about by insufficient operating knowledge on the part of the air crew, it never amounted to very much. As often as not the units were removed from the aircraft and ground-mounted to supplement the already depleted air-warning net.

In the Solomons-New Britain area, three main types of ground radar were used. One was a mobile station operating on a frequency of 196 mc/sec. with a maximum theoretical range of 150km. The second was the converted airborne set, and the third the Model 1 Type 1.

It may be of interest to the thousands of ex-R.N.Z.A.F. personnel who played so active

*(continued on page 43)*

# An AC/DC 24 Range Multimeter

**Continuing our test equipment series of articles is a multi-range meter of comparatively low cost, which is built round any suitable 0-1 ma. meter movement. A.C. ranges are provided by using a bridge-type copper oxide meter rectifier.**

One of the most useful pieces of equipment used by the serviceman, amateur, or general experimenter is a multi-purpose meter capable of measuring a wide range of A.C. and D.C. voltages, D.C. current, and high and low resistances. The unit about to be described fulfils all of these requirements, and is built round a 1 ma. D.C. meter. Any meter may be used, irrespective of its D.C. resistance, so long as the latter is known.

The accuracy of the finished instrument will depend on the meter used, the care taken in adjusting the calibrating resistors, and the accuracy of the meters used as calibrating standards. It should not be difficult to achieve an accuracy better than 5 per cent. on all ranges. As with all multi-range meters, the highest accuracy will be obtained on the D.C. ranges, and can be made to approach the accuracy of the meter itself. This is not possible on the A.C. ranges on account of variations in characteristics from one meter-rectifier to another and variations with time in those of a particular rectifier.

## RANGES PROVIDED.

These are as follows:—

- A.C. and D.C. volts: 10, 100, 500, 1000, 5000.
- D.C. milliamps: 10, 100, 500, 1000, 5000.
- Ohms: 0-1050, 10,000, 100,000, 1 meg.

The meter movement is protected from serious damage by the insertion of a 100 ma. (or smaller) fuse in series with the positive lead to the meter. This will not prevent the pointer from becoming bent if a bad overload is applied, but will protect the coil from being burnt out.

Fig. 1 is a circuit of the complete instrument.

## CIRCUIT FEATURES.

The full circuit diagram is complicated by the fact that range selection is accomplished by means of two switches. In order to demonstrate the working of the meter on the various ranges, we shall break down the full circuit into the simple circuits actually used in making the various types of measurement.

### D.C. Volts.

As the meter used has a full-scale sensitivity of 1 ma., it is said to be 1000 ohms per volt. That is, in order to use it as a volt meter, resistance must be placed in series to the extent of 1000 ohms for every volt at the intended full-scale reading. Thus, for a full-scale reading of 10 volts, the total resistance of the meter circuit must be 10,000 ohms.

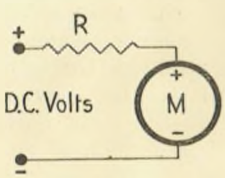

FIG. 2

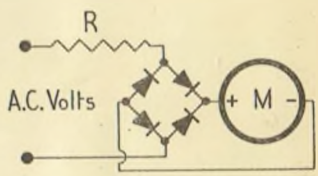

FIG. 3

For measuring D.C. volts, the circuit used is that of Fig. 2. The values of series resistance for the remaining ranges are as follows:—

| Range. | Total Resistance. |
|---|---|
| 100v. | 100,000 ohms |
| 500v. | 500,000 ohms |
| 1000v. | 1 meg. |
| 5000v. | 5 meg. |

It will be noted that we have specified the above values as being the total resistance in the measuring circuit. The resistance of the meter is therefore included in the figures given. Thus, if the resistors used have the exact values shown in the table, the total resistance will be higher by the resistance of the meter. For instance, on the 10-volt range the total resistance might be 10,100 ohms. In this case, the meter would read .1 of a volt low at full scale, which would be an error of 1 per cent. It can be seen, therefore, that the specification of total resistance is very important on low-voltage ranges. On any of the other ranges, the meter resistance is so small compared with that of the multiplier that it may be neglected without prejudice to the accuracy of the finished meter.

### A.C. Volts.

In order to measure A.C. volts, it is first necessary to rectify the voltage and apply the D.C. output to the meter. The circuit used is shown in Fig. 3, in which R is a series multiplying resistor exactly as in the D.C. circuit. However, its value for a given range cannot be the same as that used

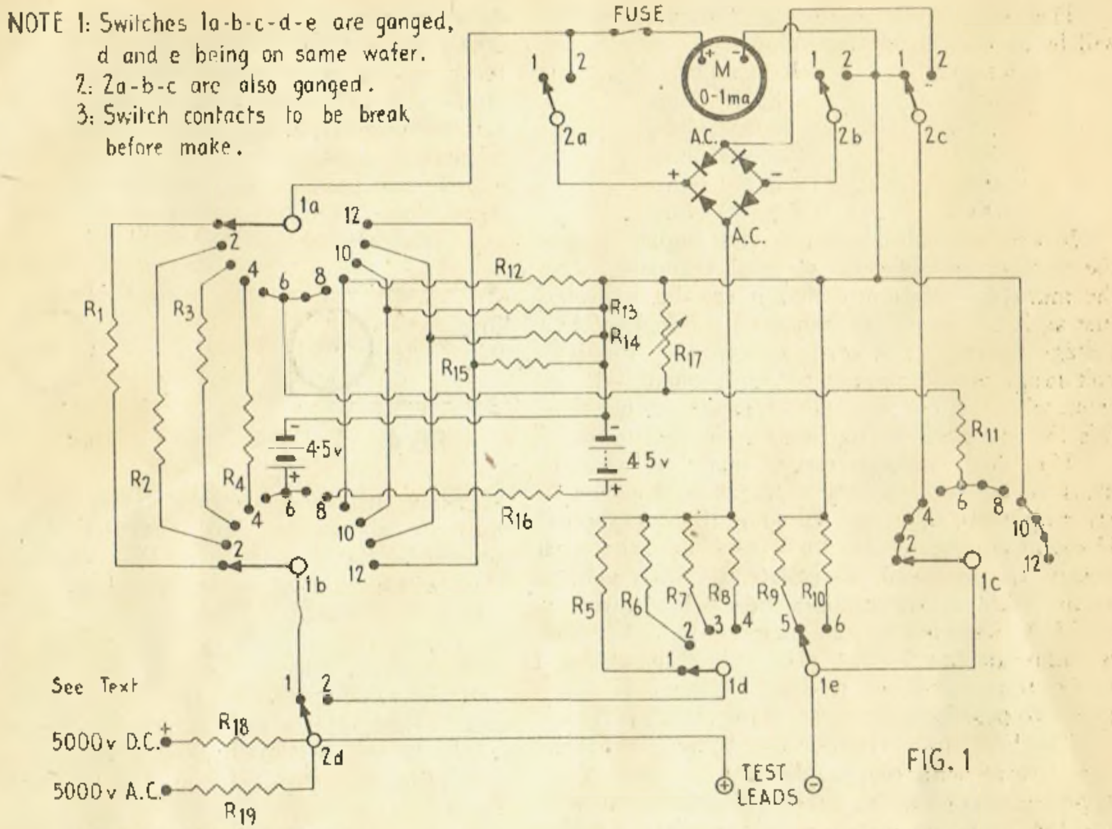


FIG. 1

## COMPONENT LIST

$R_1$ = 10k.
$R_2$ = 100k.
$R_3$, $R_7$ = 500k.
$R_4$, $R_8$ = 1 meg.
$R_5$ = 8k.
$R_6$ = 98k.
$R_9$ = 34.6ω
$R_{10}$ = 396ω
$R_{11}$ = 3550ω
$R_{12}$–$R_{15}$ = Shunts (see text).
$R_{16}$ = 31.95k.
$R_{17}$ = 500ω pot.
$R_{18}$, $R_{19}$ = 4 meg.
S1a–S1e = Main Selector (see text)
S2a–S2c = AC/DC Switch (see text).
Fuse = See text.

## SWITCH POSITIONS.

S1

| Position | Range |
|---|---|
| 1 | 10v. |
| 2 | 100v. |
| 3 | 500v. |
| 4 | 1000v. |
| 5 | R ÷ 100. |
| 6 | R ÷ 10. |
| 7 | R × 1. |
| 8 | R × 10. |
| 9 | 1 amp. |
| 10 | 500 ma. |
| 11 | 100 ma. |
| 12 | 10 ma. |

S2

| Position | Range |
|---|---|
| 1 | D.C. volts — ma. — ohms. |
| 2 | A.C. volts |

for D.C. volts, because of the resistance of the rectifier. One of the things which limit the accuracy of the rectifier-meter combination is that the resistance of the rectifier varies with the voltage applied to it. Sufficient accuracy can be obtained, however, by assuming that this resistance is constant at 2000 ohms as long as the low-voltage range is calibrated all over the scale. On the high-voltage ranges the effect is not apparent, but at low voltages the scale is not linear, so that hand calibration is really necessary for the 10-volt range if anything like accuracy is to be attained.

The series resistors for the A.C. volts ranges will be approximately as follows:—

| Range. | | Resistance. |
|---|---|---|
| 10v. | ...... | 8,000 ohms |
| 100v. | ...... | 98,000 ohms |
| 500v. | ...... | 498,000 ohms |
| 1000v. | ...... | 998,000 ohms |
| 5000v. | ...... | 4,998,000 ohms |

It will be realised that on the higher ranges the rectifier resistance is so small compared with the multiplier resistance that it can be neglected just as is the meter resistance on the higher D.C. voltage ranges. The error involved on the 100-volt range would amount to approximately 2 per cent., which is too great, but on ranges higher than this the error will be too small to be significant.

The A.C. voltage ranges may be used to measure audio frequency voltages without much error up to 10,000 c/sec. In doing this, an external blocking condenser should be used in series with one of the test leads to isolate the D.C. voltage at the plate of an amplifier tube. If desired, it could be included in the meter circuit, but this would mean that the A.C./D.C. switch would have to be four-pole-three positions instead of four-pole-two positions, as shown in the circuit diagram.

The life of the rectifier will be long, provided it is treated with reasonable care. Apart from applying overloads, no attempt should be made to use the meter on square waves or pulses, which have the same deleterious effect as an overload. The trouble is that the rectifier will not cease to work, but will give an entirely false reading.

**D.C. Milliamps.**

Since the full-scale reading of the meter is 1 ma., shunts must be employed in order to measure higher currents than this. The circuit is shown in Fig. 4. For instance, in order to produce a full-scale reading of 10 ma., the shunt must carry 9 ma. and the meter 1 ma. The value of shunt resistor required for any range is given by—

$$Rs = \frac{Rm}{N - 1}$$

where Rs equals the resistance of the shunt,

Rm equals the resistance of the meter, and

N equals the ratio of the new full-scale reading to that of the unshunted meter. For example, if we assume that the meter resistance is 50 ohms and that the new scale reading is 10 ma., we have

$$Rs = \frac{50}{10 - 1} = \frac{50}{9} = 5.555 \text{ ohms}$$

A simple and accurate method of finding the resistance of the meter without overloading it is shown in Fig. 5. C is a 1½v. torch cell, A is a 2000 ohm variable resistor, and B is a variable resistor of any convenient value up to about 500 ohms. First, B is disconnected and A is adjusted for full-scale deflection of the meter. B is then connected and adjusted until the meter reading is exactly half-scale. The resistance of B must now equal that of the meter, and can be measured by any convenient means.

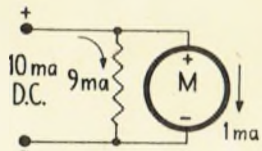


FIG. 4

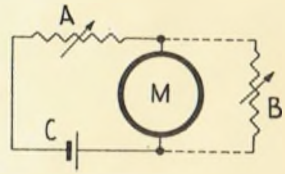


FIG. 5

Since the values required for the shunt resistors are all non-standard, they will have to be wound by the constructor. This being the case, they will have to be accurately adjusted by hand. The easiest way to do this is to wind the resistor to a value very slightly too large and to reduce it to the correct value by forming a small loop at one end and twisting this to short-circuit some of the wire. Fine adjustment can be obtained in this way while current is actually flowing, and is complete when the pointer reads the appropriate figure. The easiest way to calibrate shunts is to place the meter in series with a suitable voltage source and a meter which acts as a standard. The latter can be any meter known to be sufficiently accurate, such as a good commercial multi-meter. The current is adjusted so that the standard reads the full-scale current for the range being calibrated, and the shunt is adjusted until the meter under calibration reads full scale.

**Resistance Ranges.**

The basic circuit used for the measurement of resistance is shown in Fig. 6. The dotted resistor in parallel with the meter is the zero setting control. The battery is a 4½ v. bias type, and the series resistance is shown as 4500 ohms. For reasons which will appear, this is not the value used in the actual circuit, but is shown in Fig. 6 in order to simplify the necessary calculations. The four resistance ranges are R × 1, R ÷ 10, R ÷ 100, and R × 10. Fig. 6 is that of the R × 1 range.

**The R × 1 Range.**

With the circuit arrangement used for the other ranges, the scale for all resistance ranges is made to coincide with that for the R × 1 range, which is therefore the fundamental resistance-

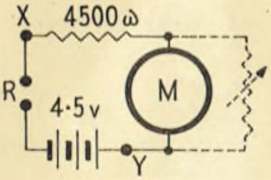

FIG. 6

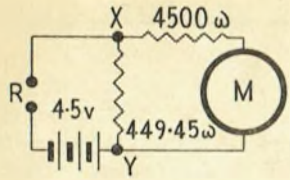

FIG. 7

measuring circuit. Forgetting for the moment about the zero-setting resistor, it is clear that, if the terminals marked R are short-circuited, the meter will read full scale. If an unknown resistance is connected at R, the meter reading will be reduced by an amount depending on the value of the unknown resistor. Suppose, now, that a 1000 ohm resistor is connected at R. The total circuit resistance is now 5500 ohms, so that the meter current will be

$$\frac{4.5 \times 1000}{5500} \text{ ma.} = 0.818 \text{ m.a.}$$

When the resistance scale is being calibrated, this point should be marked first and labelled 1000 ohms. It is the reference point by means of which the other ranges are made to coincide with the calibration for R × 1. From Ohm's Law it is found that, with the 1000 ohm resistor connected at R, the voltage between the points X and Y must be 3.681 v. at the same time as the meter is reading 0.818 ma. Calibration of the complete R × 1 scale can be done by calculation as shown above for the value of 1000 ohms. This process will give a more accurate scale than will using "known" values of carbon resistor at R and then marking the deflections obtained.

### The Zero Setting Shunt.

As mentioned above, the series resistance used in the R × 1 circuit is not 4500 ohms, but 3550 ohms. The reason for this is as follows:—As the battery ages, its voltage drops from the nominal value of 4½, so that means must be provided for compensation and adjustment of the meter to full-scale reading with R short-circuited. Reducing the value of series resistor in this way would cause a current greater than 1 ma. to flow through the meter were it not for the shunt-resistor across it. The latter allows the extra current to be by-passed when the battery is new, and at the same time ensures that correct resistance readings are obtained when the battery voltage is low without any other precautions than setting the meter to zero before taking a measurement. A little working out will show that calculation of the scale readings when calibrating the R × 1 scale is quite unaffected by this slight change of circuit, and will give the right answer.

### The R ÷ 10 Range.

This range will give us the indicated scale reading divided by a factor of ten. In other words, with a 100 ohm resistor connected at R, the indicated current will still be 0.818 ma. On the R × 1 range, a resistance of 100 ohms at R would give a reading of

$$\frac{4.5}{4600} = 0.978 \text{ ma.}$$

and the voltage across XY would be 0.000978 × 4500 = 4.401 volts. The circuit must therefore be amended to give 3.681 v. across XY when 100 ohms is connected at R. Fig. 7 shows this amended circuit, in which a resistance of 449.45 ohms has been connected across XY. This value is arrived at as follows: The current flowing through R is

$$\frac{4.5}{549.45} = 8.19 \text{ ma.,}$$

and the voltage drop across R is therefore 0.00819 × 100 = 0.819 v., leaving us with 4.5 — 0.819 = 3.681 volts across XY.

### The R ÷ 100 Range.

The circuit is similar to that of Fig. 7, except that the resistor across XY is now 44.945 ohms.

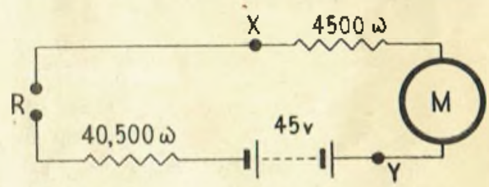

FIG. 8

### The R × 10 Range.

Since this range gives the indicated value × 10, the circuit must be arranged so that we still have 3.681 volts across XY. The circuit is shown in Fig. 8. The 4½v. battery is replaced by one of 45v., and an additional series resistor of 40,500 ohms is used to limit the current through the meter to 1 ma. In this case, the reading of 0.818 ma. is obtained when the total series resistance is 55,000 ohms, which corresponds to an "unknown" of 10,000 ohms. The voltage drop across R and the series resistor is 0.818 × 50,500 = 41.309 volts. Therefore, the voltage across XY will be 45 — 41.309 = 3.691 volts. The apparent difference between this figure and that of 3.681 is due solely to the fact that the current through R has not been worked out to five places, and does not represent an inaccuracy in the values used.

*(continued on page 47)*

## LETTERS TO THE EDITOR

Sir,—Your editorial in the May issue on British and American techniques has caused much lively comment, especially regarding British *v.* American valves and components. It seems to be generally agreed that it has not been so much the "funny" bases which have caused the former valves to be unpopular, as the fact that practically no information can be obtained about them, and such things as under-socket connection diagrams do not seem to exist.

The all round efficiency of British valves has always been recognised, and the present tendency of some of the more modern types to find favour is due less to the fact that octal bases are becoming standard, than that information regarding their characteristics is now available.

It seems to me that the prestige of British radio has suffered in this country because of the types of receivers reaching us. While giving excellent performance, and possessing pleasing outward appearance, they seem to lag far behind American or New Zealand-made sets in the matter of constructional design. The lay-out of some makes has been disgraceful, providing many a headache for the serviceman.

—I am, yours, etc., J. PEARSON.



## QUESTIONS and ANSWERS

Mr. O. G. Hansen, of Taupiri, writes as follows:

Dear Sir,—An article appeared in the *New Zealand Herald* some time ago stating that an electronic microscope had been constructed in Germany capable of magnifying T.B. germs to the size of human beings: that they could be seen living and functioning. Also that two of the Professors had been shot and the microscope destroyed.

Is it known how the microscope was constructed? Can you give me any information on electronic microscopes? Would it be possible to construct one at a reasonable price, say, at the cost of an experimental radio set, and would it be possible to make one to study disease germs down to about the size of typhus germs? I have heard that the germs have to be submitted to vacuum in an electronic microscope. Is this so?

---

[We do not like having to dampen anyone's enthusiasm, but Mr. Hansen has brought up a subject which is, as yet, quite outside the bounds of possibility for the amateur experimenter. The construction of an electron microscope is such that to build one would require the resources of such a body as the Dominion Physical Laboratory. It has recently been reported that Radio Corporation of America have succeeded in producing an electron microscope no bigger than the usual 5in. oscilloscope. Hitherto, all such instruments have been very large, have necessitated a power supply of approximately 100 kv. and have used continuously operating pumps in order to hold the very high vacuum required. The specimen being examined is situated in an evacuated chamber, so that a portion at least of the microscope is demountable, and must be re-evacuated after changing specimens. These few facts alone will show that the time has not yet arrived when these instruments can be built in the home.

The Dominion Physical Laboratory even, has found after considerable experimental work, that to develop and produce a single instrument is more costly than to import one, which could be bought from America at a cost of several thousand pounds.]

* * *

### A.F.C. CONTROL TUBES.

R. W. Dawe, Christchurch, writes wishing to know how one may calculate the effective inductance of the conventional reactance tube which has a phase-splitting network between plate and grid, and whether the constants of the network affect the result in a given case.

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[The case quoted by Mr. Dawe is that of a 6J7 reactance tube where the phase-splitting network consists of a 100k. resistor between plate and grid and a 20$\mu\mu$f. condenser between grid and cathode. There is, of course, a large blocking condenser at the top end of the network to isolate D.C. voltages.

Yes, the performance of the reactance tube does depend on the constants of the network. It also depends on the inductance of the controlled oscillator tuned circuit. For this reason, it is best to think not in terms of equivalent inductance of the reactance tube, but in terms of oscillator frequency, which may be derived if the oscillator inductance is known. The formula for controlled oscillator frequency is as follows:—

$$f^2 = f_0^2 \left[ \frac{L_0 Gm}{CR} + 1 \right]$$

where f is the oscillator frequency in cycles/sec.; $f_0$ is the frequency of the oscillator with the reactance tube at cut off, also in cycles/sec.; Gm is the mutual conductance of the reactance tube in mhos; C and R are the values of the phase-splitting network, in ohms and farads; $L_0$ is the inductance of the oscillator coil in henries.

This will enable a control curve to be drawn if the curve of mutual conductance against grid bias is known for the valve used as the reactance tube. Without this knowledge the formula will still allow the maximum frequency swing to be calculated, for by substituting the published value of Gm the highest attainable frequency can be found.

If the oscillator inductance and the lowest controlled frequency are known, the highest controlled frequency can be found from the formula. Alternatively, by assuming the lowest frequency, the highest frequency, and R, the formula will enable the required value of C to be found. It will be noted that the frequency rises with increasing mutual conductance.

As this subject will be of interest to many readers, it is proposed at an early date to publish a full article showing how to design reactance tube circuits by means of this formula and one or two other simple ones. Another noteworthy point is that, for a given value of C, increasing the value of R increases the available frequency sweep. In practice, however, R should not be reduced below about 10,000 ohms if linear control is required.]

## CLASSIFIED ADVERTISEMENTS

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## RADIO and ELECTRONICS

Back numbers of this journal may be obtained from S.O.S. Radio Service, 283 Queen Street, Auckland, and the Te Aro Book Depot, Ltd., 64 Courtenay Place, Wellington, C.3.

# THE CATHODE FOLLOWER AT HIGH FREQUENCIES

**Showing how the cathode follower's behaviour at high frequencies depends largely upon the characteristics of the load impedance on the one hand and the "generator" impedance on the other.**

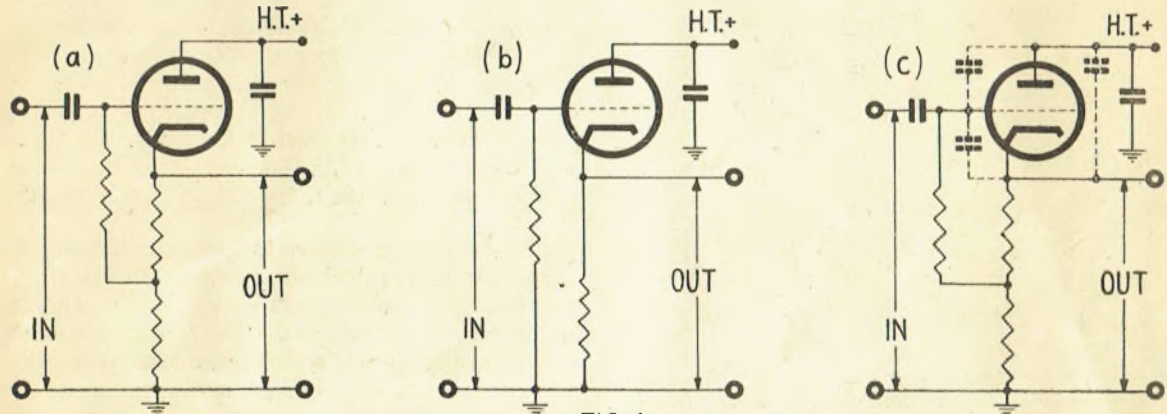



FIG. 1

In the first issue of *Radio and Electronics* was printed a descriptive article on the cathode follower, which was represented as possessing at audio frequencies the very desirable qualities of unusually high input impedance and low output impedance. This first article, though making brief mention of the fact that high-frequency working of the circuit was possible, gave no hint of what the frequency limits were or how frequency effects modified the behaviour of the circuit. It is therefore the purpose of the present article to rectify this omission, and to show what precautions are necessary in practice to obtain good results from the cathode follower at radio frequencies.

The treatment is non-mathematical, since no attempt is made to derive the results presented. The description is based on an analysis by Jeffery[1]; the formulae given are his, slightly rearranged in some cases, and in the same way the equivalent circuits, in some cases altered, are from Jeffery's paper.

The formulae and data have been given to enable actual examples to be worked out, but have been confined as far as possible to the diagrams. Anyone wishing to "skip" the formulae may therefore do so without disturbing the continuity.

## A DEFINITION.

For the purposes of this article it is necessary to define just what is meant by the term "high frequency." In Figs. 1 (a) and (b) are shown two commonly-used cathode follower circuits. As far as signal is concerned, their operation is identical.

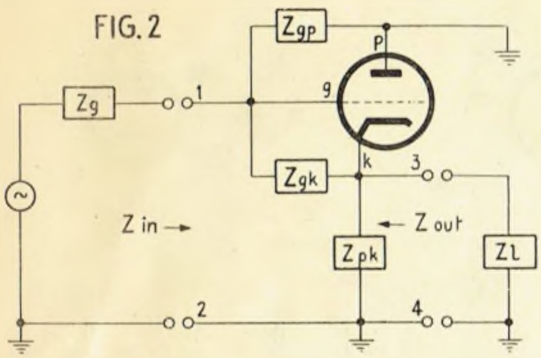
At low frequencies, the circuits as drawn are quite in order, but as the signal frequency is raised a point is reached where the inter-electrode capacities of the valve have an appreciable effect, for, although these capacities are very small, their effect can be great if very high resistances are associated with them. The true circuit of Fig. 1 (a) is shown in Fig. 1 (c), where these capacities are shown dotted. It can be appreciated at a glance that if these capacities have only a low reactance at the signal frequency, operation of the circuit will not correspond with that at lower frequencies, where the reactances of the valve capacities are so high that to all intents and purposes the capacities do not exist.

Since a great range of resistance values may be used in a cathode follower circuit, it is not possible to lay down any fixed dividing line between low and high-frequency operation. Thus high-frequency operation is defined as operation at frequencies where the inter-electrode reactances are not large compared with the resistances associated with them.

## GENERALISED CIRCUIT.

In order to find out what occurs in a circuit at any frequency, the most general form of the circuit must be drawn, and an analysis made of the general case in terms of alternating current theory. Although it is proposed here to give only the results of such an analysis (since from these, practical effects may be deduced), in Fig. 2 is shown the generalised circuit of the cathode follower, which will be of assistance in describing practical effects later on. First it will be noted that no

FIG. 2




resistances or capacities as such have been shown. This is because the fundamental property of any circuit or part of a circuit is its impedance, Z, which may be inductive, capacitative, or resistive, or yet a combination of either of the first two with the latter.

Secondly, the signal source, or generator, with its impedance Zg has been shown, although it is not part of the cathode follower itself. Similarly, the load impedance Zl has been shown separately from the circuit proper. As is indicated in Fig. 2, the input impedance, Zin is the impedance which the generator sees when looking into the circuit. For the input impedance to be found, the load Zl must be connected, since disconecting it must alter the impedance as seen by the generator. Similarly, in finding the output impedance (which is the impedance seen by the load when looking into the output terminals) the load must be disconnected, and the generator connected. Thus Fig. 2 represents the two circuits that can be used for investigating input impedance and output impedance respectively.

Fig. 2 is important, practically, because, without any further investigation, two important conclusions can be drawn:—

(1) The input impedance depends in some way upon the impedance of the load.

(2) The output impedance depends upon the internal impedance of the generator, or signal source.

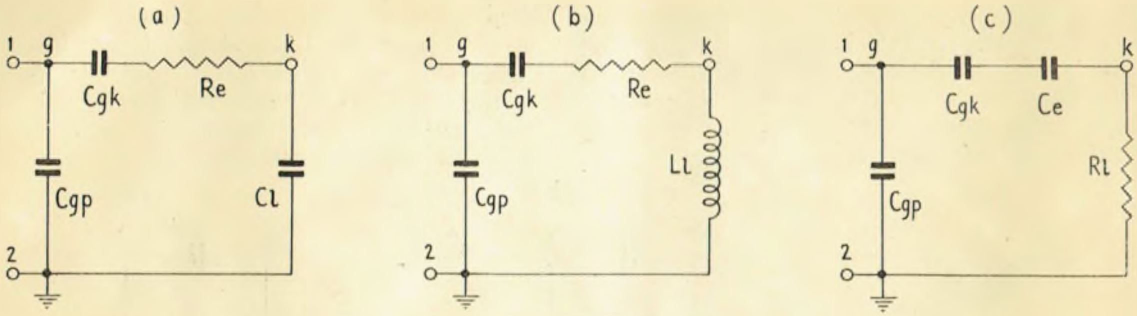
When it is realised that Zg and Zl may have any type of impedance, the necessity for generalising the problem is obvious, since otherwise there would be five possible separate problems in finding either input or output impedance.

## INPUT IMPEDANCE.

When the load is connected to the output terminals and the network evaluated, it is found that only three different modes of operation occur, whatever the load impedance. These modes are illustrated in Fig. 3, which should be compared with Fig. 2. Points on Fig. 3 labelled 1, 2, g, and k represent the corresponding points on Fig. 2; Cgk replaces Zgk, since the latter is always the grid-cathode capacity of the valve. Similarly, Cgp replaces Zgp. The components indicated between cathode and earth, Cl, Ll, and Rl, represent the three possible types of load impedance, while Re and Ce are new, and will be explained shortly.

The three circuits of Fig. 3 are known as equivalent circuits. That is to say, the components shown are not necessarily actual components, but some are hypothetical ones which, when arranged in the circuits shown, enable the performance of the more complex actual circuit to be visualised. Thus Figs. 3 (a), (b), and (c) are each simplifications of the general case of Fig. 2. Cgk and Cgp are actual, real components, being the inter-electrode capacities of the valve used, but Re and Ce are hypothetical. In other words, although the actual circuit is as in Fig. 2, it can be shown that this complex arrangement of impedances behaves as if it had the simpler configurations shown in Fig. 3. For instance, with a capacitative load, Fig. 2 amounts to the same thing as Fig. 3 (a) and acts as if an actual resistance Re had been placed in series with the grid-cathode capacity. In addition, the value of this resistance can be computed from the formula given below the circuit.

In using the components Cl, Ll, and Rl for purposes of calculation, it should be remembered that these components are not the actual capacity inductance or resistance introduced by the device used for a load, but are the resultant of all circuit elements connected between cathode and earth. For example, if the load were an inductance, Ll would be the inductance representing the actual inductive reactance between cathode and earth, and would take into account the plate-cathode capacity of the valve, which is always one component of the output impedance. To give a further instance: the load device could be an inductance, but the frequency could be such that the load, in parallel with the plate-cathode capacity, has a net capacitative reactance. In this case Fig. 3 (a) would be the appropriate circuit, not Fig. 3 (b).




$$Re = -\frac{gm}{\omega^2 Cl\, Cgk} \qquad Re = \frac{gm\, Ll}{Cgk} \qquad Ce = \frac{Cgk}{Rl\, gm}$$

FIG. 3

## PRACTICAL EFFECTS.

### The Capacitative Case.

Where the load impedance is capacitative, Fig. 3 (a) is the appropriate equivalent circuit. Re has a value given by the equation below the figure. It will be noted that the value is always negative, which is the same thing as saying that regeneration exists in the circuit. This is an important practical result, since it warns us that with a capacitative load the cathode follower may oscillate. Jeffery (loc. cit.) shows that if the input to the cathode follower is obtained from a tuned circuit, there is a maximum dynamic resistance which may be used if oscillation is to be avoided. Thus, damping the input circuit with resistance in parallel is one way of curing the trouble. A better solution, however, is to use a grid stopper in series with the lead from the tuned circuit to the grid. The value of grid stopper necessary is quite small, and decreases with increasing frequency, for a given value of Cl. This is a much better solution than damping the input circuit, for, when a grid stopper is used, there is no limitation on the dynamic resistance of the input circuit, which may be as high as possible. In addition, no damping is imposed on the circuit by the grid stopper. For a 6AC7/1852, triode-connected, and with Cl = $20 \mu\mu f$, the maximum required grid stopper is 800 ohms, so that if only the plate-cathode capacity and wiring strays are to be neutralised, a value of 1000 ohms will be effective at any frequency.

### The Inductive Case.

This is illustrated in Fig. 3 (b). Here Re is positive, and therefore constitutes a certain amount of damping on the input circuit, so that if possible an inductive load should be avoided, unless a certain amount of input damping can be tolerated. It should be pointed out, though, that the damping introduced by an inductive load is very slight at high frequencies, compared with that introduced by conventional circuits.

### The Resistive Case.

This is represented in Fig. 3 (c), and is by far the most important, since it includes the case where a cathode follower is used to match the characteristic impedance of a coaxial cable. Here, the circuit element introduced by the valve is a capacity Ce in series with the actual grid-cathode capacity. The practical effect is obviously to decrease the grid-cathode capacity. But a further examination of the circuit shows that the input capacity as a whole can never be reduced below the grid-plate capacity of the valve. In most R.F. uses this does not matter very much, since the input is usually derived from a tuned circuit.

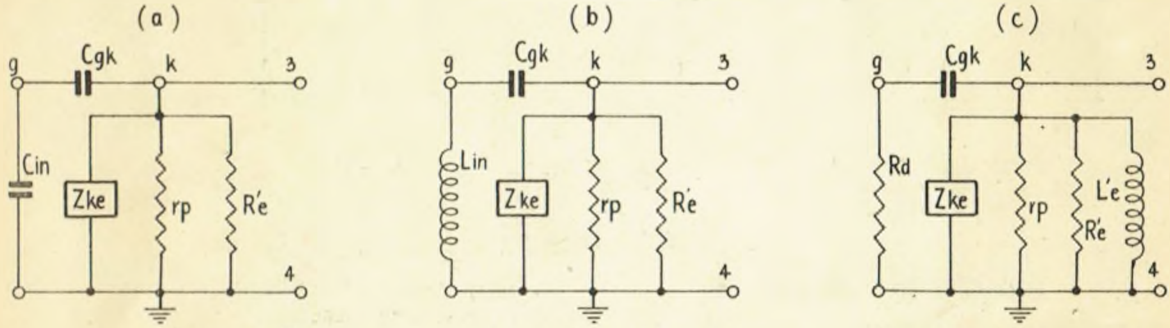
Jeffery shows also that for a 6AC7/1852 the input damping produced by the valve when connected as a triode is approximately 40,000 ohms at a frequency of 15.9 mc/sec. This figure is a striking example of the improvement in circuit behaviour that can be gained by proper use of a cathode follower at radio frequencies, for the damping at that frequency produced by the same valve in the conventional circuit is 26,000 ohms, approximately. The benefit is still greater at higher frequencies.

## OUTPUT IMPEDANCE.

As pointed out earlier, the output impedance of a cathode follower at high frequencies depends upon the impedance of the generator connected to the input terminals. The three possible cases are shown in Fig. 4, and represent situations where generator impedance is capacitative, inductive, or resistive. Zke in each diagram represents any impedance other than the load which may be connected between cathode and earth. In most cases Zke will consist of a resistance (the cathode resistor) in parallel with the plate-cathode capacity.

The latter is effectively connected between cathode and earth, since for signal purposes the plate is at earth potential. Rp is the plate-resistance of the valve, and R′e is again a hypothetical resistance, of the value shown, representing the effect of the operation of the valve.

tioning Lin and Cgk. For example, if the resonant frequency of Lin and Cgk is $\sqrt{2}$ times the signal frequency, $R'e = 0.5 \times 1/gm$. In the case of the 6AC7, triode connected, this would be 50 ohms, resistive. It will be noted in both the capacitative and inductive generator cases, the output im-




$$R'e = \frac{1}{gm}\left[\frac{Cin + Cgk}{Cin}\right]$$

$$R'e = \frac{1}{gm}\left[1 - \omega^2\, Lin\, Cgk\right]$$

$$R'e = \frac{1}{gm}\left[1 + (Rd\, Cgk\, \omega)^2\right]$$

$$L'e = \frac{1}{gm}\left[\omega\, Cgk\, Rd + \frac{1}{Rd\, \omega\, Cgk}\right]$$

FIG. 4

pedance remains resistive, apart from the effect of Cpk, included in Zke in the diagrams.

### The Capacitative Case.

Here, in Fig. 4 (a), the generator impedance is capacitative, as may be the case if input is obtained from a capacity attenuator. From the formula it can be seen that if Cin is very much larger than Cgk, R′e is approximately equal to 1/gm, which in the case of a 6AC7 is 100 ohms. At the same time, Rp is 3000 ohms, and the resistance included in Zke can be quite large, so that all the components shunting R′e are much larger than it is, so that the output impedance is almost equal to 1/gm or, in our example, 100 ohms, and at the same time is almost purely resistive, since Cgk is only *20* $\mu\mu f$.

This is an important result, because if it is essential both to achieve a low output impedance and to know with fair accuracy what its value is, making the generator impedance strongly capacitative enables this to be done, if the capacitative generator is no disadvantage from other points of view. It will be noted that R′e, and therefore the output impedance, is independent of frequency.

### The Inductive Case.

This is shown in Fig. 4 (b), from which it can be seen that R′e is not now independent of signal frequency. In particular, if the signal frequency is at the resonant frequency of Lin and Cgk, the output impedance will be zero, and there will be no output. With this arrangement, the possibility therefore exists of making the output impedance less than 1/gm, by correctly propor-

### The Resistive Case.

This is the most important case, for it represents the situation where the input is obtained from a tuned circuit, shown in Fig. 4 (c) as a resistance Rd, equal to the dynamic impedance of the tuned circuit.

With this arrangement, the effect of the valve is to produce the equivalent of an inductance L′e and a resistance R′e, both shunted across the output terminals. In other words, the output impedance tends to become inductive. Instead of being the simplest case, as might reasonably be expected, this one is the most complex, since both R′e and L′e are dependent on frequency and on the value of Rd.

One useful effect of this behaviour is that the load impedance must have quite a high capacitative reactance before the total impedance between cathode and earth becomes capacitative, producing regeneration, as described above. It shows, too, that for the cathode follower to produce a resistive output impedance under these conditions, suitable for matching to a properly terminated coaxial line, the cathode-earth capacity could be artificially increased until the proper condition is found.

It is important to note that R′e in this case is equal to 1/gm at low frequencies, but rises with frequency. Thus, at high frequencies, the output impedance will be determined almost solely by the other components, and can be made any desired value by making the actual cathode-earth resistor small, and of the value of output impedance required. This artifice will achieve the desired output impedance at the expense of gain, which may become very much less than unity.

### PRACTICAL APPLICATION.

All the statements we have produced above are subject to quite rigorous proof, and the practical effects referred to will be found to occur. As an example of this, Jeffery quotes the case of a pre-amplifier with a cathode follower output stage, used to feed the aerial circuit of a communication receiver through a length of coaxial cable. When the latter was disconnected at the receiver end, the cathode follower oscillated, because the line was no longer correctly terminated and represented a large capacitative load. The condition was cured by inserting a grid stopper.

Except where the output impedance must be accurately known, the load arrangements are not critical, as may be thought from a perusal of the preceding section. A case in point is the circuit used for the cathode follower in the 10-metre converter described in the July issue of *Radio and Electronics*. Here, a 500-ohm grid stopper was used between a tuned circuit and the tube grid. The cathode-earth resistor was 1000 ohms, and output was taken through a .001 $\mu f$. condenser to the centre conductor of a shielded cable. The latter was terminated by the primary of the input transformer on the main receiver. If the shielded cable is very short, the load impedance is inductive, consisting of the actual aerial coil inductance shunted by the "electronic" inductance L'e. In this case the input impedance would be high, and would consist of a positive resistance shunted across the input circuit. There would be no possibility of oscillation. The grid stopper, however, would have no adverse effect on the circuit operation. The output impedance would be approximately equal to 1000 ohms, the cathode resistor, since R'e would be high owing to the high value of Rd for the input circuit. This value of 1000 ohms would be a good enough match for any aerial coil likely to be found in use at the second I.F. of 4 mc/sec. The great advantage of the cathode follower here is that a quite close match can be obtained without having to wind a number of experimental low-impedance secondaries for the second I.F. transformer. In addition, the extra tuned circuit employed increases overall selectivity at the first I.F. and improves the image ratio. If a very long cable were to be used from the cathode

(*continued on page 45*)

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**This page is contributed monthly by the New Zealand DX Radio Association (Inc.), 20 Marion Street, C.2, Wellington, New Zealand. All "DX" and Club enquiries should be addressed direct to the Association.**

# THIS "DX-ING

## STATION ADDRESSES.

With this issue we introduce a new feature. It is our intention to place before our readers the postal addresses of overseas shortwave stations to assist those who wish to write away for verification of reception.

**XEQQ.**—Marroquil No. 11, Apartado 950, Mexico City, Mexico.

**CKFX.**—543 Seymour Street, Vancouver, British Columbia, Canada.

**CHTA, CKLO, CKLX, CKNC, CHOL.**—International Service of Canadian Broadcasting Corporation, 1236 Crescent Street, Montreal, Canada.

**VOHN.**—The Broadcasting Corporation of Newfoundland, Newfoundland Hotel, St. Johns, Newfoundland.

**VONF.**—Newfoundland Broadcasting Corporation, St. Johns, Newfoundland.

**CFRX.**—Rogers Radio Corporation, 37 Bloor Street, Toronto, Ontario, Canada.

**CFCX.**—Canadian Marconi Corporation, P.O. Box 1690, Montreal, Quebec, Canada.

**CBRX.**—Canadian Broadcasting Corporation, Vancouver, British Columbia, Canada.

**Radio Martinique.**—Boite Postal, 136 Fort-de-France, Martinique, Antilles Francaises.

## STATIONS TO BE HEARD.

**4.79 mcs.—"Radio Bandoeng," Bandoeng, Java,** a new wavelength put into operation by the Indonesian Republic, broadcasts typical Indonesian entertainment; signs off at 2.30 a.m. with musical chimes.

**4.87 mcs.—Singapore,** announcing as the Blue Network; relays the broadcast band outlet on 1250 kcs. until 3.30 a.m.

**5.025 mcs.—PCJ Holland,** now on this new frequency beamed to the Pacific area on Tuesdays 8-9.30 p.m. at great strength; this programme may also be heard on 15.22 mcs. and 17.765 mcs.

**6.015 mcs.—Armed Forces Radio Network, Tokio,** broadcasts popular American transcriptions on this clear channel from 9 p.m. to 1 a.m.

**7.295 mcs.—Athens Radio, Athens,** broadcasts in English language 8.15-8.30 a.m., after which follows French programme.

**9.55 mcs.—Paris Radio, France,** opens French North American service at 3.30 p.m. at good strength, while on 11.84 mcs. signal is fair; suffers interference from Moscow on 11.83mcs.

**10.22 mcs.—PSH Rio de Janeiro, Brazil,** may be heard with a fine signal operating from 10-11 a.m.

## RADIO AUSTRALIA

Schedule of English programmes effective June 3, 1946:—

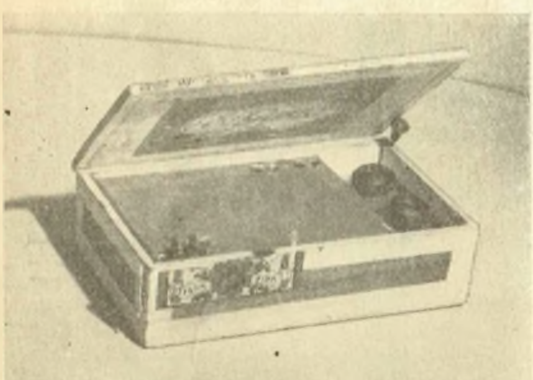
| | | Kcs. | Metres. | |
|---|---|---|---|---|
| VLA4 | 7.00 p.m.— 8.15 p.m. | 11770 | 25.49 | To England |
| VLG | 7.00 p.m.— 8.00 p.m. | 9580 | 31.32 | |
| VLA3 | 4.00 a.m.— 4.00 a.m. | 9680 | 30.99 | |
| VLC8 | 3.00 a.m.— 3.45 a.m. | 7280 | 41.21 | |
| VLG | 3.00 a.m.— 3.45 a.m. | 9580 | 31.32 | |
| VLG3 | 5.00 p.m.— 5.45 p.m. | 11710 | 25.62 | To U.S.A. |
| VLC4 | 5.00 p.m.— 5.45 p.m. | 15320 | 19.58 | |
| VLC5 | 12.00 p.m.— 1.15 a.m. | 9540 | 31.45 | |
| VLG4 | 4.00 a.m.— 5.00 a.m. | 11840 | 25.35 | |
| VLC6 | 4.00 a.m.— 5.00 a.m. | 9615 | 31.20 | |
| VLC9 | 11.40 a.m.— 1.50 p.m. | 17840 | 16.85 | |
| VLG10 | 8.35 p.m.—10.00 p.m. | 11760 | 25.51 | To Asia |
| VLC6 | 8.35 p.m.—10.00 p.m. | 9615 | 31.20 | |
| VLG10 | 10.30 p.m.—11.15 p.m. | 11760 | 25.51 | |
| VLG10 | 12.00 p.m.— 1.00 a.m. | 11760 | 25.51 | |
| VLA6 | 12.00 p.m.— 1.00 a.m. | 15200 | 19.74 | |
| VLA6 | 2.00 a.m.— 2.29 a.m. | 15200 | 19.74 | Asia and India |
| VLC6 | 2.00 a.m.— 2.50 a.m. | 9615 | 31.20 | |
| VLG | 2.15 a.m.— 3.00 a.m. | 9580 | 31.32 | |
| VLA6 | 9.15 a.m.—11.00 a.m. | 15200 | 19.74 | |
| VLA6 | 2.00 a.m.— 4.00 p.m. | 15200 | 19.74 | Forces |
| VLG6 | 2.00 p.m.— 4.00 p.m. | 15230 | 19.69 | |
| VLC4 | 2.00 p.m.— 4.00 p.m. | 15320 | 19.58 | |
| VLA6 | 8.35 p.m.—12.00 p.m. | 15200 | 19.74 | |
| | Saturdays only | | | |
| VLA6 | 2.00 p.m.— 6.30 p.m. | 15200 | 19.74 | |
| VLC11 | 6.00 p.m.— 7.30 p.m. | 15210 | 19.72 | |

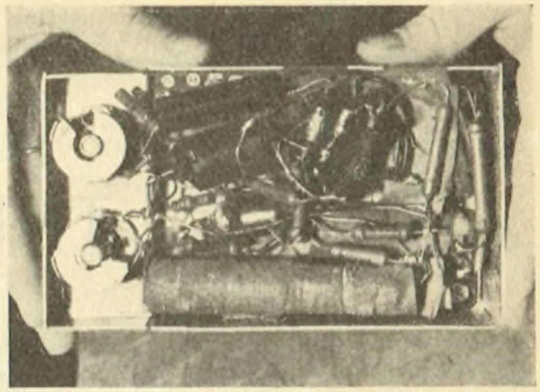
# TRADE WINDS

Speculation has been rife as to the origin of a new Wellington organisation, "Electronic and General Industries, Ltd." We called on Mr. Watkins, the Manager, and he gave us these details, which will be of interest to all connected with the radio industry. The Company has been formed to manufacture, import, and distribute as wholesalers special radio and electronic devices. Although not a subsidiary of Messrs. Collier and Beale, Ltd., the well-known firm of radio and electrical engineers, the new firm, through its Directorate, is very closely allied thereto. The Chairman of Directors is Mr. P. C. Collier, Governing Director of Messrs. Collier and Beale, Ltd., who is at present visiting England and the U.S.A. on behalf of the new organisation. The Company's manufacturing and merchandising activities are being developed and it has taken over complete distribution of Collier and Beale's radio components stock. We are told that this new firm will have some pleasant surprises for the radio trade in the near future.

* * *

Recently brought to Australia by an engineer of the Philips Company and a member of the Dutch Underground in Holland, who had enlisted in the Netherlands Forces, was a compact cigar-box radio, one of thousands made secretly under the very noses of the Nazis by Philips' employees in accordance with designs and instructions issued by Philips' supervisors and engineers. The radio uses two miniature valves and covers a wavelength of from 28 to 55 metres. It was used principally under cover to pick up Free Dutch broadcasts from the B.B.C. and to receive





instructions before and after "D" Day.

The receiver is of straight design using a screen grid Acorn tube as Reinartz detector, resistance coupled to a screen grid Acorn used as audio amplifier for phones.

An interesting feature of the set is the power supply, using a half-way dry rectifier with a 5000-ohm resistor as a choke by-passed by two midget electrolytics. A particularly small transformer supplies 3 volts for filaments, H.T. being taken straight from the mains.

No aerial coil primary is included due to space restrictions, the aerial being connected to the grid through a small mica condenser.

Tuning and control of reaction is by two midget condensers.

Range of tuning, 10.8-5.5mc.

* * *

Again active in the component manufacturing field is Mr. Ted Palmer, who operates under the name of "Inductance Specialists." Before the war, Ted was manufacturing inductances, and has returned after five years' overseas service with the R.A.F. to re-open his business.

While with the R.A.F. he spent most of his time as radar instructor at Yatesbury and Cranwell, in England. He will, no doubt, be remembered by many Air Force radar personnel who attended courses at these schools.

Ted has had the usual difficulties associated with opening a business these days—but he now has the factory in full swing, and is specialising in the manufacture of R.F. inductances.



## 'Radio and Electronics'

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# ATOMIC ENERGY

By Ian D. Stevenson, M.Sc., A.M.I.E.E.

To form a conception of atomic energy we must consider the nature of matter and of Energy. and Water were elements because they believed The ancients thought that Fire, Air, Earth these things to be basic. With the development of Chemistry it became apparent that none of these could be classed as elements but that there were many substances which could not be analysed into different components by chemical means and these substances were called elements. Hydrogen, Oxygen, Nitrogen, Iron, Copper and Uranium are elements,

In 1869 a brilliant Russian chemist, Mendeleeff, tabulated the chemical elements according to their characteristics in repeating groups of eight (with certain exceptions) just as the eight notes of an octave in music repeat each other on the keyboard of a piano. There were many gaps in his table of 92 elements, but most of the missing elements he prophesied have been subsequently discovered.

From a study of chemical behaviour Dalton put forward a theory that all elements were comprised of atoms, each atom being indivisible and being the smallest part of an element that could exist. This theory fitted the then known facts and for chemical purposes holds good to-day.

Chemistry indicated that matter (or an atom) was indestructible and this is THE PRINCIPLE OF THE CONSERVATION OF MATTER.

Just 48 years ago J. J. Thompson, father of the scientist who has figured so prominently in the development of the atomic bomb, discovered the electron, a particle of minute size compared with an atom and carrying a negative electric charge which is considered to be the smallest quantity of electricity which can exist and is therefore the Unit of Electricity. It was clear electrons were component parts of all atoms which would of necessity also have other components positively charged since normal substances are electrically neutral. Lord Rutherford showed in 1911 that each atom consisted of a relatively large positive portion in addition to electrons and he called this part the NUCLEUS.

The modern conception of an atom is that of a central nucleus with a positive charge equal to its atomic number in Mendeleeff's table with a corresponding number of electrons rotating around it in orbits much as the planets of our solar system rotate around the sun as a nucleus. This conception fits the known facts and it is largely due to Niels Bohr, the Danish scientist figuring in the news.

This conception of the structure of matter means that all substances, solids, liquids and gases comprise mostly empty space between exceedingly minute particles which are kept in position by large forces delicately poised and balanced. In other words, matter is very discontinuous and exceedingly small particles can pass through it with or without collisions, but the forces are such that a particle injected into the spaces must have great energy if it is going to get far. We are, of course, not conscious of this discontinuity of solid articles because the "mesh" is so small. There are about ten thousand billion atoms in a pound of Uranium.

The arrangement of the central positive nucleus and its associated electrons making up the atom of most chemical elements is so stable that chemical changes do not disturb it except for interchange of a few electrons in the outermost orbits which normally result in chemical combinations. In nature as we know it, therefore, the atom is practically inviolate. With the discovery of radio-activity it became apparent that atoms are not inviolate and that they can be broken down into simpler atoms and even built up into more complex ones. This is transmutation of elements—the alchemist's dream—but as far as we know it occurs naturally on the earth only in the case of a few of the heaviest elements.

Until very recently it appeared that such natural transmutations were completely uncontrollable.

## ENERGY.

Reverting now to energy, a few definitions are necessary. ENERGY is defined as the capacity for doing work. POWER is the rate of doing work or the rate of output of energy.

Primitive man had at his disposal only such energy as could be produced by his muscles or the muscles of his slaves and domestic animals. Later he was able to derive energy from the wind and from flowing water. We can call this Mechanical Energy. The efforts of a man are very puny. A strong man can produce ¼ horsepower for only short intervals and he can work continuously only at a very small fraction of a horsepower. (A gallon of petrol will give much more work than a man is capable of in a day.)

With the invention of engines that can derive energy from chemical changes such as the burning of coal or oil the amount of energy available to us was increased tremendously. Upon this chemical energy the whole of our civilisation is based. Transport and manufacture would be very limited without chemical energy. This was the condition in the middle ages. Other forms of energy commonly used are electricity and heat, but these are derived from mechanical origins (hydroelectric power) and chemical origins (steam engines and internal combustion engines).

Study of energy transfers in mechanical processes indicated that energy was never lost. It always occurred in some other form, and this led to the hypothesis of "THE CONSERVATION OF ENERGY," meaning that the energy of the universe remains unchanged but small parts of it are continuously changing in form from heat to electricity, mechanical energy, etc., and vice versa.

## MASS-ENERGY.

The study of the structure of the atom at the beginning of this century revealed a fact formerly not known. This very important fact was that the atom contains locked up within itself vast and staggering quantities of energy. The atomic energy locked up in the atoms of the new source of atomic power is equivalent to about three million times the energy available from the same weight of petrol. Actually the amount of energy contained in any atom can be calculated from a relationship put forward by Einstein. The crowding of the positive particles in the nucleus of a complex atom results in the nucleus having a different weight from the sum of the individual weights taken separately. In the combination of these particles to form a nucleus tremendous energy is absorbed and on disintegration this energy is released. The discrepancy in weight represents stored energy, and the staggering fact is that a very small mass (or weight )represents a vast amount of energy. In absolute units Einstein's relation says that one unit of mass is convertible into 900,000,000,000,000,000,000 units of energy. Matter can be annihilated with the consequent release of much energy. We did not know this before because the change from matter to energy does not normally happen within our experience. These facts of course upset the "conservation of mass" and "conservation of energy" theories. However, the same facts bring them together and mean that in proper units the total of mass plus energy in the universe remains fixed. It may be that having passed through the eras of mechanical energy and chemical energy we are now entering the era of atomic energy.

In the sun we probably have the breaking down of complex atoms with the consequent release of vast amounts of energy, while on the earth the breaking down process has progressed to the stage where stability has been reached except in the few radio-active substances sparsely scattered through the earth, and presumably they will peter out in time, unless man takes a hand in the game.

The radio-active elements yield their locked-up energy so very slowly that as a source of power they did not appear to promise much, as there appeared no way of accelerating the release of energy. In fact, artificially induced changes always yielded less energy than it took to produce them.

In 1932 the whole picture was changed. The discovering by Chadwick, a former pupil of Rutherford, of the neutron, a particle with no electric charge and the same weight as the nucleus of the simplest atom (hydrogen) provided a new projectile for splitting atoms with an expenditure of very little energy. At the same time it was found that by splitting certain atoms of uranium the release of energy was very much greater than normally happens because the disintegration was much more complete.

These atoms disintegrated were a form of Uranium known as U235. The Uranium occurring naturally on the earth consistently contains about threequarters of 1 per cent. of U235, and this is most difficult to separate from the rest because it is not a chemical separation.

It would seem that the two biggest problems faced by the scientists who developed the atomic bomb were:—

*Firstly*, the separation of U235.

Indications before the war were that it would take America millions of years to separate out 1-lb. weight of U235 with the existing technique.

*Secondly*. The arrangement of the material so that a slow neutron would release from an atom of U235 other neutrons which would in turn be slowed down to strike further atoms and so on, giving a "chain" or regenerative action.

It so happens that slow neutrons are required for disintegrating U235.

We now know that there is another approach to production of atomic energy. A new element, Plutonium, can be produced by laboratory methods and it behaves like U235 in so far as the release of atomic energy is concerned. Plutonium is outside the range of the 92 elements postulated by Mendeleeff and as far as we know does not occur in nature, either on earth or in the sun. That an "element" can be built up indicates that the meaning of element definitely implies "chemical element." Nuclear physics goes further than chemistry, just as chemistry can go much further than mechanical mixing or sieving.

It may well be that ever more potent elements than plutonium may be built up in the future and it may also be that with the building up of elements like plutonium, our dependence on natural sources of uranium for atomic energy will vanish, with the consequence that there will be no practical limit to the amount of atomic energy available to mankind.

## ATOMIC ENERGY FOR USEFUL WORK.

The atomic bomb to be effective required colossal energy to be available from a small weight and space and this energy had to be given up very rapidly.

In looking to atomic energy as a source of power for the future there are some facts we still require to know about the development of the atomic bomb and there is other information not yet possessed by anyone which will have to be found out.

There is no shortage of energy in the world. Wind, tides, rivers, coal, oil, and natural gas offer us power far beyond our present requirements.

The real problem is to apply the energy at the place and time and in the form in which it is required, and it is in accomplishing this that the bulk of the cost of power is incurred.

The rate at which a source of power yields its energy is a prime technical consideration. For example, some explosives like TNT and dynamite once started yield energy so rapidly that they can only be used at present for destruction. They cannot ever be used for propelling projectiles, as their action is too rapid.

At the other extreme we have the natural radioactive process which yields energy at too slow a rate for it to be of much use. In between these extremes we have fuels like coal and oil, and while these are now satisfactory for most purposes, in that power output can be controlled by controlling the quantity of fuel (or the oxygen it combines with) it must be remembered that someone had to invent and perfect engines capable of using these fuels. Even now attempts are made to slow up the combustion of petrol to prevent it from knocking in the cylinder of an engine. Likewise power can be drawn from wind and moving water at the rate required.

A big problem in investigating atomic power will be to control the rate of output of energy

*(continued on page 48)*

# Some Tests of the Infinite Impedance Mixer

By ZL2ML.

The article in *Radio and Electronics'* May issue describing the infinite impedance mixer prompted some experimenting with this system of frequency conversion. Being interested at the time in a good receiver for use on the amateur bands, the idea of a noise-free converter appealed considerably, particularly as the wide-spread interest in the recently-opened 10-metre band has evoked much discussion on suitable receivers.

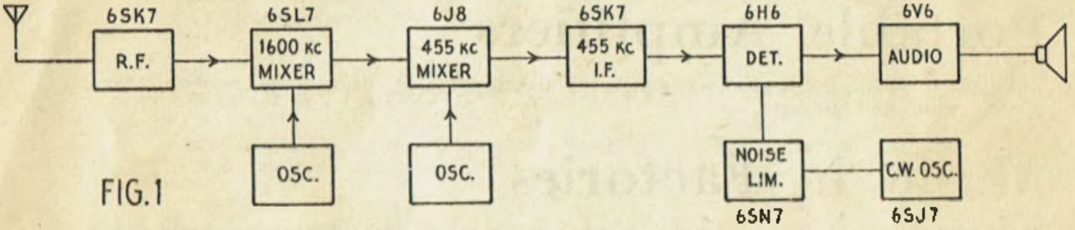



FIG. 1

A receiver was being constructed using orthodox circuits, and it was not much trouble to make the few alterations necessary to use an infinite impedance mixer. Figure 1 is a block-diagram showing the layout of the receiver as intended, the double channel I.F. being tried in an endeavour to obtain a combination of selectivity and image rejection. With a normal mixer circuit, a fairly poor signal-to-noise ratio could be expected, but it was hoped to overcome this to some extent by the use of a good aerial system, directional on 10 metres. Although it had been intended to use a separate oscillator tube for the first mixer in the original set-up, the required hole had not been punched in the chassis, so that when it was decided to try an infinite impedance mixer rather than wait until a socket hole could be made, a twin triode was wired into the circuit. The first tube tried was a 6SN7, and although it worked, the oscillator section ran very hot, drawing excessive current, and had a tendency to squegg. These troubles could probably have been overcome by trying a lower plate voltage, and altering the grid resistor, etc., but the easier way was taken and a 6SL7 substituted.

This operated very well at lower frequencies, being excellent on the 80-metre band, but on the higher frequencies it was found that harmonics of the second oscillator were strongly received in spite of the shielding employed. In addition, it was noticed that the sensitivity on 10 metres was not good enough. Fig. 2 shows the 6SL7 mixer circuit that was used, fed from a 6AC7/1852 R.F. stage, and feeding into the 6J8 second mixer. Since there is no valve gain in the infinite impedance mixer circuit, the effective loss of sensitivity compared with a conventional mixer circuit has to be made up, and as mixer noise is at a minimum, some extra I.F. gain is permissible. To obtain maximum selectivity for the somewhat (?) congested 80-metre band, 455 kc/sec I.F. was retained. How about image-rejection on 10 metres? Well, let's try a high-gain preselector stage ahead of the normal R.F. stage, using separate tuning. The block-diagram, Fig. 3, shows the final line-up.

This arrangement was found to be first class. Results on 80 metres were extremely good. The signal-to-noise ratio was so high that the effect was uncanny. In tuning across the band it was very easy to pass over a station that was not modulating at the moment, because of the absence of the usual hiss and rush. Weak stations that ordinarily would be only QSA-3, owing to noise, were brought up to QSA-5. "Yanks" on the low frequency end of the band were easily readable.

Coils were then constructed for the 10-metre band, and, after some cutting and trying, the band was located and the coils tracked up. Again the results were excellent. Noise—the bugbear of 10 metres—was very low, all that present coming in from the aerial. DX was great!

The success achieved with this receiver caused an eye to be turned in the direction of a receiver which was notoriously noisy and had stayed on the shelf for a long time for this very reason.

This receiver has two stages of I.F. amplification, on 455 kc/sec., and tunes from 3.5 to 25 mc/sec., in two bands, switched. The same mixer circuit was used as for the previous receiver, the old 6K8 being removed and a 6SL7 substituted. Measurements of sensitivity were taken before and after the change, and gave the following figures:

| Frequency. | Sensitivity. Before. | After. |
|---|---|---|
| I.F. | 200$\mu v$ | 250 $\mu v$ |
| 4 mc/sec. | 10$\mu v$ | 8 $\mu v$ |
| 10 mc/sec. | 2 $\mu v$ | 10 $\mu v$ |
| 22 mc/sec. | 15$\mu v$ | 20 $\mu v$ |

Since the I.F. was well biassed back, these figures could easily have been improved by increasing the I.F. gain. The drop in sensitivity at 10 mc/sec. was due to regeneration having been eliminated by the change.

The signal-to-noise ratio of the receiver was 30 $\mu v$ for 15 *Db.* That is, it required 30 $\mu v$ of signal to produce a difference of 15 *Db.* between signal and noise. After the change, the signal-to-noise ratio had improved out of sight to a figure of 8 $\mu v$ for 15 *Db.* The receiver is now back in use!

Finally, the circuit was tried in a standard broadcast receiver which had also been labelled "noisy." The sensitivity over the broadcast band was approximately 2 $\mu v$ and the signal-to-noise ratio at 1000 kc/sec. was 21 $\mu v$ for 15 *Db.* After the circuit alteration, the gain was brought up by letting up the bias on one of the two I.F. stages, so that the sensitivity was much the same as before. But the signal-to-noise ratio was now found to be 8 $\mu v$ for 15 *Db.*! The difference in performance was most pronounced. 1YA could be heard perfectly, whereas before it had been lost in the "hash."

The figures quoted give some idea of the improvement that can be obtained by using the infinite impedance mixer. The "ham" receiver now in use utilizes the preselector on the higher frequencies only—at present the 10-metre band. For 80-metre reception it is switched out, and the aerial brought into the 6AC7/1852 R.F. stage in the usual way. The I.F. stages are well biased back, and coupling in the transformers is less than critical to obtain a high degree of selectivity. The

(continued on page 48)

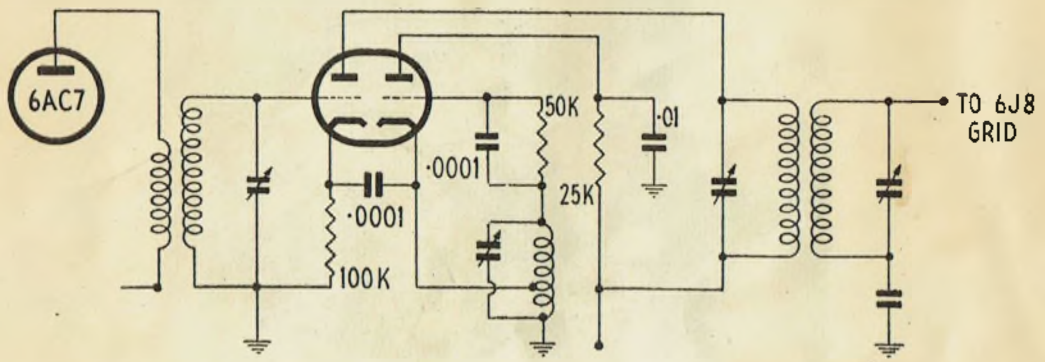



Fig. 2: The circuit used by ZL2ML. The double triode is a 6SL7. Note the absence of A.V.C. on the mixer section, and the 0.01 decoupling condenser in the oscillator plate.

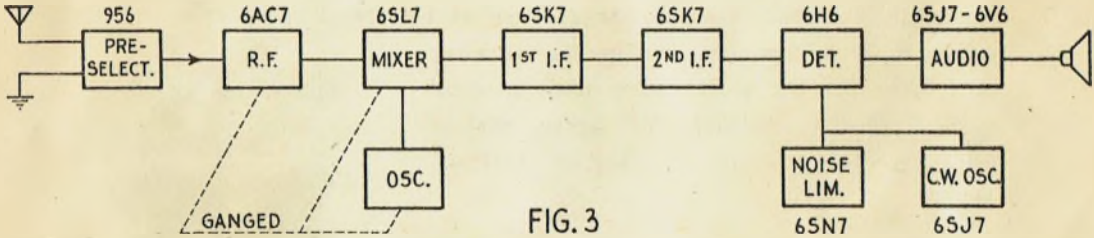



FIG. 3

# A 50-WATT AMATEUR TRANSMITTERS' MODULATOR USING P-P 807's

**This modulator will provide 100 per cent. plate modulation of any class C final stage whose input power is not greater than the 100 watts allowable in this country.**

Many amateurs are deterred from building transmitters of 100 watts input because they are primarily interested in 'phone transmission, and because 50 watts of audio is an expensive item to produce. The modulator presented here uses inexpensive tubes, and its power supply requirements are not exorbitant. It is straightforward in design, and yet suffers from none of the disabilities often introduced into amateur equipment by a desire for cheapness at all costs. In short, it "does its stuff" admirably, with low distortion, and at a reasonable cost. Possessed of such a modulator, a transmitting enthusiast is able to use it to modulate any R.F. end he is liable to think up, leaving himself free to experiment with R.F. circuits on any of the bands available to him.

## TUBE LINE-UP.

The tubes and their functions are as follows

- $V_1$ is a 6SJ7 microphone pre-amplifier.
- $V_2$ is a 6N7 voltage amplifier and phase inverter.
- $V_3$ and $V_4$ are push-pull 6J5's as the driver stage, while
- $V_5$ and $V_6$ are the 807 modulators, transformer coupled to the modulated amplifier.
- $V_8$ is a 1½in cathode ray tube used as a modulation indicator.
- $V_7$ is the C.R.T. high-voltage supply rectifier using a 5Y3-G.
- $V_9$ is another 5Y3-G bias supply rectifier.
- $V_{10}$ and $V_{11}$ are the main H.T. rectifiers and are 866's or 866A's.

## CIRCUIT.

The circuit of $V_1$ is quite conventional. As drawn, the input is suitable for any microphone which has a high-impedance output through a transformer, but, if a crystal microphone is used, a suitable load resistor must be connected between grid and earth. No recommendations as to its value are made here, since the different makers specify the load resistors that should be used with their microphones. $P_1$ is a chassis-mounting microphone socket of the shielded type, and is strongly recommended if R.F. is to be kept out of the modulator. There is no gain control on this stage, as it can never become overloaded at the low signal level of the microphone.

The 6N7 is used as a voltage amplifier and phase inverter. In its grid are two gain controls connected in a parallel mixing circuit. $R_5$ and $R_7$ act as isolating resistors, and prevent one control from short circuiting the other when the first is at low settings. The input through $J_1$ can be used for a gramophone pick-up or high-level microphone. The first section of $V_2$ has its output coupled through $C_5$ to the grid of $V_3$. The resistors $R_{11}$ and $R_{12}$ form a voltage divider applying approximately one twenty-fifth of the output voltage of the first half of $V_2$ to the grid of the second half. Since the gain in this section is 25 times, the output of the second half is the same as that of the first half, but is 180 degrees out of phase with it. Thus, $V_4$ is excited in opposite phase to $V_3$, with an equal voltage. When this circuit is used, it is common practice to make the tapping for the input of the second half of $V_2$ by means of a potentiometer, so that exact balancing can be obtained. This is not really necessary, as the balance obtained with the values given is quite accurate enough for all practical purposes. Also, in a phase inverter of this type, it is common practice to omit the cathode bypass condenser, $C_4$. This has been retained, as it was found necessary to eliminate hum from the stage.

The push-pull driver stage using 6J5's is quite conventional. The bias resistor here is left unbypassed, as the level at this point is too high for any hum to be apparent, and, since this is a proper push-pull stage, there is no negative feedback introduced by omitting the condenser.

The output stage is operated in Class AB2, which means that it runs into grid current on the positive peak of the input cycle to each 807. In order to keep the grid circuit impedance as nearly constant as possible over the input cycle, and to minimise driver distortion, a step-down transformer is used having a ratio of 6: 1 over-all. To further assist in this matter, each half of the secondary is loaded with 10,000 ohms. The network $C_8$ and $R_{18}$ is used from grid to grid in order to limit the high-frequency response to a reasonable extent, since too much merely extends the bandwidth occupied by the signal, while adding very little to its intelligibility. (In passing, it can be noted that the coupling condensers, $C_3$, $C_7$, and $C_8$ in the earlier part of the circuit have been purposely limited to 0.01 $\mu f.$, so as to give the whole amplifier a fairly sharp low-frequency cut off after about 100 c/sec. This also leaves intelligibility unimpaired, while reducing extraneous low-frequency noise that may get to the microphone.

## OUTPUT STAGE BIAS.

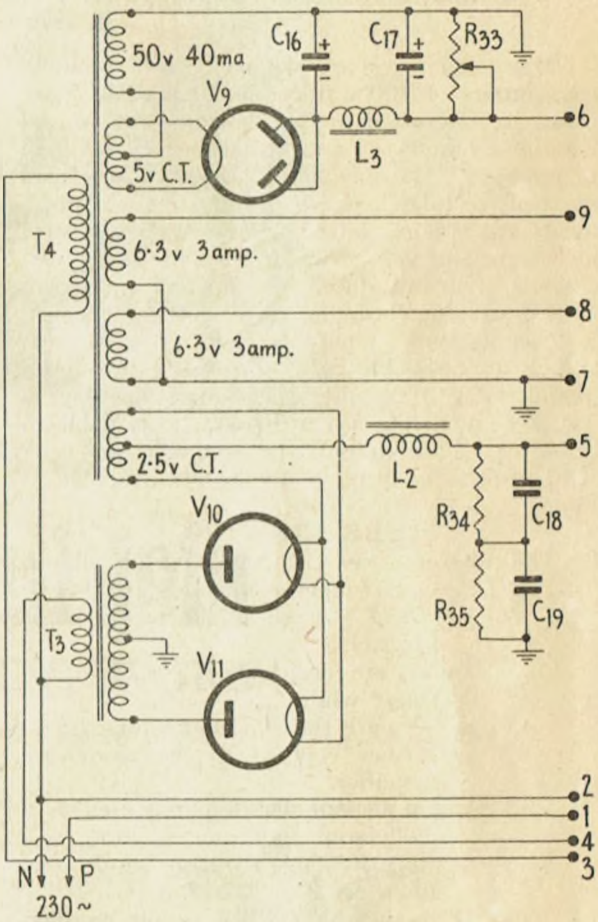
This is obtained from a special 50v. winding on the main filament transformer. A 5Y3-G is used as a full-wave rectifier, and a condenser-input filter is used for smoothing. The choke $L_3$ is a 40ma. vibrator-type component, and with two 50 $\mu f.$ electrolytic condensers, provides a hum-free bias supply. The correct bias of 25 volts is obtained by means of the pre-set variable resistor which is connected as a bleeder across the bias supply. This should be adjusted with the aid of a meter before the main H.T. is first applied to the 807's.

## SCREEN SUPPLY.

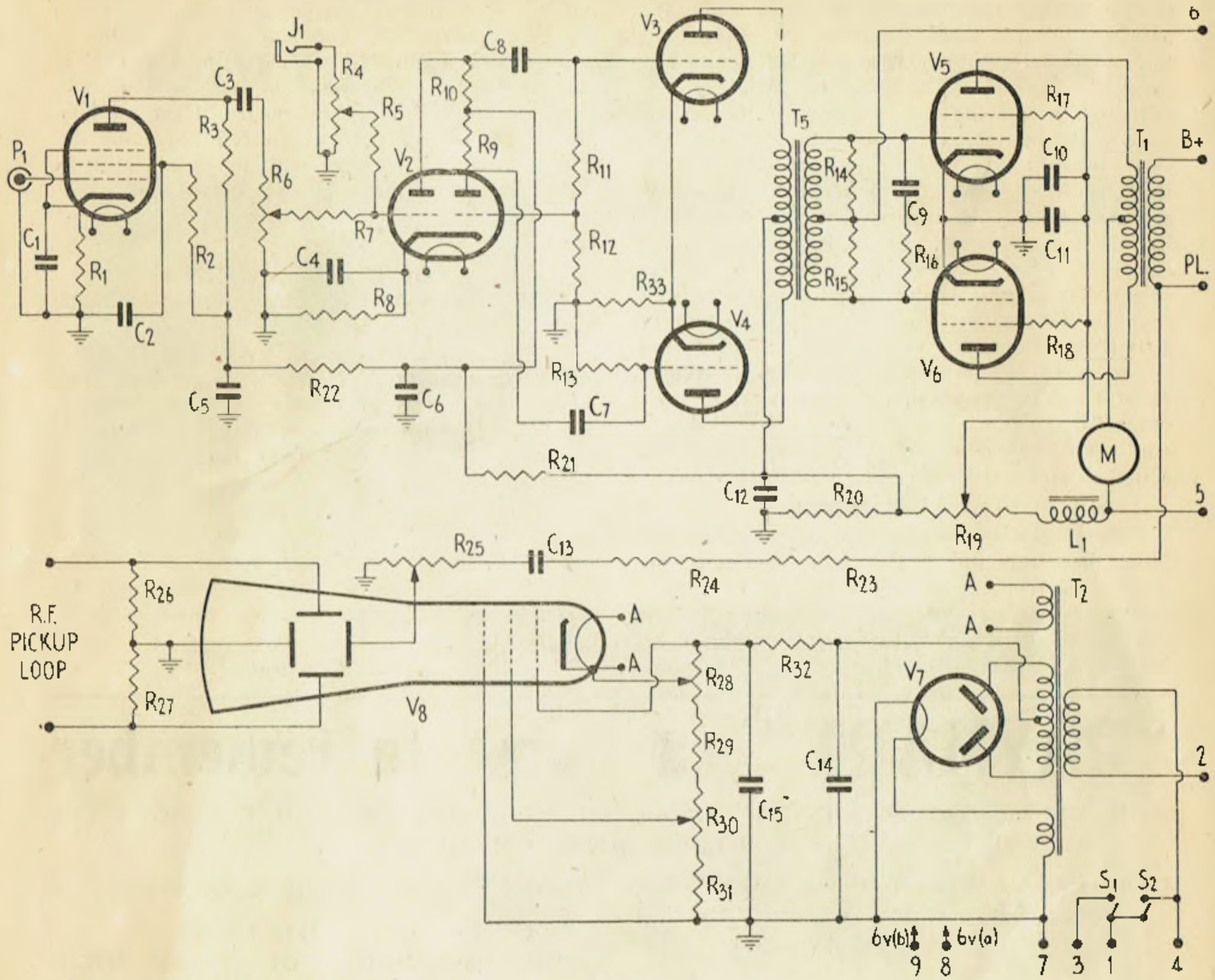
The screen supply of 300v. is obtained by means of a bleeder consisting of $R_{19}$ and $R_{20}$ in series. The bleeder draws approximately 20ma. which is sufficiently greater than the combined screen currents of the 807's to provide good screen voltage regulation. This portion of the circuit is one of the reasons why the full output of 50 watts is realised without difficulty, for a poorly-regulated screen supply is a frequent cause of poor operation at high signal levels. The correct setting for $R_{19}$ will be found quite close to the low-voltage end, so that the slider should be set somewhere near this point prior to first switching on, in order to avoid excessive plate current. The screen resistors $R_{17}$ and $R_{18}$ are 100 ohms each, and should on no account be omitted. In the original model, the modulators were oscillating at some quite high frequency before these suppressors were inserted, with the result that only about 20 watts of undistorted output could be obtained. Inserting the 100-ohm resistors, which should be placed right at the valve sockets, effectively cured the trouble.

## THE C.R.T. CIRCUIT.

The cathode ray tube was built into the modulator chassis, and is a British tube with a 1½in diameter screen. This is quite large enough to give a good trapezoidal picture, and has an advantage over, say, a 913, in that all deflecting plates are brought out to base-pins. This allows symmetrical deflection to be used for the vertical axis which is fed from a small loop coupled through twisted pair to the Y plates of the tube. Asymmetrical deflection is used for the X axis, which is fed with audio voltage from the plate side of




$R_1$, $R_8$ = 1000ω.
$R_2$, $R_{25}$, $R_{21}$, $R_{26}$, $R_{27}$ = 1meg.
$R_3$, $R_{11}$, $R_{13}$, $R_{34}$, $R_{35}$ = 250k.
$R_4$, $R_6$, $R_{23}$ = 50k. Pot.
$R_5$, $R_7$ = 500k.
$R_9$, $R_{10}$, $R_{22}$ = 100k.
$R_{12}$, $R_{14}$, $R_{15}$, $R_{24}$ = 10k.
$R_{16}$ = 5k.
$R_{17}$, $R_{18}$ = 100ω.
$R_{19}$ = 5k., 20w., adjustable.
$R_{20}$ = 20k., 20w.
$R_{28}$ = 25k., w-w Pot.
$R_{29}$, $R_{32}$ = 20k.
$R_{30}$ = 50k., w-w Pot.
$R_{31}$ = 150k.




$R_{33}$ = 500ω.

$R_{33}$ (on Power Supply Circuit) = 1000ω w-w Pot.

$C_1$, $C_4$, = 25 µf. 25v. electro.

$C_2$, $C_3$, $C_7$, $C_8$, $C_{13}$ = 0.01 µf. 600v.

$C_5$ + $C_6$ = Dual 10 µf. 450v. electro.

$C_9$ = 0.005 µf.

$C_{10}$ = 0.01 µf. mica.

$C_{11}$, $C_{12}$, $C_{18}$, $C_{19}$ = 8 µf. 450v. electro.

$C_{14}$, $C_{15}$ = 0.5µf. 600v.

$C_{16}$, $C_{17}$ = 50 µf. 50v. electro.

$T_1$ = Mod. transformer (see text).

$T_2$ = 385v.-a-side Receiver Transformer, with 4v. heater winding, A-A.

$T_3$ = Main H.T. Transformer, 690v.-a-side, 400ma.

$T_4$ = Heater and Bias Transformer; Windings as indicated.

$T_5$ = Driver Transformer.

M = 0-250ma. D.C. meter.

$J_1$ = Open circuit jack.

$P_1$ = Single conductor mike socket.

NOTE: Microphone load resistor (not shown) should be connected between grid of $V_1$ and earth; value dependent on mike used.

$V_1$ = 6SJ7.

$V_2$ = 6N7.

$V_3$, $V_4$ = 6J5.

$V_5$, $V_6$ = 807.

$V_7$, $V_9$ = 5Y3-G.

$V_8$ = C.R. Tube.

$V_{10}$, $V_{11}$ = 866 or 866A.

$L_1$ = 30H. 100ma. choke.

$L_2$ = 10-15 H. 400ma.

$L_3$ = 40ma. Vibrator choke.

the modulation transformer secondary. $R_{23}$, $R_{24}$, and $R_{25}$ form a voltage divider so proportioned that a suitably-sized picture can be obtained by using the control $R_{25}$. The Y axis deflection is adjusted by varying the coupling of the pick-up loop to the modulated amplifier tank circuit. No shift-controls have been provided for the C.R.T., since, with a single-purpose scope like this, they are not needed. $R_{28}$ is the brilliance control and $R_{30}$ the focus control. The C.R.T. power supply circuit is quite conventional and uses a 385v.-a-side receiver transformer, which is standard, except for the fact that the C.R. tube used requires a 4v. heater supply. This can be provided from an ordinary 6.3v. winding by using a dropping resistor. The latter should have a value of 2 ohms for the G.E.C. tube, type E-4103-B-4. To run cool it should be of 5-watt rating, though the actual dissipation in it is just under 2½ watts.

## POWER SUPPLY.

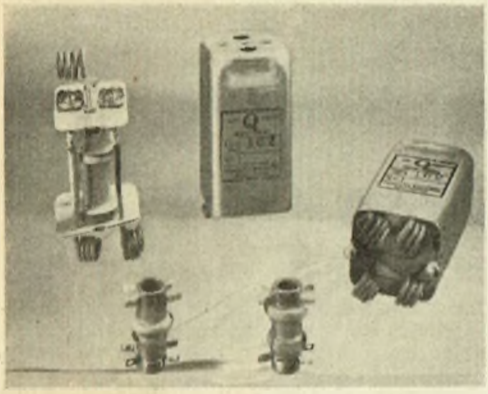
The power supply was built on a separate rack from the modulator itself. On the circuit diagrams, corresponding terminals of the power cable are marked with the same numbers. The A.C. switches $S_1$ and $S_2$ are shown on the modulator chassis, which is a convenience if the power supply is on one of the lower racks. $S_1$ turns on all filaments and the bias supply, while $S_2$ controls the main H.T. supply and the C.R.T. power supply. The latter is switched on with the main H.T. because, otherwise, if the modulator is turned on before the R.F. section, the C.R.T. would be running with no signal input to either axis, resulting in an undeflected spot which would be in danger of burning the screen of the tube.

## LAYOUT AND WIRING.

The layout and wiring can follow conventional audio practice, care being taken to keep $V_1$ and $V_2$ as far as possible from $T_3$, the C.R.T. power supply transformer. It may be necessary with some layouts to put a baffle-shield round the wiring and components of $V_1$ in order to exclude hum and R.F. voltages. It is essential to use a separate earthing point for each stage in the modulator to keep R.F. from getting in, but, apart from this, no extra precaution had to be taken. A proper trapezoidal picture will not be obtained on the C.R.T. unless the final amplifier and the modulator chassis have a common earthing point.

(*Continued on page 43.*)

# INDUCTANCE SPECIALISTS



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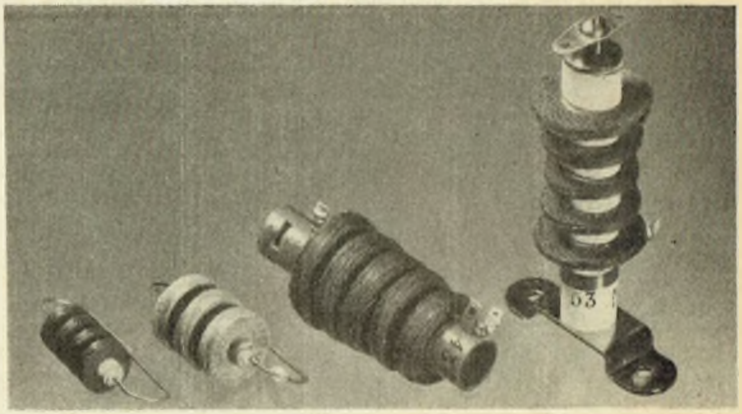
**TRICITY HOUSE, CHRISTCHURCH**

**S.O.S. RADIO SERVICE, AUCKLAND**



## HIGH FREQUENCY CHOKES

*(Illustrated from left to right.)*

| No. | Inductance | Rating | Resist. | Former | Mounting | Pyes | Dis. Cap |
|---|---|---|---|---|---|---|---|
| 33 | 2.5MH | 125MA. | 35.0 ohms D.C. | Ceramic | Pigtail | 4 | 1mmF. |
| 23 | 1.0MH | 300MA. | 10.0 ohms D.C. | Ceramic | Pigtail | 3 | 1mmF. |
| 43 | 4.0MH | 600MA. | 10.0 ohms D.C. | Ceramic | Vertical | 5 | — |
| 53 | 1.0MH | 600MA. | 6.0 ohms D.C. | Ceramic | Vertical | 5 | — |

*Or Direct from . . .*

# INDUCTANCE SPECIALISTS

202 THORNDON QUAY, WELLINGTON, N.I.

# A Practical Beginners' Course

## EDITOR'S INTRODUCTION.

**For some time it has been felt that "Radio and Electronics" should cater, not only for those versed in the art, but also for those just setting out on the road to radio. Some will be boys at school, but others will be older, and possibly will have the advantage of having studied electricity and magnetism at secondary school, if only in an elementary way. However, all beginners feel the need of a little guidance at one time or another, and it is to fill this need that we are embarking on the "Practical Beginners' Course." In it, the emphasis will always be on the practical side of radio, and theoretical matters will be touched on as lightly as possible. This policy will suit those readers who wish to concentrate upon building things and making them work. Others may desire to study the subject more thoroughly—perhaps with a view to making it their profession later on—and to these we would say, "Get all the practical experience you can, but remember that the expert radio man has a good theoretical knowledge as well. (Anyone who says that he 'knows all about radio,' but who has no theoretical knowledge, is not the expert he pretends to be.) If you are still at primary school and are serious about taking up radio as a profession, see that when you go to secondary school you take mathematics and electricity and magnetism, for these subjects are the foundation of all radio knowledge. In the meantime, have as much fun as you can building crystal sets and simple valve sets. In this way you will learn many things, the reasons for which you will find out when you have learned something of electricity and magnetism. Your radio work will show you that these subjects are not dry-as-dust, but living and full of interest, and of the greatest importance if you are to learn more about radio than the next man, and become, in short, an expert radio engineer."**

**Here, then, is the first instalment of the "Practical Beginners' Course." It commences after this introductory instalment with the simplest possible crystal set, and will lead, by easy stages, to the point where the reader will be able to take an interest in the more advanced articles and circuits found in the main body of "Radio and Electronics."**

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## Part I.

## WHAT IS RADIO?

This is the first part of what the Editor has described as a practical course. That is to say, readers of these pages can expect to be shown how to build radio sets. However, before we can commence a description of our first set, it is necessary to consider for a short while what radio waves are, and what a radio receiver is expected to do. If we do not do this, it will be impossible to explain many of the terms used in connection with radio and really to understand what goes on in even the simplest set.

The first question to which many will desire an answer is: "What **are** radio waves, anyway?" This, though a very reasonable request, is, strangely enough, very difficult to answer. The only **real** answer is the one which was given to the world by a very famous mathematician, Clerk Maxwell, but it is quite impossible to set it out here, for none of our readers would understand it if we did. At least, not unless they also were mathematicians. However, it was Maxwell's mathematics which caused radio to be likened to waves in the first place, for he proved that, in many ways, what we know as radio, behaves much as do waves on the surface of a sheet of water. (This was all the more remarkable, since, in Clerk Maxwell's day, no one had discovered practically that any such things as radio waves could be produced, let alone be used for communicating between remote places!)

So, we have it that radio waves are like waves in water, but they are very different from water waves because they can be neither seen nor felt. This is where the radio set comes in. Its job is to allow us to detect the radio waves. Ordinarily the set does this by transforming them into mechanical vibrations which cause sounds that can be heard by our ears.

Another way of describing radio waves is as electric currents which have escaped from the wires which carry them. Many of you will not know what an electric current is, but for our purposes this does not matter very much, for electricity had been known and used for centuries before its real nature was discovered. However, electric currents are very important in radio, because radio waves are simply a form of electricity which is able to travel through space in any direction. Producing the waves is the job of the transmitter, but, since we are at the moment more interested in receiving, let us see what the waves can do.

Suppose we erect a piece of wire a few feet above the ground. If a transmitter is operating, the waves sent out by it strike the piece of wire and cause a minute electric current to flow in it. This current is so small that none of the usual methods of demonstrating the presence of an electric current will tell us it is there. First and foremost, then, our radio set is an arrangement which will reveal the presence of very minute electric currents. In radio terms, the set is said to **detect** the radio currents in the **aerial** (our piece of wire), and the set is therefore called a **detector**. Very simple sets such as crystal sets do nothing but detect the radio currents and make them audible in a pair of headphones. In more complex sets, though, valves are used to **amplify** the radio currents collected by the aerial. That is, the valves work in such a way that we obtain bigger radio currents than the very minute ones made by the wave in striking the aerial. In these sets, the amplifier portion is followed by a **detector** which has exactly the same purpose as the simple set itself, namely, so to change the radio currents that they can be made to work a pair of headphones or a loud-speaker.

To summarise what we have already learned—

(1) Radio waves travel outwards in all directions

from a transmitter.

(2) These waves strike the listener's receiving aerial and cause very minute electric currents to flow in it.

(3) The purpose of the radio receiver (or set) is to change these radio currents into such a form that they can operate a pair of headphones, giving rise to sounds we can hear.

(4) Valve sets often contain **amplifiers** which make the radio currents from the aerial bigger, after which a portion of the set called the **detector** performs the step described in (3) above.

## WHAT AMPLIFIERS ARE FOR.

The next question might easily be: "Why do we have sets with many valves, when sets can be built without valves at all?"

There are three main reasons. In the first place, crystal sets containing no valves will not operate a loud-speaker, but only a pair of headphones. Secondly, a crystal set does not amplify the radio currents before detecting them, so that only the strongest stations can be received, even with headphones. Thirdly, it is difficult to be sure that a crystal set will allow us to hear a weaker station when there is a very strong one transmitting.

All these disadvantages can be overcome by using valves, because of their amplifying properties.

## WHY BOTHER ABOUT CRYSTAL SETS?

This is not a difficult question to answer. Valve sets are too complicated for the very beginner. There are too many reasons why even a simple valve set may not work, for it to be undertaken before a simpler set. It is only by finding out at first hand the limitations of crystal sets, that the advantages of valve sets can be fully realised. Besides, many will find a valve set too expensive for a first effort. All the parts used in building various crystal sets can be put to use when we come to build our first valve set, so that as we progress, a few parts at a time can be purchased. Thus, the putting of the first valve set into operation will not be too much of a strain on the pocket when the time comes for it.

## WHAT TO BUY?

For building crystal sets, and also small valve sets, the first necessity is a good pair of headphones. Notice the word "good." It is very important. The 'phones are the only expensive item you will have to buy, so it is as well not to buy a cheap pair. These are seldom worth the money paid for them, and, even if a good pair costs twice as much as a poorer pair, the expensive ones will give better than twice the results of the poor pair.

There is a simple test that will enable you to be sure you are getting a good sensitive pair of 'phones. At the end of the cord are two metal tips by means of which the 'phones are connected to the set. Put the 'phones on, making sure that the ear-pieces fit snugly. Take a coin (preferably a half-crown, which has a milled edge) between the thumb and fore-finger of the left hand. Then, take one of the 'phone tips and hold it between the remaining fingers of the left hand and the palm. Finally, take the second 'phone tip in the right hand and rub it gently along the milled edge of the half-crown. If the 'phones are sensitive, this will make an easily-heard sound in the 'phones.

If a pair of 'phones does not respond to this test, it is not good enough to use in crystal sets or in simple valve sets. This does not mean that they will not work at all, but in sets like this, the 'phones must be as sensitive as possible if the best results are to be obtained. A poor pair of 'phones can make all the difference between excellent results and results that are only poor to medium. When purchasing headphones, always apply this test. If you cannot obtain any result, the pair is not a good one, whatever the name on the box may be!

The next necessity is a piece of coil-former on which to wind the coils for your set. This should be a piece of the cardboard tube sold for the purpose, and should be three inches in diameter. It is as well to buy a piece six inches long, for the extra length will come in handy later. Three-inch diameter coils are sold already wound for use with crystal sets, but you are strongly advised to make your own. The experience is good, and moreover, the crystal sets we are about to describe require specially made coils which cannot be bought ready made.

You will need a quantity of 24 gauge D.C.C. copper wire with which to wind your coils. A quarter of a pound should be enough for quite a bit of experimental coil winding. Copper wire sizes are indicated by gauge numbers, as above. Thick wires have low numbers and the thinner the wire, the higher the number. Thus, 36 gauge wire is very thin, while 24 gauge wire is about three times as thick as 36. The letters D.C.C. stand for "Double Cotton Covered." That is to say, the wire is covered with two layers of cotton thread, so that when a coil is wound, the cotton acts as insulation and prevents the turns from touching each other. Three main insulating materials are used for radio wire, enamel, silk and cotton. Enamelled wire is specified as, say, 28 gauge en., whilst a single covering of silk is abbreviated to S.S.C., standing for "Single Silk Covered." Sometimes, both enamel and a single layer of cotton are used on one wire, which is then described as cotton-enamel wire.

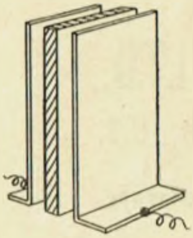


**Fig. 1 (a). Simple 2-plate condenser, showing block of insulating material between plates.**

**Fig. 1 (b). Sandwich-type condenser, showing large plate area in small space.**

In addition to the above, you will need a variable condenser, so it would be as well to explain what a condenser is.

Condensers are found in all radio circuits, and are of many different kinds. However, they are quite simple devices really, and all have the same basic construction, although different kinds differ greatly in appearance.

A condenser consists only of two plates of metal placed close to each other, but separated by some insulating material. Each plate has a terminal wire, or solder-lug, by which connecting wires are attached to it. This description applies to any condenser you may see, however it is constructed or shaped. The great variety of shapes and sizes found in practice simply represent the many methods used for making condensers of various electrical sizes. Some use air for the insulating material. Others use waxed paper, mica, plastic materials, or even oil for this purpose. Again, not many condensers have only two plates.

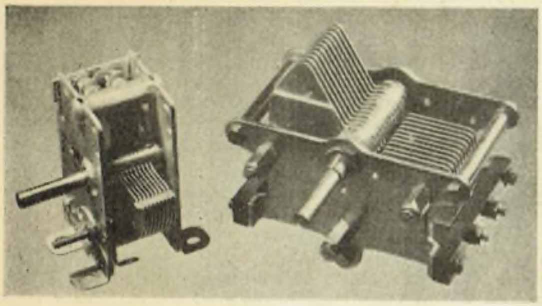


Fig. 2.
Two types of variable condenser.

Most of them have two stacks of plates put together sandwich-fashion, and with pieces of the insulating material between each pair of plates. Fig. 1 (a) shows a simple two-plate condenser. Fig. 1 (b) is a diagram showing how two stacks can be inter-leaved with insulating material. Each stack has all its plates connected together at the edge, so that the stacked condenser is really still only a two-plate condenser. The electrical size of a condenser depends, for one thing, on the area of the two plates, so that the stacking makes possible a condenser with a very large plate area and therefore large electrical size, but no bigger to look at (except perhaps in thickness) than the two-plate condenser. Condensers are described as "fixed" or "variable." A variable condenser is one whose electrical size can be altered—usually by turning a shaft. Most variable condensers have air for the insulating material, and are of the stacked construction. Each set of plates is rigidly mounted, but one set can be rotated. In this way, the amount of movable plate that is inter-leaved with the fixed set can be varied by turning the shaft, and we have a condenser whose electrical size can be changed by turning a knob attached to the shaft. This is what happens when any ordinary radio set is tuned. If you look inside the back of your set at home, you will probably see the tuning-condenser, as it is called, and be able to watch the moving set of plates as the tuning knob is turned. A fixed condenser is one whose capacity (which is the correct radio word for electrical size) can not be changed in this way.

To get back to our list of parts, you will require a variable condenser for your experiments. It will be used as the tuning control for our crystal sets, and later, for our first valve sets when we come to them. The right size to get is one of 0.00035 microfarads. The word **microfarad** is the name of an electrical unit that is used for specifying the capacity of condensers. It means "one millionth of a Farad" and is used because the farad (called after Faraday, the famous English scientist who made many important discoveries about electricity, a long time ago) is too large a unit for ordinary purposes. Just as we have miles, chains, yards, feet and inches as units of length, so we have farads, microfarads and micromicrofarads. This last one means one millionth of a microfarad, so you can see that it is quite small compared with a Farad. In radio, most condensers used have values between several micromicrofarads (mmf. or $\mu\mu f.$ for short), and several microfarads (mf. or $\mu f.$). Thus, the one we have recommended can be called either 0.00035 $\mu f.$ or 350$\mu\mu f.$, which, as a little arithmetic will show, amount to the same thing, just as 35 yds. is the same thing as 105 ft.

The value we have given should be obtained, if possible, for reasons which will be explained in our next instalment, but a condenser of between 0.0003 $\mu f.$ and 0.0005 $\mu f.$ will do. We have mentioned this because if the pocket will not run to a new condenser, a second-hand one may be used, as long as it is in good order. The main thing is to see that, as the shaft is turned, the moving plates do not, at any stage, touch the fixed plates.

In addition to the above, the other main component you will need is a crystal detector, and a crystal to go in it. A description of this will have to be left till next time, when we will describe our first crystal set. However, if you spend the intervening time in buying the parts we have talked about, and in learning to solder, you will be all ready for your first bit of construction.

Soldering is really very important, for these days practically no parts are built with screw-terminals, but have only lugs to which connecting wires have to be soldered. Soldering is not difficult, and you will soon become quite good at it. The best idea is to get someone you know does radio work to teach you, and let you practice with pieces of wire and old valve sockets until you can make a good soldered joint. In our next instalment we ourselves will give you a few tips on soldering, but if you can get in some practice in the meantime, so much the better.

# REGENERATIVE DETECTOR CIRCUITS

**Since regenerative sets first came into use, many years ago, an almost endless variety of regenerative detector circuits have been published, differing greatly in detail but not at all in principle. This article presents the main types of regeneration circuit and shows how many variations of them arise. Taking everything into account, there is very little to choose between most of them, for all give reasonable results when properly adjusted.**

Most people who build simple sets with regenerative detectors have wondered at the almost endless variety of circuits that have been printed, and still are, in the popular radio publications. Many of these circuits are developed by enthusiastic experimenters, who claim, more often than not, that theirs is the best of all regenerative circuits. Is there anything in these claims? Is there any good reason for such a wide variety of circuits? If so, what distinguishes the better circuits from the poorer ones? These are a few of the questions which this article sets out to answer. Printed here are eight basic regenerative detector circuits. Many more can be drawn simply by combining some features of one of them with other features of a second. Before starting on a detailed description one or two points should be mentioned in connection with all of them.

(1) No aerial coupling arrangements have been shown. This is because the interest of this article is centred on that part of the circuits used for obtaining regeneration. Coupling of the circuits to an aerial or to a preceding R.F. stage affects very slightly, if at all, the choice of a regeneration circuit, though the coupling used will usually have some slight effect on such matters as the number of turns on the tickler coil.

(2) Similarly, output coupling arrangements have been shown in each case as a pair of headphones. It should be realised that the primary of an audio transformer could be substituted for the headphones without any effect on the regeneration circuit. Even using a resistor and condenser to couple to the grid of an audio amplifier would have only a minor effect, and so is not fundamentally a variation in the regeneration circuit.

## TRIODE CIRCUITS.

Because they are simpler, we will discuss triode circuits first. Again, because most people use filament type tubes, at least for their first attempt, these will be treated first.

Fig. 1 shows one of the simplest and oldest triode regeneration circuits. In the drawing, the tickler has been shown at the grid end of the grid coil. Sometimes, this same circuit is drawn, and the coil is recommended to be made, with the tickler at the earthed end of the grid coil. Whichever method is used has very little effect, if any, on the operation of the circuit. The variable condenser C is the regeneration control. This is one of the earliest methods of controlling regeneration and has man points in its favour. Chief among these is that it gives a very smooth control. That is to say, if the number of turns on the tickler is correctly adjusted, turning up the regeneration control causes the set to go smoothly into oscillation, without the sudden plop which does not allow the detector to be used in its most sensitive condition. Almost anyone who has experienced this undesirable effect will realise how great an advantage this is. It will be noted that B plus has been shown as 45 volts. This does not mean that 45 volts must be used, since the circuit will work perfectly well with as little as 12 volts on the plate. It should be remembered, however, that if this is done, more tickler turns will be required than when the plate voltage is 45 volts. The use of a radio frequency choke R.F.C. should be noted as this is necessary to prevent fringe howl. This last statement applies equally to all the circuits shown, especially when the output is taken through an audio transformer rather than a pair of headphones. In this case an additional precaution is to shunt a high resistance, say, ½ meg., across the secondary of the transformer, but this need not be done unless it is found that fringe howl develops without it. The same remarks apply where choke capacity coupling is used. If fringe howl develops here, the resistance is shunted across the choke. Sometimes, the primary of an audio transformer is used as a choke, with the secondary left disconnected. In this case, the resistor should be placed across the tranformer secondary.

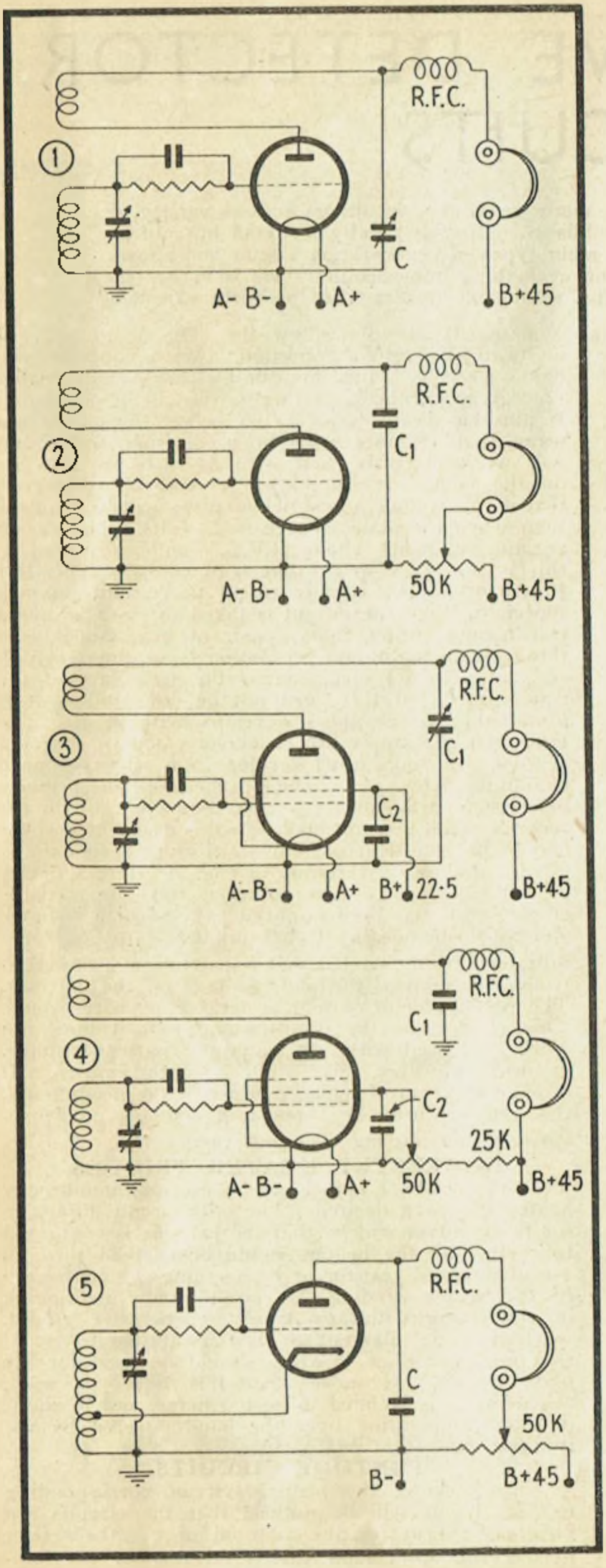
Fig. 2 shows a variation of Fig. 1. Here a tickler is still used to obtain reaction, but the variable condenser C has been replaced by $C_1$ which is fixed, and should be between 0.0001 and 0.0005 $\mu f$. The only difference from Fig. 1 is that regeneration is now controlled by varying the plate voltage on the detector. The potentiometer should preferably be wire-wound. This circuit has the disadvantage that it does not work very well with low values of battery voltage. It does, however, give quite smooth control. If moving the control makes a noise in the headphones, this can be cured by connecting a 0.1 $\mu f$. condenser between the moving arm and earth.

## INDIRECTLY HEATED TRIODES.

Both circuits 1 and 2 can be used with indirectly heated triodes if desired. The only circuit difference for these valves will be that the cathode is connected to earth, and the heater should be earthed through a centre-tapped resistor or by earthing the centre tap of the heater winding. A point worth mentioning in connection with any triode regenerative circuit, whether using filament or heater-cathode tubes, is that no more than 45 volts should be used for the plate supply. If more than this figure is used, regeneration is inclined to be too fierce, and to result in uneven operation over the band covered by the tuning condenser if this is large.

## PENTODE CIRCUITS.

Fig. 3 shows the pentode circuit corresponding to Fig. 1. It will be noticed that the circuits are identical, except for the addition of $C_2$, the screen bypass condenser, and the connection of the sup-




pressor grid. In most battery pentodes the suppressor is connected to A— inside the valve, but indirectly heated pentodes have the suppressor brought out to a separate pin, so that the connection must be made on the valve socket. Although a battery pentode has been shown in Fig. 3, an indirectly heated tube may be used with the same modifications as indicated in the case of triodes.

Fig. 4 shows a very popular pentode circuit. $C_1$ is a fixed regeneration condenser as in Fig. 2, but it will be noted that the reaction control has been shifted to the screen. $C_2$ has a value of 0.1 $\mu f$ and, as well as bypassing the screen, prevents noise from the potentiometer from appearing. This circuit, too, can be used with indirectly heated tubes if the necessary modification is used as indicated above. The H.T. voltage in the circuit of Fig. 4 is not limited to 45 volts, but can be as high as 135 volts for battery tubes and 250 volts for indirectly heated tubes. The voltage divider in Fig. 4 will not do for H.T. voltages as high as 250 volts, when the 25k. resistor should be replaced with one of 50k. In all circuits where screen control of regeneration is used, the reaction coil should be adjusted so that regeneration is obtained with approximately the correct operating voltage on the screen. For example, suppose a 6J7 were being used, the number of turns on the tickler should be adjusted so that oscillation is obtained when the screen voltage is approximately 100 volts. Too many tickler turns will cause oscillation to commence at low screen voltages, resulting in loss of sensitivity.

## HARTLEY TYPE CIRCUITS.

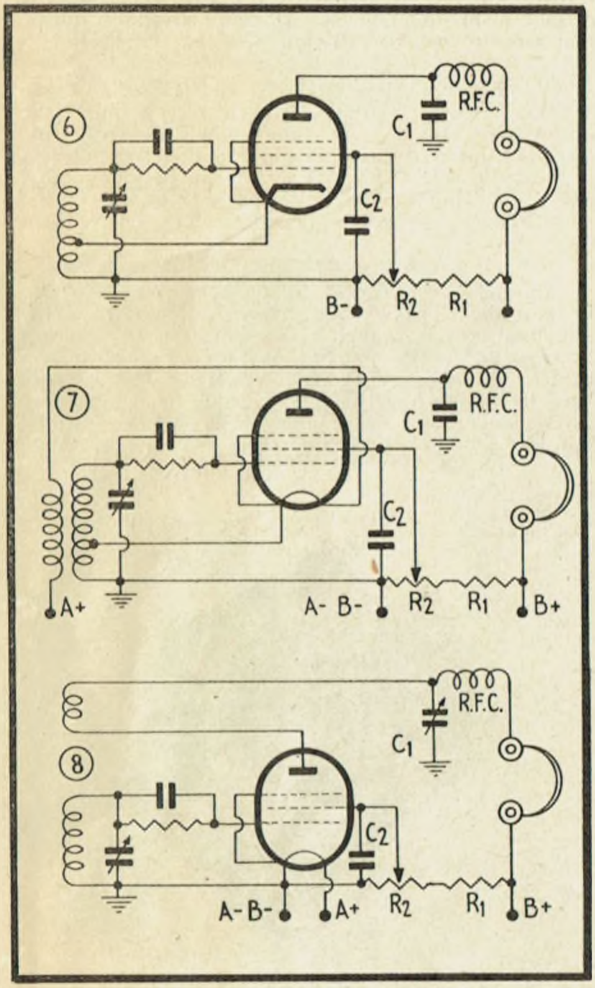
These are shown in Figs. 5, 6 and 7. They are more suitable for use with indirectly heated types, as an examination of the circuits will show. In Fig. 5, C is the usual fixed reaction condenser, and variation of plate voltage is used as regeneration control. Hartley circuits, in general, have the advantage of being excellent oscillators at high frequencies, and are possibly the best type to use in short wave sets, for that reason. Fig. 5 has been included mainly for purposes of illustration, for the pentode circuit of Fig. 6 is usually preferable. Here, as before, $C_1$ is the fixed reaction condenser and $C_2$ the screen bypass condenser. $R_1$ and $R_2$ should be so proportioned that the voltage at the top end of the potentiometer is approximately 100 volts in the case where 250 volts is used on the plate, and correspondingly lower with lower plate voltages. The remarks applying to the tickler turns in the case of Fig. 4 apply equally well to the turns between cathode and earth in Figs. 5 and 6.

Fig. 7 shows how the whole filament in a battery tube may be kept above earth potential so that the cathode tapping system can be used with these valves also. The extra coil shown in the A plus lead should have the same number of turns as the section of the main coil between the tapping point and earth, and should be wound immediately over it with finer wire so that the turns sit in the grooves between the turns of the main coil. It may be necessary with this circuit to place a bypass condenser of 0.01 $\mu f$. directly between the bottom end of this coil and earth. The extra coil should be wound in the same direction as the main coil, and the top end taken to the valve filament pin.

Fig. 8 is an example of a combination of circuit features. The tickler coil is used in common with Figs. 1, 2, 3 and 4, a variable reaction condenser is used as in Figs. 1 and 3, while a variable screen voltage control is used as in Figs. 4, 6 and 7. This particular circuit is quite a good one, for it allows considerable latitude in the choice of the tickler winding. It enables the screen voltage to be kept high at points on the dial where, with $C_1$ fixed, it would have had to be kept too low for the best sensitivity.

### SUMMARY.

In brief, the information given above may be summarised as follows. Any of these particular circuits may be used with success if certain precautions are taken as outlined. It cannot be said that any one of them is the best because some are better for using with indirectly heated valves, while others are more suitable for battery valves. The triode circuits with plate voltage control are perhaps not quite so good from the point of view of sensitivity as those with condenser control. No attempt has been made to make the list complete, for there are a number of regeneration control methods not represented. However, the circuits given may be used to build up combination circuits for special purposes, such as Fig. 8, and, if due care is taken, will operate as well as any of the basic circuits.

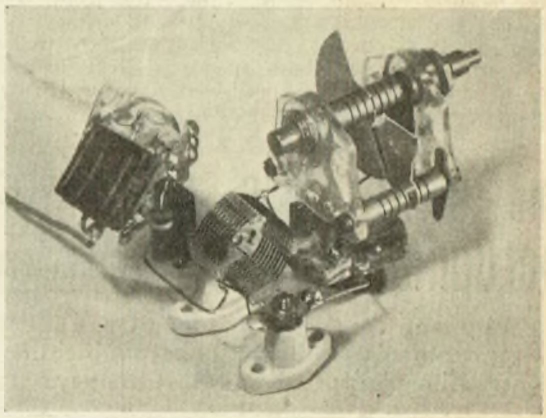



### BROADCAST AND SHORT WAVE.

Although this point, strictly speaking, has nothing to do with individual methods of obtaining regeneration, it should be included as a warning to those who have not discovered it for themselves. It is this: pentode regenerative detector circuits are not very suitable for use in sets which include the broadcast band. The reason for this is that the pentode is much more easily overloaded than the triode, and a single strong local station can cause it to behave in a most peculiar manner. Although pentodes give slightly more gain than triodes, the latter should always be used where broadcast band operation is desired.

# 10-Metre Converter

Since the appearance of our July issue, we have received inquiries as to how it is possible to build the oscillator section of the converter into so small a space. The accompanying photograph shows how the oscillator circuit was completely built up outside the shield box, the solid wire leads having been made of such shape and length as to allow the components to fall naturally into place when the oscillator, completely wired, is slipped into the shield box.



In addition, the photograph clearly shows the construction of the coil, the midget stand-off insulators used for mounting it, the polystyrene valve socket, and the grid condenser and grid leak.

A quite important point in connection with the special 4mc/sec. I.F. transformers was not mentioned in the original article. The trimmers are of the Philips type, in which adjustment is made not by means of a screwdriver, but with a "spin-tite," which fits the top of the moving plate, which is shaped like a hexagonal nut. The important thing to note is that the plate trimmers are at H.T., so that, unless an insulated tool is used, short-circuiting to the case will occur while adjustment is being made. The adjustable part of the grid trimmers are at signal voltage, so that again an insulated tool must be used, otherwise the signal will be short-circuited during adjustment.

These trimmers are meant to be adjusted and then left. Repeated screwing in and out, or the use of force in adjusting them, will result in the movable portion jumping off the thread or in damaging it, thus ruining the trimmers.

# OUR GOSSIP COLUMN

Mr. J. Malcolm, of Malcolm's Radio Service, Huntly, has been in Brisbane for the last three months snatching a few Australian speedway championships.

Well known in radio and motor-racing circles, Mr. Malcolm is captain of the New Zealand speedcar team now in Australia. His achievements across the pond may be summarised by quoting the following Press message:—

A crowd of 39,000 saw New Zealand beat Australia in the second speedcar test match by 26 points to 22. J. Malcolm's brilliant driving gained a win in the captains' heat for New Zealand.

* * *

Among callers at the office of "Radio and Electronics" was Mr. Alan Clarke, of International Radio Co., Ltd., Auckland. He had just returned from the West Coast and was moaning about the cold weather in those parts. But, Alan, it was cold—even in Wellington, so what?

* * *

Saw Keith W. Walker, of Nelson, in the Capital City recently. Keith, who is head of Keith W. Walker, Ltd., has a well-established business in Nelson and is one of the "old-timers" in radio. Away from business, Keith spends a great deal of time at Lake Rotoiti—a speed-boat and the elusive trout are no doubt the attraction!

C. H. Hart, Sales Manager, National Carbon Co., has been away in the South Island, no doubt trying to find "where the batteries go in winter time," or is it to tell customers why they do not get all the batteries they want? Both appear to be pretty tough assignments.

Rep. Maurrie O'Sullivan, of N.C.C., was in Wellington for a few days before going north again.

Doug. Freeman, Production Manager, has been transferred back to Sydney. We wish him the best of luck in his new sphere. Doug's colleagues "threw him a party" on the 7th—but why pick on Friday?

* * *

We believe Alex. Russell, of Russell's Cycle Works, Gisborne, is busy on cycle tyre permits (the cycles are coming some time), but apparently this does not interfere with his golf and active interest in the radio side of his store. He can be seen almost any day gazing fondly at the pre-war photos of the store filled to the gills with stock. Yes, Alex., them were the days!

* * *

Another Gisbornite—or is it Gisbornarian?—active in the radio world is P. R. Stevens. Apart from the sales and service branch of his business, he operates Station 2ZM. A popular feature of this station is the children's night each Thursday. P.R. is very keen to develop local talent. He will be remembered as a pioneer in New Zealand radio—he was transmitting as far back as 1912. (ah hem!

Another visitor to "Radio and Electronics" was Ken Pragnall, of Pragnall's Radio Service, Auckland. Ken spent some years as a radar mechanic in the Air Force, but has now been released and has returned to his business.

* * *

Mr. Harold Walsh, Manager of Radio Centre, Ltd., Auckland, was in Wellington recently and spent some days at Columbus Head Office.

* * *

Mr. T. P. Quick, of T. P. Quick, Ltd., Te Awamutu, recently called to H.M.V. Head Office. Another H.M.V. dealer, Mr. Scott, of Scott's Radio Service, Te Kuiti, was in Wellington a short time ago, and his business this time was to obtain a range of H.M.V. models for the Te Kuiti Show. We trust the show was successful and that many sales were completed.

## 50-Watt Modulator

*(continued from page 32)*

### MODULATION TRANSFORMER.

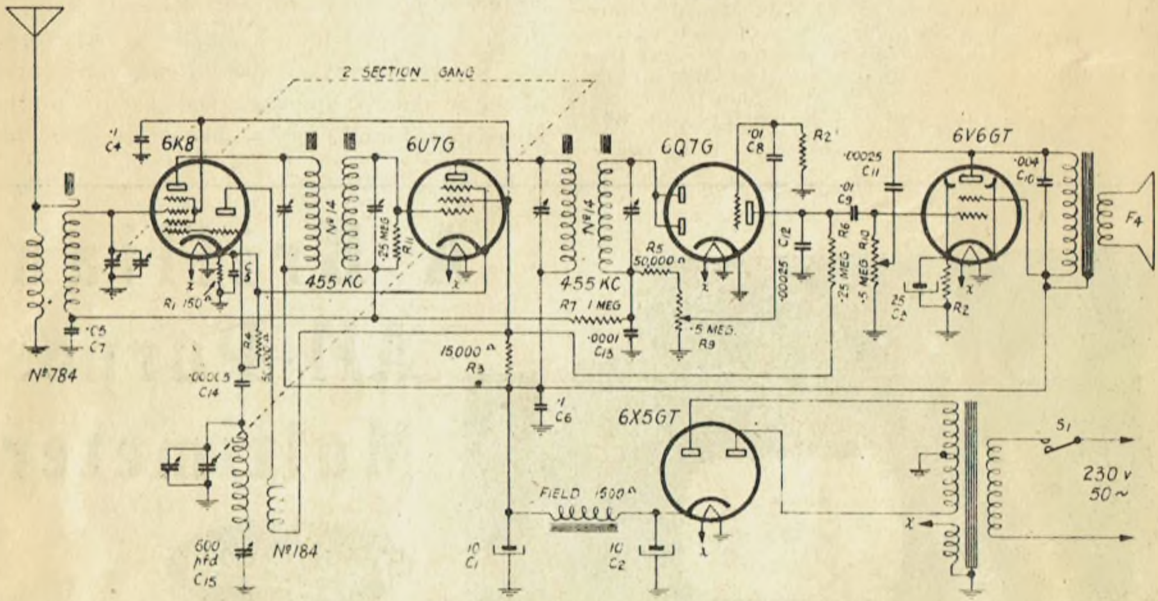
The transformer used in the original model was a commercial multi-match unit manufactured in this country. No details can be given of the correct taps to use with any Class C stage, but the user can easily work out the correct taps to use, knowing the D.C. plate voltage and current of the modulated amplifier, and that the p-p load impedance for the 807's should be 4200 ohms.

# FOR THE SERVICEMAN

## 5v PACEMAKER RECEIVER MODEL 515D

SCHEMATIC DIAGRAM

FREQ. RANGE 530-1720 KC




The above diagram applies also to Model 515-2, which is identical with Model 515-D, except that 515-2 has a three-gang condenser, one section being unused.

### Alignment Sensitivity Figures:

Note.—The I.F. is 455 kc/sec., and both transformers should be adjusted for maximum output. Under no circumstances should a staggered adjustment be used, as this procedure reduces the sensitivity too much. Adjustment of the I.F. transformers should be made with the gang-condenser fully open. The second I.F. transformer should be aligned first. The figures given below are for a signal generator modulated 30 per cent. at 400 c/sec. Standard output is taken as 50 milliwatts at the 3-ohm voice-coil, being 0.385v. R.M.S.

| Sig. Gen. Connection. | Sensitivity. |
|---|---|
| I.F. Grid | 2,600 $\mu v$ |
| Mixer Grid | 30-45 $\mu v$ |
| Aerial Term. | Approx. 6 $\mu v$ |

### Alignment Frequencies:

Trimming should be carried out at a frequency between 1500 and 1600 kc/sec.

Padding adjustment should be carried out at 600 kc/sec.

Note.—Final adjustment of trimmer condensers should be made after the padder has been adjusted.

### Pointer Setting:

Fully mesh the tuning condenser and adjust the pointer to the datum line, which is the horizontal line bisecting the scale.

### Low Sensitivity:

If the sensitivity is much less than shown in the table attached, the following points should be checked:—

(1) Low emission in mixer and I.F. amplifier tubes.

(2) 6V6 Cathode bypass condenser, $C_3$.

(3) Diode bypass condenser, $C_{13}$.

## Japanese Radar (*continued from page 5*)

a part against the Japanese to find out at last just how the enemy deployed his warning net.

- At Poporang, Buin, Kieta, and Cape St. George, the mobile units.
- At Buka, Cabanga, and Cape Lambert, the converted aircraft sets.
- At Cape North, Toma, and Guadalcanal, the Model 1 Type 1.

In theory, the operational organisation for making the best use of the radar information was excellent. Each airfield was responsible for a sector, and stations covering the area reported directly to the field "operations," who would initiate air defence. The system was flexible and efficient as long as there were aircraft to alert to their own defence. However, towards the end these were reduced to a scant half-dozen airworthy aircraft, hopelessly ineffectual against the powerful Allied raids.

### ERRORS AND OMISSIONS

Since the inception of *Radio and Electronics* there have been a number of errors and omissions. By far the greatest number of errors have been purely typographical and of little or no technical significance. For the benefit of constructors of equipment described in these pages, we give here a list mainly of omissions in component lists, but also of corrections.

**Vol. I, No. 1:**

Page 7: List of call signs. Headings "Broadcast" and "Shortwave" should be interchanged.

Page 25: Column 2, Line 2: The first valve mentioned should have been 6C5.

Page 28: Component List: $C_5$ is 0.05, not 0.005 $\mu f$. as shown.

Page 33: Component List: $C_2 = C_3 = 8$ $\mu f$. not .8 $\mu f$. as shown.

**Vol. I, No. 2:**

Pages 8 and 9: Missing from the component list are the following:—

$C_7$, $C_{10}$, $C_{13}$, $C_{21}$ = 0.5 $\mu f$.

$C_8$, $C_{22}$, $C_{36}$ = 1 $\mu f$.

$R_7$ = 25k.

Page 11: Column 2, Lines 25 and 28: For X read Y in both cases.

Page 22: Column 2, Line 14: For 1 $\mu v$ read 10 $\mu v$.

Page 27: Coil Data: Headings "Shortwave A," etc., and "Shortwave B," etc., should be interchanged.

Page 31: Fig. 2: The feed-back section of the oscillator coil has been shown short-circuited. The lead to earth from the lower plate of the tuning condenser should loop over the cathode lead, not join as shown.

**Vol. I, No. 3:**

Page 16: Circuit Diagram: $R_9$ unlabelled should be 1000 ohms.

Page 20: Column 2: Last sentence should read: " . . . where Tp/Ts is the transformer turns ratio." This mistake was noticed and rectified during printing, so that it occurs in approximately one-half of the copies printed.

Page 30: Circuit Diagram: The bottom rail should be shown earthed; also $C_8$ not shown in component list is 0.0001 $\mu f$.

**Vol. I, No. 4:**

Page 7: Circuit Diagram: A condenser of 0.1 $\mu f$. should be connected from the low-voltage end of $R_5$ to earth.

Page 30: Circuit Diagram: The 0.001 condenser coupling the moving arm of the diode load potentiometer to the triode grid of the 6Q7-GT should be 0.005 $\mu f$.

## Cathode Follower

(*continued from page 17*)

follower, it would be necessary to ensure that its characteristic impedance was matched at each end to avoid the development of standing waves. In this case a better arrangement might have been to feed the cathode follower from an inductive source, such as a choke-coil used as plate load for an amplifier stage and to adjust the values of the choke's inductance and the grid cathode capacity until the required output impedance is obtained.

### CHOICE OF VALVES.

Jeffery, in his analysis, shows that a figure of merit useful to indicate the best tubes for cathode follower use at high frequencies is given by gm/Cke.$C^2$gk. Figures for various well-known types are given below. All pentode types are assumed to be connected as triodes, with all elements except $G_1$ and cathode connected to the plate. In order to make comparison easy, the values for all types have been reduced to a fraction of that for the best tube, which is given the value of 100.

| Tube. | Fig. of Merit. |
|---|---|
| 6J5 | 100 |
| 6SJ7 | 30 |
| 6AC7 | 12 |
| 6J7 | 9 |

From the above, it would appear that of the types listed, the 6J5 is by far the best, but these figures should be taken with some reservations. If low output impedance is the most desirable characteristic, the 6AC7 is four times as good as the 6J5. If low input capacity is the most important point, the grid-plate capacity is the deciding factor, and there might be some advantage in using a pentode-connected tube. On all other counts, however, the triode connection is superior.

## SUMMARY.

Taking everything into consideration, the best valve to use is probably the 6AC7, on account of its high mutual conductance.

A grid stopper is the best method of preventing instability or oscillation. With a 6AC7 its value should be approximately 1000 ohms.

The best circuit to use when the input is derived from a tuned circuit is that of Fig. 1 (b), in which the cathode resistance should be made between 100 and 1000 ohms. With the lower values it may be necessary to use extra bias applied to the grid through the input circuit.

In order to assure a high input impedance, the output should be correctly terminated, and the factor gm/C"gk should have as high a value as possible. In this connection the 6J5 might be the best tube to use.

Reference: "An Analysis of the High-Frequency Operation of the Cathode Follower," by C. N. Jeffery, B.Sc., A.W.A. Technical Review, Vol. 6, No. 6, 1945.

## 24-Range Multimeter

(*continued from page 9*)

### CONSTRUCTIONAL DETAILS.

The physical layout of an instrument such as this is of very little importance to its operation. One of the main considerations is compactness, which, in this case, may be limited by the use of a 45v. battery, but several types of miniature battery are on the market, and even smaller ones will be in production before long, so that little difficulty should be experienced in building a compact portable instrument.

The 5000 v. A.C. and D.C. ranges and the 5 amp. D.C. range are optional. Separate terminals should be used for the 5000 v. ranges as shown in Fig. 1, since the voltage is too high to be safely used with wafer-type switches; 5000 v. is read with the main switch set to the 1000 v. range and the positive lead in the separate terminal. Since the selector switch should not carry more than 1 amp., the 5 amp. shunt should be connected externally. Its value should be such that when the meter is switched to the 1 amp. range and the external shunt connected a full-scale reading of 5 amps. is obtained.

Switch No. 1 requires three banks of 12 contacts each. These are the ones marked S1a, S1b, and S1c. The two wafers marked S1d and S1e have only four and two contacts respectively. These sections can be two complete 12-contact wafers on which the spare contacts are left disconnected, but, if the appropriate wafer can be obtained, S1d and S1e could consist of only the correct number of positions, mounted with S1d on one side of the wafer and S1e on the other.

In wiring up the main selector switch S1a, etc., the contact nearest the contact arm should be used for the 1000 v. position, as this will minimise the likelihood of breakdown between contacts.

The best way to adjust multiplying resistors to the correct values is to select carbon resistors slightly low in value. They may then be brought up to the desired value by filing one or more fairly deep nicks in each until measurement shows that the right value has been obtained. After filing, the resistors should be given a coat of clear lacquer to seal them against the absorption of moisture.

## Atomic Energy

*(continued from page 23)*

and design suitable engines for utilising the energy.

Although one atomic bomb may have the same energy output of 20,000 tons of TNT or millions of gallons of petrol it may well be that the cost of producing one atomic bomb far exceeds the cost of that amount of TNT or that amount of petrol.

At the present time, for the expenditure of 500 million pounds the result is:—

(a) Two bombs which have given satisfaction.

(b) Other bombs (probably still a liability and not an asset).

(c) A great deal of information and plant of un-assessed value.

A question, the answer to which we do not yet know, is whether the energy expended in mining the uranium, separating the active part, and making the bomb exceeds the energy released by the bomb exploding. If this should prove to be so the only advantage of atomic power at present is the small parcels in which it can be packed.





## Infinite Impendance Mixer

*(continued from page 27)*

cathode bypass condensers may be omitted, too, as there is more than enough gain available, and additional selectivity results.

The overall result is a receiver which, on 80 metres is selective, and very quiet in operation. On 10 metres it still has a high signal-to-noise ratio, accompanied by good image-rejection *and* high sensitivity.

The infinite impedance mixer offers plenty of scope to the "ham" with his natural bent for trying things. If he is prepared to make up for the gain lost by using the infinite impedance mixer, by adding another stage, he will find he is rewarded by greatly-improved signal-to-noise ratio.

Congratulations to the editors of "Radio and Electronics" for the production of a very useful magazine, containing as it does a variety of thought-provoking articles. Long may it keep up the good work!

Printed by Harry H. Tombs, Ltd., 22 Wingfield Street Wellington, New Zealand.

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