In your workshop

As is their habit in August, Dick and Smithy take time off away from the Workshop to enjoy the dual pleasures of fresh air and sunshine. But not to escape from matters electronic, for Smithy takes advantage of the break to explain the circuit of his bedside radio receiver incorporating the integrated circuit type ZN414

"Ah," said Smithy blissfully, "this is the life."

He leaned back on the park bench and surveyed the scene in front of him. In the distance a cluster of children played around a group of swings and a slide. The far corner of the park was taken up by a cricket pitch, and the occasional thwack of bat and ball reached his ears comfortingly. Lazily, he watched the players, musing idly on the time which elapsed between the hitting of the ball and the instant when the resultant sound reached his ears. Soothed by the warm August afternoon sunshine, he closed his eyes and fell into a state of philosophic meditation.

"Stap me," came a voice beside him. "I've only got to leave him on his own for five minutes and he darned well falls asleep."

ZN414 RECEIVER

Smithy opened his eyes and looked irritably up at his assistant.

"I am not asleep," he stated scathingly. "As it happens, I'm pondering."

"Pondering? On what?"

"On the mysteries of life," replied the Serviceman loftily. "Do you realise, Dick, that we are, every one of us, all slaves of time?"

"Blimey," remarked Dick, impressed by this intelligence. "In what way?"

"Well," said Smithy. "When the batsman in that game of cricket over there hits the ball I assume that I see him at the exact instant that he does so. But I don't, because the light rays reflected from him take a finite time to reach my eyes. Then again, if I rely on my ears to judge when he hits the ball there is, relatively, a very large time lag between his hitting the ball and my aural perception of his doing so. Even the batsman himself isn't aware of the precise instant at which he hits the ball, because the sensation from his hands takes at least a fraction of a second to travel through his nerves up to his brain."

"I don't think I like the sound of this," commented Dick uneasily. "If you carry your argument to its conclusion, everything happens in advance of our realising it."

"That's exactly so."

"You shouldn't dwell on things like that," stated Dick firmly. "Mysteries are best left as mysteries. Anyway, here are the ice-creams."

Abruptly, Smithy turned his thoughts from abstractions to realities.

"Hey, I said wafers."

"They didn't have any wafers. They've only got these ones on sticks."

Sitting up, Smithy took the ice-cream from his assistant and looked at it with disfavour.

"Nothing's the same as it used to be," he complained. "In the old days you could get a nice runny wafer with a bit of toilet paper put round it so you didn't get the ice-cream on your fingers. Nowadays, it's all these things on sticks. What nourishment is there in a stick?"

But there was no reply from his assistant, who was already busily engaged in licking away the outer layers of his ice-cream. Smithy proceeded to do likewise. When he was about half-way through the ice-cream he glanced at his watch, then produced a rather large plastic case from his pocket. This had three knobs on the front face.

"What's that?" queried Dick.

"Just a radio I've knocked up," replied Smithy. "It's really a bedside set, but I thought I'd bring it along with me today just to hear the news."

Smithy consulted his watch once more, switched on the receiver and adjusted its tuning control. Almost immediately the Radio 4 time signal became audible, to be followed by the announcer recounting a summary of the day's strikes, demonstrations, hi-jackings and riots.

"Just the same old things," grunted Dick, as Smithy switched off the radio. "Dead boring the news is these days."

The pair returned to their ice-creams. After some moments, a thought occurred to Dick. He turned to examine the radio receiver, which Smithy had now placed beside him on the bench.

"Is there anything peculiar about that set Smithy?" he asked curiously. "I can't see you spending your time making up a conventional radio when you've got plenty of manufactured ones available to you."

"It is a bit unusual," replied Smithy. "Actually, it's a set which incorporates the Ferranti ZN414 integrated circuit."

"The ZN414, eh?" repeated Dick, his interest aroused. "Isn't that the integrated circuit which provides all the r.f. amplification, together with detection, for an a.m. receiver?"

"It is," confirmed Smithy. "In its simplest form the ZN414 can be employed in a circuit which requires only one resistor, two fixed capacitors, an earphone and a ferrite rod aerial tuned circuit. Wait until I've got through this ice-cream and then I'll show you what I mean."

The pair finished their ice-creams at about the same moment, after which Dick took the two sticks and pieces of wrapping paper and deposited them in a nearby litter bin. As he returned to the bench he noticed a very scruffy old man just entering at the park gate.

Then he glanced once more at Smithy's receiver, and the latter once more took up all his attention.

Smithy had taken a piece of paper from his pocket, and was sketching out a circuit on it.

"As it happens," he remarked, "I had the circuit of the receiver on me, but before I get down to that let me show you the basic ZN414 circuit."

Smithy showed Dick the circuit he had just drawn. (Fig. 1).

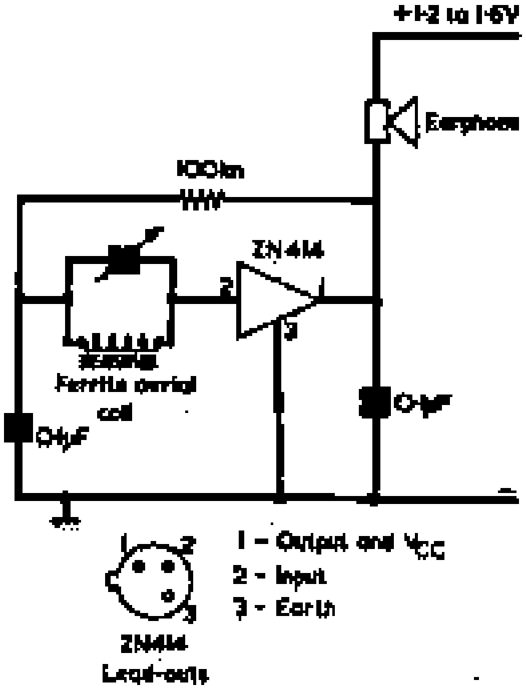


Fig. 1 The ZN414 integrated circuit may be employed in a basic circuit of the type shown here. The earphone should have a d.c. resistance of 250Ω or more

"You couldn't," he continued, "have anything simpler than this. The ferrite aerial can be a medium wave type and the a.f. output from the ZN414 is sufficiently high, at around 30 millivolts or more, to operate a reasonably sensitive earphone having a suitable impedance. Or, of course, the earphone can be replaced by a load resistor and the output fed to an a.f. amplifier which then drives a speaker."

"In that case," said Dick, "what you've got in your receiver must obviously be a ZN414 followed by an amplifier and speaker."

"You're right," confirmed Smithy. "Now, there's nothing particularly marvellous in making an a.f. amplifier, and so I decided to concentrate on making an amplifier which was pretty well as simple as it could be. To my way of thinking, the very simple circuit around a ZN414 should be complemented by an almost equally simple a.f. amplifier circuit, and that's what I've attempted to provide in this radio of mine. It doesn't have as high an a.f. output as the usual superhet does, but it can give adequate volume for a bedroom or a similarly quiet place from the local medium wave B.B.C. stations."

LOW SUPPLY VOLTAGE

"If the circuit is so simple," asked Dick, "could it be made up to give a really miniature radio?"

"Well, it could," replied Smithy. "But I don't recommend such a course because you would then have to use a very small speaker, and this would be rather insensitive. This circuit works best with a speaker having a cone diameter of about 4 inches or more. When I tried it out after I built it I connected it to an 8 inch speaker housed in a proper cabinet, and I got quite an appreciable volume level from this. Anyway, I'll now show you the complete circuit."

Smithy turned over the sheet of paper on which he had sketched the basic ZN414 circuit. The circuit of the receiver had already been drawn on the other side. (Fig. 2).

"Blow me," remarked Dick. "The battery supply is only 3 volts in this circuit."

"True," agreed Smithy. "The specified supply voltage range for the ZN414 is 1.2 to 1.6 volts, with 1.3 volts recommended by the makers. The current consumption is tiny, being only 0.3mA typical and rising to 0.5mA under strong signal conditions. It seems reasonable, therefore, to supply the ZN414 from one 1.5 volt cell of the battery and to use the full 3 volts from this and a second 1.5 volt cell to supply the a.f. amplifier. The fact that the voltage dropped across the base-emitter junction of a silicon transistor is around 0.6 to 0.7 volt then enables a very simple amplifier to be made up, as I'll explain to you in more detail shortly."

"Well," remarked Dick, "the circuit doesn't seem to be particularly complicated."

"It isn't," said Smithy. "Now, seeing that we are thinking in terms of a 3 volt supply the best choice of speaker impedance is 3Ω. There won't be much a.f. output voltage available so we'll obtain the greatest output power by using the lowest standard speaker impedance. If the two output

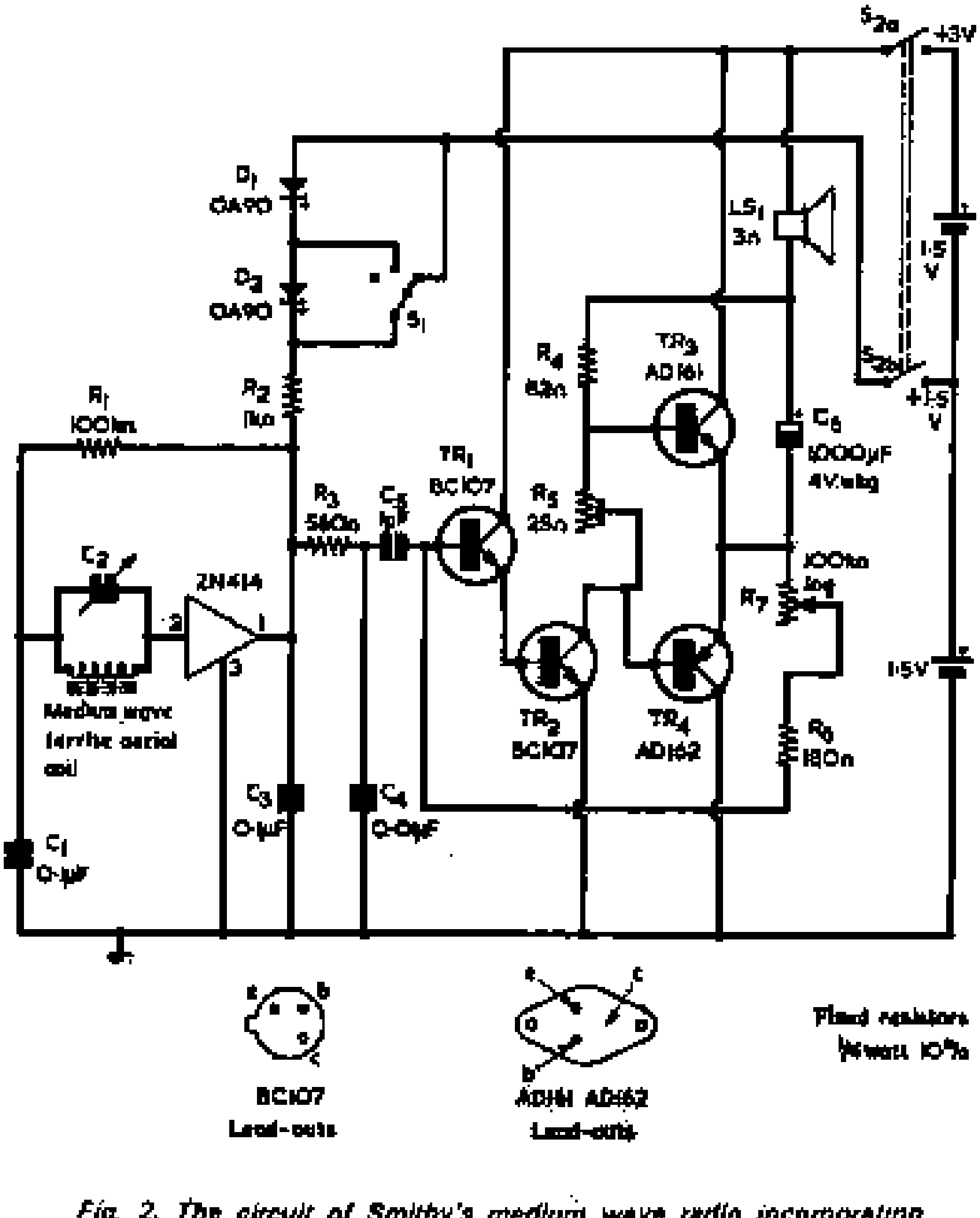


Fig. 2. The circuit of Smithy's medium wave radio incorporating a ZN414

emitters are at half supply voltage in the absence of signal we can assume for the moment that they are then able to swing positive and negative by up to nearly 1.5 volts. This corresponds to an r.m.s. value of about 1 volt. Now, the r.m.s. output power is equal to voltage squared divided by speaker impedance, and the figures I've just mentioned point to an output of a third of a watt. In practice the r.m.s. output power will be lower than this because the two output emitters won't be able to swing positive and negative by quite as much as I assumed and because there'll be a small loss in the 1,000μF capacitor coupling the emitters to the speaker, I would guess that the maximum output power is of the order of 250 milliwatts or so."

"Even that," remarked Dick, "isn't to be sneezed at. I see that you've used power transistors type AD161 and AD162 for TR3 and TR4 in the output stage. Aren't these rather large types for use in a low power stage like you've got here?"

"They are," agreed Smithy, "and, in fact, they're considerably under-run. I had some difficulty in selecting the output transistors when I was working out the circuit. To start off with, the output transistors must be germanium as there just isn't enough supply voltage available to allow silicon transistors, with their relatively high base-emitter voltage drops, to be used. Now, in theory, the output emitters should be capable of applying 1.5 volts to a 3Ω load, and this corresponds to an output current of half an amp. Also, if an excessively high signal were applied to the output stage, clipping could cause the output transistors to handle what is effectively a square wave with a peak-to-peak amplitude of 3 volts. Each output transistor would then dissipate a power equal to 1.5 volts multiplied by 0.5 amps, or 750 milliwatts, for half the time. The average dissipation for each transistor would then be 375 milliwatts. These theoretically possible output currents and powers made me a little unhappy about using smaller transistors, such as the AC127 and AC128. So I decided to plump for the AD161 and AD162, even though they would be used far below their normal dissipation level. Since the design is not intended to be for a miniature radio, little is lost by using bulkier transistors. The AD161 and AD162 do not need to be fitted to heat sinks."

"I notice," remarked Dick, "that you haven't fitted any series resistors in the output emitter circuits to counteract thermal runaway."

"There isn't," grinned Smithy, "enough output voltage available to allow such resistors to be employed! Also that's another of the marginal reasons which caused me to use the AD161 and AD162. Their cases are large enough to keep them cool in normal working, and in the very unlikely event of thermal runaway actually taking place they almost certainly wouldn't come to any harm anyway. Both types are capable of passing currents up to 3 amps, and all they'd do under thermal runaway conditions would be to run the supply battery down very quickly."

FEEDBACK CIRCUIT

A shadow fell across them and they looked up, to see that the unkempt old man who Dick had spotted at the park gate was now shuffling past. At this closer range, Dick was able to examine him in greater detail. On his head he wore a cloth cap with a ragged brim whilst, lower down, Dick noted a torn and rugged jacket from one pocket of which hung a repulsively filthy rag which presumably served the function of handkerchief. Crumpled and dirt-stained trousers augmented the ensemble, which was completed by dust-laden shoes, the sole of one of which flapped up and down as its owner shambled by. He was muttering peevishly to himself, and a large drop hung precariously from the end of his nose.

Dick and Smithy watched the old man as he proceeded shakily along the park path. Eventually, he passed out of earshot, and they tore their eyes away.

"What a disgusting old man," said Smithy.

"I'll say," agreed Dick. "He ponged a bit too, didn't he?"

"I think it's a scandalous state of affairs," commented Smithy, "letting people like that into public places. Anyhow, he's gone past now, thank goodness, so let's forget about him. What were we talking about?"

"You were describing the output stage of your radio."

"Was I? Oh yes, I remember now. Well, as I was saying, I decided after a lot of thought to choose the AD161 and AD162 as output transistors. Both of these have a minimum current gain of 80 whereupon, if they are to pass output currents of half an amp, they need a minimum base drive of half an amp divided by 80. This works out at just over 6mA. In consequence, the standing current in the collector load for driver transistor TR2 needs to be quite a bit higher than this. The collector load is R4, and I've given it a value of 82Ω. Assuming a voltage drop of 1.5 volts across this resistor, the current which flows through it then works out at just a little lower than 20mA. In practice it's about 18mA or so because some of that 1.5 volts is dropped in R5. A current of 18mA in R5 is quite high enough in practice."

"I notice," remarked Dick, "that you've bootstrapped the top of R4 to the lower terminal of the speaker."

"True," agreed Smithy. "You may remember that we were talking about a.f. amplifier output stages and bootstrapping during our last gen sesh, so we don't need to go into that subject all over again, apart from saying that the bootstrapping causes R4 to have a much higher effective resistance at a.c. than its physical value of 82Ω."

"Fair enough," said Dick. "Now what exactly do TR1 and TR2 do?"

"TR1," replied Smithy, "acts as a current amplifier feeding into TR2. And here we come to a point which I mentioned at the start and which is very helpful in the present design. Both TR1 and TR2 are silicon transistors, which means that there is a voltage drop of 0.6 to 0.7 volt across their base-emitter junctions. Thus, the voltage at the base of TR1 is about 1.2 to 1.4 volts positive of the negative supply rail. Negative feedback is applied from the output emitters to TR1 base via R7 and R6, with the result that the output emitters are also held at around 1.2 to 1.4 volts positive of the negative rail. As you can see, this voltage is quite close to the half-supply voltage. What happens here is that R4 attempts to pull the output emitters up to the 3 volt positive rail, but as soon as they go sufficiently positive for current to flow into the base of TR1 both TR1 and TR2 conduct and hold them at this level. The circuit is then in a state of balance. If, for any reason, the output emitters went positive, base current in TR1 would increase as also would its collector current and the collector current of TR2. The increase in TR2 collector current would then cancel out the positive excursion of the output emitters." (Fig. 3(a).)

"Blow me," remarked Dick. "That's a bit of luck, Smithy! Just by using a couple of silicon transistors in a very simple amplifying circuit you can automatically set up the output emitters really close to half-supply voltage."

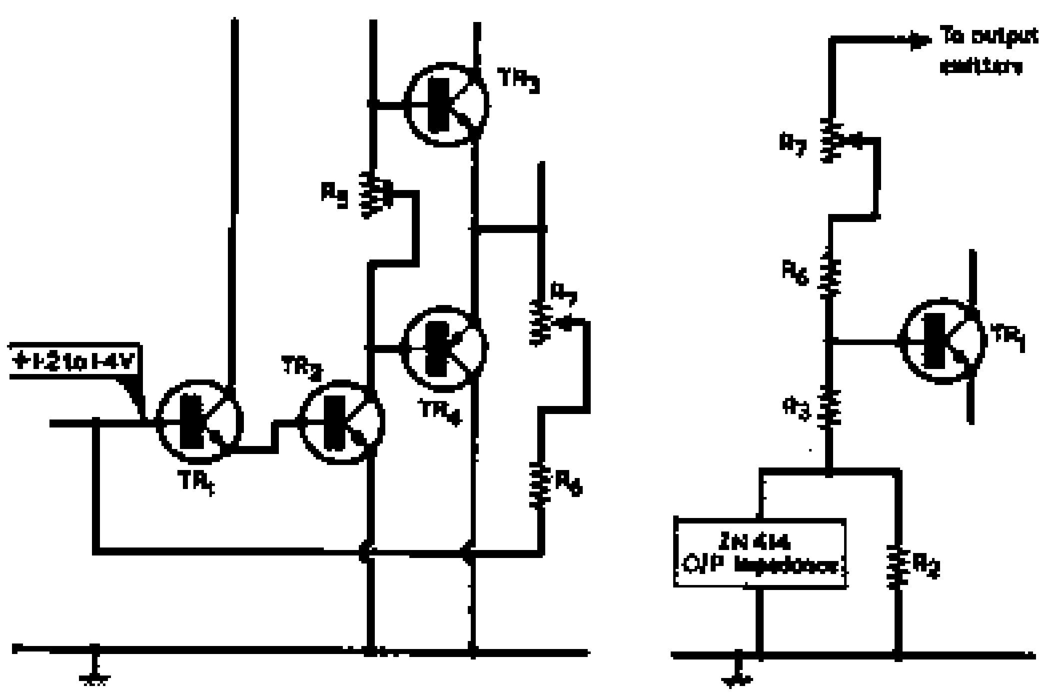
"Yes, it's an extremely fortunate state of affairs," agreed Smithy. "In my set I find that the output emitters actually sit at around 1.4 volts. They go slightly more positive as R7 inserts more resistance into circuit but only by a tiny amount."

"Now, that's something else I was going to ask you about," said Dick. "What is the idea behind making R7 variable?"

"R7 is the amplifier volume control," said Smithy. "The feedback circuit which keeps the output emitters at half-supply voltage is a d.c. arrangement, and the feedback components at d.c. are just R7 and R6 on their own. But the a.c. feedback circuit is quite different, because at audio frequencies C5 has a low impedance. The feedback circuit becomes a potential divider, with R7 and R6 forming the upper arm, and the lower arm being given by R3, the output impedance of the ZN414 and R2." (Fig. 3(b).)

"Won't the input impedance of TR1 base also be in the lower arm of the potential divider?"

"It will be," confirmed Smithy. "However, it will be very much higher in value than the resistive components and the output impedance



(a) (b)

Fig. 3 (a). The d.c. feedback loop in the a.f. stages of the receiver. This causes the output emitters to take up a potential slightly higher than that at the base of TR1

(b). Assuming that C5 has zero reactance and that the upper end of R2 is at chassis potential, the a.c. feedback loop takes up the form shown here

of the ZN414, and it can be ignored. So also, incidentally, can the reactance of C3, which is of the order of 15kΩ at 1kHz. When R7 is set to insert minimum resistance into circuit, the upper arm of the potential divider is given by R6 on its own. The very high level of feedback at the base of TR1 results in the a.f. amplifier stages having almost zero gain. When R7 is set to insert maximum resistance into circuit the upper arm of the potential divider is given by R6 in series with all of R7, and the amount of feedback is negligible. Under these conditions the amplifier is working virtually all out. R7 offers a very smooth control of volume, the minimum volume position being given when it inserts zero resistance into circuit, and the maximum volume position occurring when it inserts full resistance. A log pot is used here, and it is wired so that it inserts increasing resistance as its spindle is turned clockwise. If desired, this can be a pot fitted with a double-pole switch, and the latter can then be the on-off switch, S2(a) (b)."

"Why did you put R6 into circuit?"

"To avoid the situation where there is zero resistance between the output emitters and the base of TR1," explained Smithy. "Without R6 the a.f. stages would tend to go into r.f. oscillation when R7 slider is right at the minimum resistance end of its track. R6 prevents this happening."

ZN414 OPERATION

"Well," remarked Dick, "that seems to have the a.f. amplifier part all buttoned up. What about the coupling between the ZN414 output and the base of TR1?"

"Things are pretty straightforward here," replied Smith. "C3 and C4 are r.f. bypass capacitors, and C5 is a plastic foil a.f. coupling capacitor. Resistor R3 is part of the r.f. filter, and it also provides part of the resistance needed in the lower arm of the a.f. negative feedback potential divider. One important practical point is that C3 must be wired very close to the earth and output lead-outs of the ZN414. If it isn't, the ZN414 tends to become a little unstable; which isn't surprising, of course, when you consider the fantastic amount of gain it has at radio frequencies. Also, input wiring should be kept well spaced from output wiring."

As Dick turned to look once more at Smithy's circuit, he noticed something out of the corner of his eye.

"Ye gods, Smithy," he muttered, "just look over there."

Smithy glanced in the direction indicated by his assistant and stiffened.

"Why, the dirty old man," he snorted disgustedly.

"Shocking. I call it," said Dick, primly.

"It didn't ought to be allowed," stated Smithy firmly. "Quite disgraceful."

"I've seen everything now," pronounced Dick censoriously. "Just imagine it, going through the litter bins like that. I suppose he's looking for scraps to eat or something."

"This is a Welfare State," retorted Smithy, "and there should be no necessity for behaviour like that. I wish he wouldn't keep hanging around us here, though."

"Oh, let's forget about him," stated Dick, purposefully turning his gaze back to the circuit of Smithy's receiver. "What are those germanium diodes for at the top of the 1kΩ resistor?" (Fig. 4).

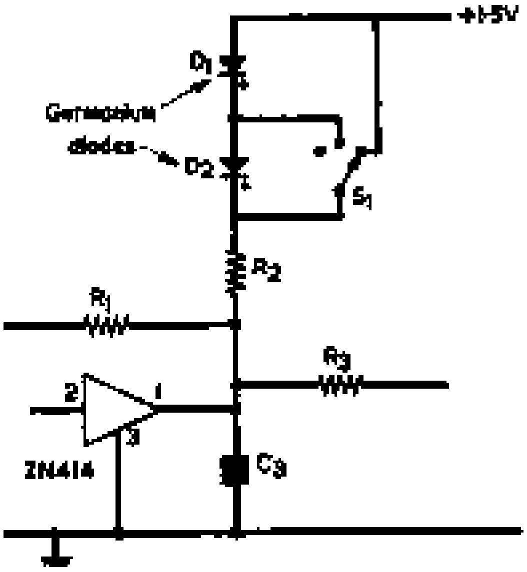


Fig. 4. Switch S1 and diodes D1 and D2 enable varying supply voltages to be applied to the ZN414

"They're to enable different supply voltages to be applied to the ZN414," said Smithy. "This integrated circuit is very sensitive to supply voltage changes between about 1.2 and 1.6 volts. I found that, if the supply voltage is at the high end of this range, the ZN414 tends to become a little chirpy and to give heterodynes on either side of the received signal, with the result that tuning becomes rather the same as the tuning of a t.r.f. receiver with the reaction advanced a little too far. Reception of the more powerful stations is still possible under these conditions, presumably because the a.g.c. action in the ZN414 decreases its gain when the signal is properly tuned in and thereby takes it just below the oscillation point. When switch S1 is at its right-hand contact, the full 1.5 volts from the battery is applied to R2. If S1 is set to the middle position the voltage applied to R2 is 1.5 volts minus 0.1 to 0.2 volts dropped in diode D1. Setting S2 to the left hand position puts both diodes in circuit and the supply voltage drops by another 0.1 to 0.2 volt. Having the diodes in series does not affect the load resistance given by R2 to any great extent because, whilst the diodes drop the supply voltage, the resistance they present into circuit is only their low forward slope resistance. I find S1 is very useful for setting up the ZN414 at just the right supply voltage for a particular station. It also caters for the situation given when the battery voltage falls with age. I've shown the diodes as OA90 in my circuit, but in practice almost any germanium diodes could be used here."

"That seems to be a jolly good circuit approach," commented Dick. "What about the ferrite rod aerial?"

"Any medium wave ferrite aerial can be used," said Smithy. "I used a ready-wound aerial and simply connected its tuned winding into circuit. The value of C2 is that required for the particular aerial being employed and would, typically, be 208pF."

"How about long waves?"

"I wouldn't recommend this receiver for long wave reception," said Smithy, "unless it is to be used in an area where the Radio 2 signal on 1,500 metres comes in at pretty good strength. Incidentally, whilst talking about long waves, there's one point I would like to bring up. Ready-wound ferrite rod aerial assemblies for medium and long waves normally have the medium and long wave coils separate. If no connection is made to the long wave coil it is quite possible for it to resonate, with its own self-capacitance, at a frequency in the medium wave band. It then acts as an absorption tuned circuit and considerably attenuates medium wave signals picked up on the medium wave coil." (Fig. 5).

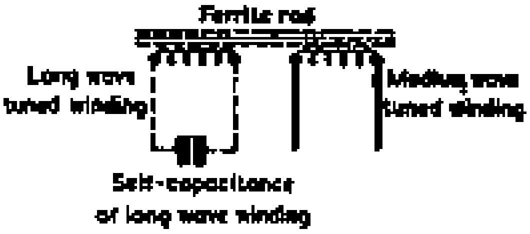


Fig. 5. It is possible for the long wave tuned winding on a ferrite rod to resonate, with its own self-capacitance, at a frequency in the medium wave band

"That's awkward," commented Dick. "How do you know if the long wave coil is doing this?"

"By simply slipping it off the ferrite rod," replied Smithy, "whereupon any effect it has on medium wave reception should disappear. It's because of this absorption trouble that the long wave ferrite aerial tuned coil is frequently short-circuited in medium and long wave sets when medium waves is selected. Anyway, we're straying from our subject, which is this medium wave set of my own."

"Fair enough," said Dick. "What about current consumption?"

"It's about 24mA from the 3 volt battery under quiescent conditions," stated Smithy. "And it rises up to well over 100mA or more when it's reproducing a signal at the maximum volume level."

"Blimey," said Dick, "that's a bit high, isn't it?"

"Not really," replied Smithy. "Don't forget that the supply voltage is only 3 volts. The current consumption compares quite favourably with the usual situation in a superhet receiver having a 9 volt battery, where quiescent current is around 10mA, rising to 50mA or so at high volume levels."

"What sort of battery do you recommend?"

"Probably the best buy here," said Smithy, "is a twin cell cycle lamp battery, such as the No. 800 made by Ever Ready. If you pull up the cardboard at the top of this battery it's quite easy to solder a lead to the internal wire joining the two cells. This gives the 1.5 volt supply needed by the ZN414. The advantages with these cycle lamp batteries are that they are intended to provide quite high currents for long periods, they have a low internal resistance and they're relatively inexpensive." (Fig. 6.)

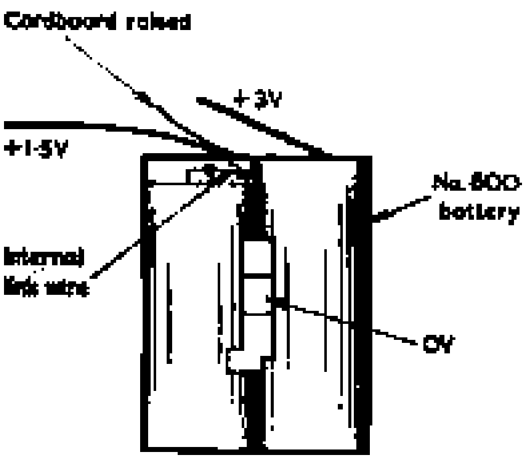


Fig. 6. An Ever Ready No. 800 battery, or equivalent, can be used to power the receiver. A connection made to the internal wire linking the two cells provides the positive 1.5 volt point

"I see," commented Dick. "Now there's only one final question I want to put to you."

"Fire away."

"How do you set up R5?"

"That's not too difficult," remarked Smithy. "When the set has been assembled, you connect the negative supply rail to the negative terminal of the battery, and the 3 volt rail to the positive battery terminal via a testmeter switched to read currents of the order of 25mA. R5 should be initially set to minimum resistance, and the 1.5 volt supply rail is not connected to the battery. Then switch on. You don't need to worry if the meter gives a reading that's a little lower than the 18mA I mentioned earlier as the current which flows through R4; the lower reading is merely due to the fact that testmeters tend to drop a relatively large voltage across their terminals when they're switched to the higher current ranges. Then gradually increase the resistance inserted into circuit by R5 until the current reading increases by about a third. If, for instance, the original reading was 15mA, then R5 is adjusted for a reading of 20mA, and so on. Incidentally, you can't use a skeleton pre-set for R5 as these aren't normally made for values below 100Ω, and so this resistor can be a small wire-wound potentiometer. It should also be in reasonably good condition because, if the wiper is in poor contact with the track, it will present a high resistance between the bases of TR3 and TR4, and these transistors could pass an excessively high current as a result." (Fig. 7.)

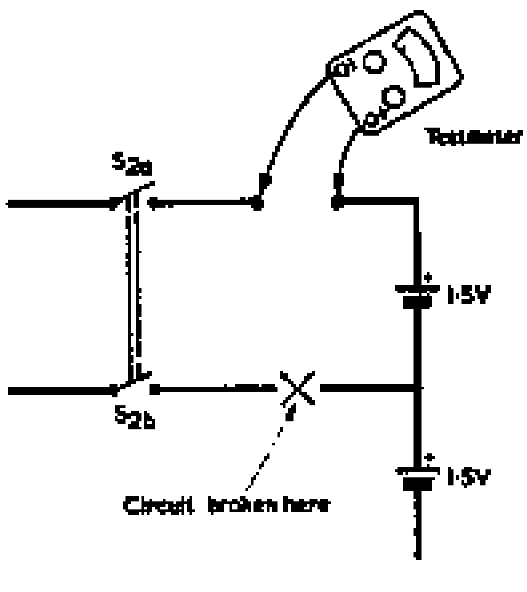


Fig. 7. The test set-up required for adjusting R5. This potentiometer should be initially adjusted to insert zero resistance into circuit

DESTINY

Smithy folded up the circuit diagram of his receiver and returned it to his pocket. Even Dick's enquiring mind seemed to be satisfied for the time being, and a long peaceful minute passed as they sat contentedly in the sunshine.

"Hey, guv," wheezed a tremulous voice at Smithy's ear.

Startled, Smithy shook himself out

of his reverie and found himself gazing into the rheumy blood-shot eyes of the disreputable old man who had been haunting them during the afternoon.

The old man drew a faltering breath and brought his face closer to Smithy. The Serviceman leaned back as far as he could on the bench.

"Have yer," continued the old man purposefully, "got the price of a cup of coffee?"

"I'm not certain if I have," replied Smithy, attempting the near-impossible task of talking without inhaling. "In fact, I don't even know how much coffee costs these days. I always drink tea myself."

The old man looked at the Serviceman with acute distaste.

"It's always the same," he grumbled. "Nobody's ever prepared to help me."

Dick decided to come to Smithy's rescue.

"You should be ashamed of yourself," he said sternly, "going around begging like this."

Quivering, the old man turned towards Smithy's assistant.

"Hah," he coughed bitterly, "it's all right for you young ones, you've got all your time in front of you. I was starry-eyed and full of hope myself once, but the world has cheated me. I can only look back now on a wasted life."

Dick's ever-present curiosity rose above his aversion to the disreputable figure in front of him.

"How do you mean, your life was wasted?"

"I chose the wrong career," faltered the old man. "A life of drudgery is all I've known, and all of it to no purpose."

"What career did you choose?"

The old man, now in an ecstacy of self-pity, drew himself, trembling, to his full height.

"I was," he intoned, "a radio and TV service engineer!"

"You were a *what*?" spluttered Smithy.

"I was a radio and TV service engineer, mate. Just think of it: all those years breathing in solder fumes, getting shocks and fixing sets free for in-laws."

The old man drew in a rasping breath.

"But worse was to come."

"Don't tell me," implored Smithy. "Just don't tell me."

"I *must* tell you," said the old man. "I was promoted to Service Manager."

"Oh no," breathed Smithy.

"So," went on the quivering voice, "not only did I have the solder fumes, the shocks and the in-laws, but I also had staff troubles and non-delivery of spares. Well, that's the story of my life, and now I haven't even got the price of a cup of coffee."

Hastily, Smithy reached into his pocket, fished out a tenpence piece and handed it over to the old man. He clutched the coin with a muttered grunt of thanks, then set off towards the park gate. Dick and Smithy watched in silence as he shuffled along the path and eventually disappeared outside the gate.

There was a thoughtful pause, after which Smithy reached down absently at the park bench beside him. A frown creased his brow, and, unwillingly, he looked down.

"Why, the old devil," he burst out. "Do you know what he's done?"

"No," replied Dick, "what has he done?"

"He's pinched my radio!" snorted Smithy furiously. "He's been and gone and nicked my darned radio!"

The Serviceman rushed feverishly towards the park gate and then started to search the streets on the outside.

But, as he himself had observed, we are indeed the slaves of time. Just as apart from rare moments of precognition the future is hidden from our eyes, so also had the aberrant old man, in the few minutes vouchsafed to him, apparently disappeared off the face of the earth. ■

Dammit Jackson! WHY does it have to be TODAY when the Board discover the results of your METRIC CONVERSION TRAINING PROGRAMME?