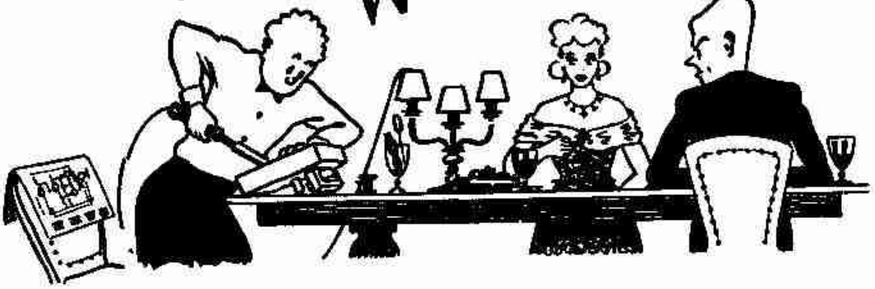
IN YOUR WORKSHOP



This month, Smithy the Serviceman, aided by his able assistant Dick, investigates a mysterious line output stage fault. He also discusses noise limiting circuits and the new Mullard PC97 tuner unit triode.

"On its own, Kelly's eye!" The muttered words were just audible across the Workshop.

"Shiny Ten, Downing Street!"

Puzzled, Smithy the Serviceman put down his soldering iron.

"Legs, Eee-*leven*!"

Smithy turned round and his perplexed expression deepened. His assistant seemed to be entirely engrossed in the television chassis on his bench.

"One and Two, just a doz!"

There was silence for a moment.

"Oh yes, I forgot that one. On its own, the Temperance Seven!"

Smithy looked more closely at his assistant. The latter, having just taken a voltage reading in his receiver, turned round and caught the full intensity of Smithy's scrutiny.

Poor E.H.T. Regulation

"Is everything O.K.?" asked Dick, slightly alarmed at Smithy's expression.

Smithy was disconcerted at the complete lack of concealment in his assistant's youthful and innocent face, and he momentarily forgot the question he had prepared.

"It was funny you should look round then, anyway," continued Dick artlessly, "because I was just about to tell you how I've successfully traced rather a queer snag."

As always, Smithy was hooked by the mention of a peculiar fault.

"Oh yes," he said, the phenomenon which had previously caused him to turn round slipping from his mind, "what was it?"

"Well," replied Dick, "to start at the beginning, this set came in with insufficient height and a bad case of 'blooming'. The vertical scan was reasonably linear, so I left the frame timebase alone for the time being."

"Fair enough," commented Smithy. "Incidentally, by 'blooming' I suppose you mean the effect given when the picture expands in size as you increase brilliance?"

"That's right," said Dick. "In this case I could get a fairly dim picture resolved which looked quite O.K., apart from the lack of vertical height. But when I turned the brilliance up to a normal setting the picture 'bloomed' out like billy-oh. If I turned the brilliance control further the picture faded out completely, and I had to turn the control right back and wait for a few moments before I could even get back to the dim picture."

"It seems a fairly classic case of line output stage trouble," said Smithy. "The 'blooming' effect is due, of course, to poor e.h.t. regulation. As you increase brilliance you increase the e.h.t. current drawn by the tube. The poorly regulated e.h.t. voltage then goes down, giving you the effect of the picture expanding."

"I've never," interjected Dick, "quite understood exactly why the picture expanding business takes place."

"What happens," explained Smithy, "is that when e.h.t. drops there is a reduction in the velocity of the electrons travelling to the final anode. In consequence, these electrons spend a longer time in the field given by the deflector yoke and, therefore, suffer greater deflection. So your picture 'blooms' out."

"I'm with it now," commented Dick.

"Fair enough," said Smithy. "Now let's get back to the line output stage. (Fig. 1 (*a*)). You had a second effect in which, after you had advanced the brilliance control, the picture faded out completely and you had to wait several moments with the brilliance turned fully back before it reappeared. That second effect was almost certainly due to the fact that the heater of the e.h.t. rectifier was only getting sufficient power from the line output transformer to just warm up to emitting temperature in the first place. When the line output transformer was loaded by increasing the brilliance, the power available for the e.h.t. rectifier heater dropped. It went below emitting temperature and you lost your e.h.t. The delay before e.h.t. reappeared was needed to allow the rectifier to heat up again."

"I thought, myself, that something like that was happening," said Dick.

"You were quite right then," replied Smithy. "A minor point to bear in mind, when both e.h.t. voltage and e.h.t. rectifier heater power suffer from bad regulation, is that this means that both the e.h.t. circuit and rectifier heater circuit are receiving insufficent power from a *common source*. You can, then, fairly safely forget about poor e.h.t. regulation occurring in the e.h.t. circuit only."

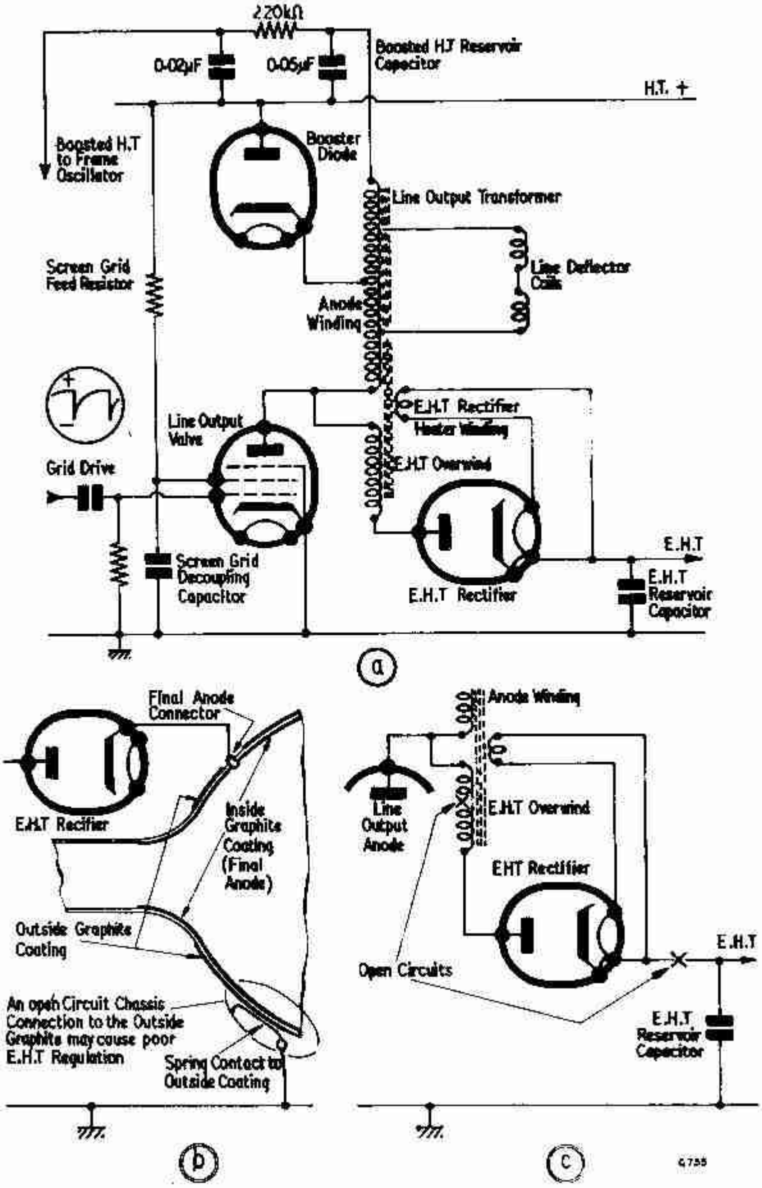


Fig. 1 (a). The basic line output circuit employed in Dick's television receiver. The capacitors and resistor in the boosted h.t. circuit are given typical values

(b). The e.h.t. reservoir capacitor of (a) will, in practice, be formed by inside and outside graphite coatings on the cathode ray tube. If the chassis contact to the outside coating is open-circuit, poor e.h.t. regulation may result

(c). Poor e.h.t. regulation may also result if an open-circuit appears in the e.h.t. circuit, as in either of the two examples shown here. A spark bridges the gap for a period until the open-circuit points finally burn away

"What would cause poor regulation in the e.h.t. circuit?"

"There aren't many things," admitted Smithy. "A low e.h.t. reservoir capacitance due to bad earthing of the outside graphite on the tube could conceivably do it, (Fig. 1 (*b*)), although this fault doesn't always cause excessive 'blooming'. You may occasionally have an open-circuit in the line output transformer overwind, or in the e.h.t. connection to the tube, (Fig. 1 (*c*)). A spark can bridge the gap here and allow e.h.t. with poor regulation to appear for quite a while before the open-circuit finally burns away. Anyway, in this particular case, we don't need to worry about things of this nature because of the common fault which has also reduced rectifier heater power."

"Seeing that I had the slow rectifier warm-up effect," broke in Dick, "the first thing I did was to change this valve."

Smithy looked a little puzzled.

"There's no harm in changing the rectifier," he commented, "but I don't quite see the logic of doing so."

"I did it," said Dick, "because I thought that, if the rectifier cathode were only *just* hot enough to emit, this could be due to a fault in either the cathode or the filament. The rectifier could then insert quite a lot of resistance into the e.h.t. circuit on its own."

"Ah, I see," said Smithy, light breaking in. "Anyway, there's no harm in changing it, and you might have been lucky. My own experience with valve e.h.t. rectifiers is that they're either 'on' or they're 'off', as it were, and you don't get the case where they insert the few odd megohms needed to cause 'blooming'. *Did* changing the rectifier clear the snag?"

"No," admitted Dick. "I next swapped the line output valve and the booster diode, but there was no joy here, either. After that I took a few voltage measurements. The h.t. applied to the anode of the booster diode was 195 volts, so I assumed that the circuit had enough h.t. to work with. I then checked the boosted h.t. voltage, and I found that this was only 250 volts above chassis at the boost reservoir capacitor, instead of the usual 500 or 600 volts. So that's it!"

"What's it?"

"The fault, of course," said Dick impatiently.

"But what *is* the fault?"

"Why the line output transformer! If you aren't getting enough boost volts it's obvious that the line output tranny is up the wall and needs replacing."

Low Boost Voltage

Smithy sighed and sat down.

"Dear, oh dear me," he said, "will you *never* get rid of that line output transformer complex of yours? Just because you've swapped a couple of bottles and taken two voltage measurements you immediately jump to condemning the line output transformer. Anyone would think you *enjoy* changing line output transformers!"

"Well, *couldn't* it be the cause of the trouble here?"

"Of course it could! But there are several other things a darned sight simpler to replace than the line output transformer and they could just as easily cause the fault. For instance, the screen-grid feed resistor to the line output valve could have gone high. Again, if the screen-grid has a bypass capacitor this could have gone leaky or open-circuit."

"Wait a minute," broke in Dick, "I can understand a leaky screen-grid capacitor causing trouble, because it would reduce screen-grid voltage. But I don't see how an open-circuit capacitor could cause the fault as well."

"It can do with some circuits," replied Smithy. "You see, the screen-grid bypass capacitor allows the screen-grid to retain a high potential during the latter part of the scan when the valve passes most current. You would, in fact, be surprised at the loss in line output power that results in some sets if this capacitor goes open-circuit. Another snag which could cause the trouble is insufficient drive to the line output grid, although this would normally also play tricks with horizontal linearity. Any components connected across sections of the line output transformer anode winding, such as capacitors or width or linearity controls, can also cause the trouble although here again horizontal scanning in the reproduced picture would probably suffer as well. Finally, there is the possibility of trouble in the boost reservoir capacitor."

"Well, it isn't leaky," remarked Dick defensively, "because I checked for that after I found the boost h.t. voltage was low."

"Then perhaps the capacitors' gone open or low value. The boosted h.t. reservoir capacitor is a very busy component, you know, and it suffers more electrical strain than most of the other paper capacitors in the set."

Smithy's last words were lost, because Dick had already rushed to the spares cupboard. He quickly found a replacement component and soldered it into circuit in place of the boost capacitor previously fitted. Hopefully, he switched on the receiver and waited for it to warm up.

The screen came to life and exhibited a comfortably bright picture with considerable vertical overscan. Dick adjusted the brilliance control and was pleased to see that the previous "blooming" effect was completely absent.

"That's cleared the e.h.t. snag, Smithy," he said, exultantly. "All I've got to do now is to get the vertical circuits working properly. Where previously I had vertical underscan I now have vertical overscan."

"There's a knob at the back for that," chuckled Smithy. "If you'd looked a bit more closely at the circuit for this set you'd have noticed that the frame oscillator gets its h.t. from the boosted h.t. line. When the boosted h.t. voltage was low someone must have turned the height up to overcome it. All you've got to do now is to turn it down again!"

Dick had the grace to look slightly abashed, and Smithy returned to his bench.

Tuner Triode

It was about half an hour later (after Dick had returned his repaired television receiver to the rack and had successfully treated another) that the muttering commenced again.

"One and Three, unlucky for some!"

Smithy paused and listened expectantly.

"Two-Oh, blind twenty!"

There it was again.

"Two and One, key of the door!"

Smithy turned quietly.

"All the Twos, dinkey-doo!"

As had occurred previously, his assistant appeared to be completely absorbed in his work.

"Two and Six, bed and breakfast!"

By looking very carefully, Smithy was just able to make out the movement of his assistant's lips.

"Three-Oh, blind thirty!"

"*House*!" yelled out Smithy.

The effect on Dick was galvanic. He suddenly lost his balance and fell sideways off his stool, the screwdriver he had held in his right hand describing a graceful parabola in the air. At the same time his feet became entangled with his soldering iron cord, causing the iron to trace out an arc of a circle whose radius was the free length of lead from Dick's legs. Smithy avoided the iron nimbly as it flashed past him, noting simultaneously that a crash from the vicinity of the sink indicated that the flying screwdriver had reduced the meagre Workshop stock of cups by one. He was, however, too late to avoid Dick's stool, which toppled neatly over on to his left foot, the seat edge falling precisely on his instep.

Smithy's roar of anguish caused Dick to look up from his prone position on the floor, whereupon he thoughtfully devoted his attention to the spectacle of the dancing Serviceman. After some moments he was distracted by a smell of burning. He got up to retrieve the soldering iron, which was by now almost lost in a cloud of vapourised linoleum. Dick quietly put his stool into its correct position by his bench, and sat down on it.

"What on earth," he asked eventually, "possessed you to do *that*?"

Smithy was, for once, completely at a loss.

"Do what?" he gasped weakly.

"Yell out at me like that. I nearly shot out of my skin!"

"It's your own fault," retorted Smithy, recovering himself. "You shouldn't have kept muttering Tombola numbers all the time."

"Tombola?"

"Housey."

"Oh, you mean *Bingo*!"

Grunting in affirmation, the Serviceman aggrievedly took off his left shoe and sock, and very carefully inspected his foot for injury. There was not the slighest evidence of abrasion, of bruising, or of any other damage whatsoever.

"I don't *think* there are any bones broken," Smithy remarked eventually, in a relieved tone of voice.

His thoughts returned to his assistant.

"Anyway, what *was* the idea of saying those numbers all the time?"

A gleam of pride came into Dick's eyes.

"I was practising," he said, grandly. "You may not know it, but I'm the new official number-caller for the Bingo Club at 'La Vie Bohème'."

"Where?"

"'La Vie Bohème'. You know, Joe's Caff."

"I thought it was 'El Picador' since he got the bamboo wallpaper up."

"He put a Formica top on the counter last week," explained Dick, "so he's changed it again. He always changes the name when he gets something new in."

Smithy absorbed this news quietly, and a thought struck him.

"What happened to the previous official number-caller?" he remarked.

Dick looked a little uncomfortable. "Well, there *was* a bit of a punch-up," he remarked. "You see, he got Number Six upside down and called Doctor's Orders during the Snowball House. Nobody's seen him since."

Smithy chuckled.

"It sounds a dicey occupation," he grinned, "and I should watch it, if I were you. Anyway, it's about time we got back to the grind."

"I suppose so," replied Dick. "Incidentally, have you seen this new t.v. set I've got here? It doesn't use a cascode in the tuner input stage at all—just a single triode."

"Ah yes," said Smithy. "That'll be the new Mullard PC97."

"You don't sound very surprised," commented Dick aggrievedly.

"I'm not," replied Smithy. "For one thing, triode input stages have been used in the States over at least the last three years."

"I didn't know that," said Dick. "Anyway, how can you get a triode to amplify at v.h.f.? Surely, it would oscillate like the clappers!"

"Not if you neutralise it," said Smithy. "Although, even then, you want to design the valve so that the capacitance between grid and anode is as low as possible. With a conventional cascode like the PCC89 the capacitance between anode and grid of the earthed-cathode triode is of the order of 1.9pF whilst that of the earthed-grid triode is approximately 4.1pF. (Fig. 2 (*a*)). The Mullard PC97 has a much lower

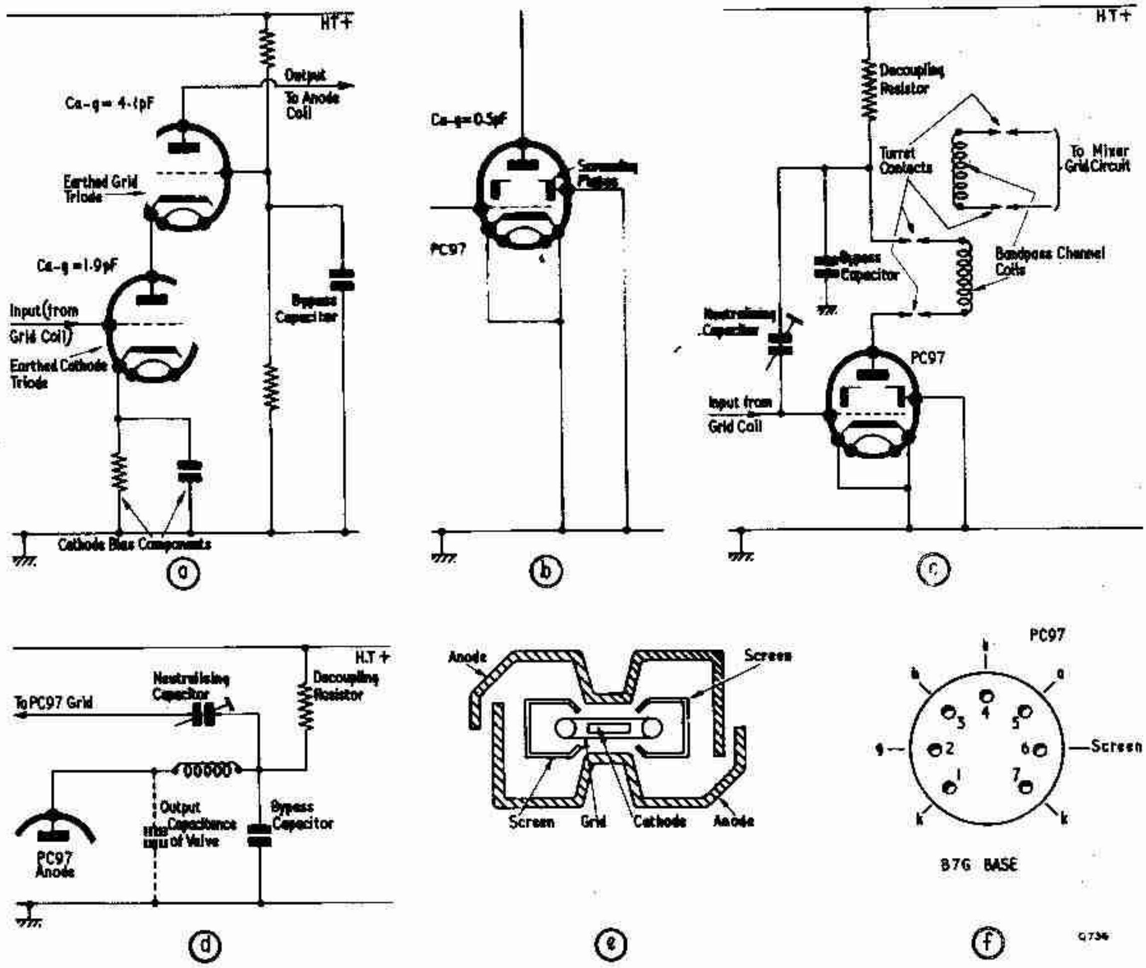


Fig. 2 (a). The basic cascode tuner unit amplifier. The grid of the upper triode is normally held at approximately half the full h.t. potential. The anode-grid capacitances quoted are those for the PCC89
(b). The anode-grid capacitance of the Mullard PC97 is maintained at the very low level of 0.5pF
(c). Neutralising the PC97 by coupling the remote end of the anode coil to the grid via a neutralising capacitor. The bypass capacitor has a relatively low value, a typical figure being 100pF. The decoupling resistor may be 1 to 5kΩ, and the neutralising capacitor have a range of some 2 to 12pF
(d). The anode circuit of the PCC97 can be represented as a pi tuned circuit
(e). The internal structure of the PC97, showing the effect of the screening plates. The special shape of the anode also contributes towards the low anode-grid capacitance
(f). The pin layout of the PC97. Two cathode pins are available

capacitance between grid and anode, this being around 0.5pF only." (Fig. 2 (*b*)).

"I see," said Dick, musingly. "Of course, with the cascode the lower, earthed-cathode, triode works into the low cathode impedance of the upper triode. This low impedance should keep voltage gain in the lower triode down, in any case, and thus help in preventing oscillation."

"That's pretty near it," said Smithy, "although you do in practice neutralise the lower triode of a cascode."

But Dick was pursuing his ideas in his own way.

"And, of course, there's no risk of feedback in the upper triode," he continued, "because the earthed grid comes between cathode and anode."

"W. G. Morley," remarked Smithy encouragingly, "could not have put it more succinctly."

"Do you really think so?" exclaimed Dick, forgetting his train of thought.

"Definitely."

"Well, I suppose I am a bit of a gen kiddy at times," said Dick modestly. "I *do* know, you know."

"I'm quite certain you do," replied Smithy soothingly. "Anyway, let's get back to the PC97. As you have just, in your masterful manner, explained, the basic make-up of the cascode assists towards stability. The very low anode-grid capacitance of the PC97 also assists towards stability, because, amongst other things, it makes neutralising requirements much less critical."

"How *do* you neutralise it, Smithy?"

"By getting a neutralising voltage," replied Smithy, "from the h.t. end of its anode coil." (Fig. 2 (*c*)).

"But that point's decoupled to chassis!" protested Dick.

"Not by all that much it isn't," said Smithy somewhat inelegantly, "because you use a decoupling capacitor having a lowish value around 100pF. This lowish value brings you back to the old pi tuned circuit (Fig. 2 (*d*)) in which the coil is really tuned by the decoupling capacitor and the output capacitance of the triode in series. The r.f. voltage on the end of the coil remote from anode will be 180° out of phase with that at the anode itself, and so you've got a nice little bit of neutralising voltage all ready for feeding back, via a capacitive trimmer, to the grid. Since the value of the decoupling capacitor is fairly low, enough r.f. appears across it for neutralising purposes."

"It's very neat, isn't it?" commented Dick. "One thing I notice is the extreme simplicity of the circuit around the triode as compared with the usual cascode arrangement."

"That's a considerable advantage of the triode," said Smithy, "and it makes tuner unit design simpler and cheaper. You will usually find, incidentally, that the bypass capacitor for the anode coil is of the feed-through variety, this being done to keep inductance in this part of the circuit down to a minimum. I should add also that, in practical tuners, adjustment of the neutralising trimmer will not normally be done by the likes of us; it will, instead, be carried out at the factory with special test equipment."

"How is the capacitance between grid and anode brought down to a value as low as 0.5pF?"

"By putting C-shaped screening plates around the two backbones of the grid," said Smithy, "that is, the two thick vertical wires which support the grid wires. (Fig. 2 (*e*)). Although these plates kill the relatively high capacitance between the backbones and the anode they still leave free access from the working areas of the grid to the anode. The screening plates come out to a separate pin which may then be connected to chassis."

"This all seems very knobby," said Dick approvingly. "Any other points?"

"Oh yes," said Smithy. "The PC97 has got a frame grid, with all the advantages that *that* confers. And the cathode comes out at two pins (Fig. 2 (*f*)), which reduces cathode lead inductance."

"Won't the gain of a single triode be lower than that of a cascode?"

"It may be a little lower," said Smithy, "but that doesn't necessarily matter, because you can pick up the lost gain very easily in the i.f. strip anyway. The limiting factor to receiver sensitivity is *noise-factor*, and the noise factor of a tuner input stage using a PC97 is of the same order as that of a cascode stage."

"Well, the PC97 certainly seems to be a welcome introduction as far as I'm concerned," commented Dick. "If only because it may simplify tuner circuits and make servicing easier!"

"I'm quite certain you're right there," commented Smithy, looking at the clock. "Anyway, it's about time we got back to work again."

Interference Limiter

Obligingly, Dick returned to his bench and peace descended on the Workshop once more.

But not for long.

"Three-Oh, blind thirty!"

Dick was taking up again where he had left off.

"All the Threes, feathers!"

Smithy started. He'd forgotten that one. A poignant and long-forgotten scene of wartime canteen Housey schools filled his mind, and he sat down dreamily for a moment.

"Five and Seven, Heinz Varieties!"

"Wait a minute," called out Smithy. "You've forgotten one."

Dick looked round.

"Which one is that?" he asked.

"Four and Five," said Smithy, "Half-Way!"

"I haven't heard that one before," admitted Dick. "I'll have to remember it for the next session. Anyway, there aren't many out-of-the-ordinary numbers after thirty-three. There's All the Sixes, clicketty-click. After which you get All the Sevens."

"I know that one," said Smithy proudly. "All the Sevens, walking sticks!"

Dick glanced at him in surprise.

"Walking sticks?"

"That's right; the sevens look like walking sticks."

Smithy's assistant pondered.

"I don't think much of that one," he pronounced eventually. "It's dead corny."

"All right then," said Smithy irritably, "What's your version?"

"All the Sevens," replied Dick firmly, "Sunset Strip!"

Smithy looked blank.

"I'm completely lost there," he remarked, after a moment. "You'll have to explain it to me."

However Dick knew that, with Smithy, such explanations tended to become involved, and he decided to change the subject.

"Let me first complete this t.v. chassis," he said, craftily. "It shouldn't take long; all that's wrong with it is weak and distorted sound."

"Oh yes," said Smithy, rising once more to the bait. "Have you checked back to the grid of the voltage amplifier triode?"

"I have," replied Dick, "and it gives a good fat hum when I touch it. So the triode and output pentode should be in pretty good trim."

"Try the sound interference limiter diode," said Smithy. "See what voltage it has on it with reference to chassis."

Obediently, Dick located the interference limiting diode (Fig. 3 (*a*)) and checked the voltage on both its anode and cathode.

"There ain't any volts," he pronounced shortly.

"Fair enough," said Smithy. "Then it's pretty certain that the resistor between h.t. positive and the diode anode has gone open. Very common fault, that."

"Yes, I've met it before," said

Dick equably. "Incidentally, I've never quite been certain how these sound interference limiter circuits work."

"It's easy enough, really," said Smithy. "Normally, the diode is held in a conducting condition by reason of the current flowing through it from the h.t. supply via the resistors above and below it. In consequence, the a.f. applied to its anode appears on its cathode, and may then be passed on to the following a.f. stages. A capacitor is connected across the lower resistor and the combined time constant, when the diode is conducting, is sufficiently low to anable the diode cathode to 'follow' the a.f. voltages on the anode."

Smithy paused to light a cigarette.

"Now you will note," he continued, "that the sound detector is so connected that the rectified i.f. signal at the top of the detector load is negative-going. If an interference pulse is applied to the sound detector, the latter causes this to be rectified to a sharp-sided negative-going pulse. This pulse is applied to the anode of the noise limiter diode and makes it go negative, thereby causing the diode to stop conducting. The cathode of the diode cannot go negative as quickly as the anode during the pulse, because of the capacitor across the lower resistor. Therefore, no a.f. at all is applied to the a.f. stages for most of the duration of the pulse and the latter is, in consequence, limited."

"Very smart," remarked Dick. "And quite a simple little circuit, too."

"It's an effective one as well," said Smithy, "and you'll find it used in a very high percentage of the television receivers you service, the diode being either a thermionic valve or a crystal diode according to make and model. The resistors in series with the diode require high values, and these may lie between 0.5 and 10MΩ. It's a common fault for one of these resistors to go open, whereupon the sound becomes weak and distorted, as occurred with your set. Most frequently, it's the top resistor which goes faulty because this normally has the higher value of the two."

"I knew it was the top resistor in my case," said Dick thoughtfully, "since there was no voltage on the diode. However, if it had been the bottom one I might have been led up the garden, because my meter would still have given me a voltage reading on the diode which was lower than the h.t. voltage. The drop would be caused by the meter current drawn through the top resistor, but it might well have made me think the circuit was O.K."

"That's true enough," said Smithy, "and it might be advisable to finally check between the h.t. positive line and the diode if you wanted to be absolutely sure. In practice, however, you would almost certainly find that the act of connecting the meter across the open-circuit lower resistor (Fig. 3 (*b*)) would bring back the sound at full, or nearly full, level, because the meter would draw current through the diode once more. The fact that sound returned would tell you that there was something very queer with the lower resistor."

"You're assuming the use of a moving-coil meter here, aren't you?"

"Oh yes," said the serviceman, "A very high resistance valve voltmeter probably wouldn't, for instance, draw enough current through the diode to make it work properly. At the same time, such a meter would tell you that the diode was very nearly at h.t. potential, so you would know where the fault was anyway."

"Yes, of course," said Dick. "I hadn't thought of that."

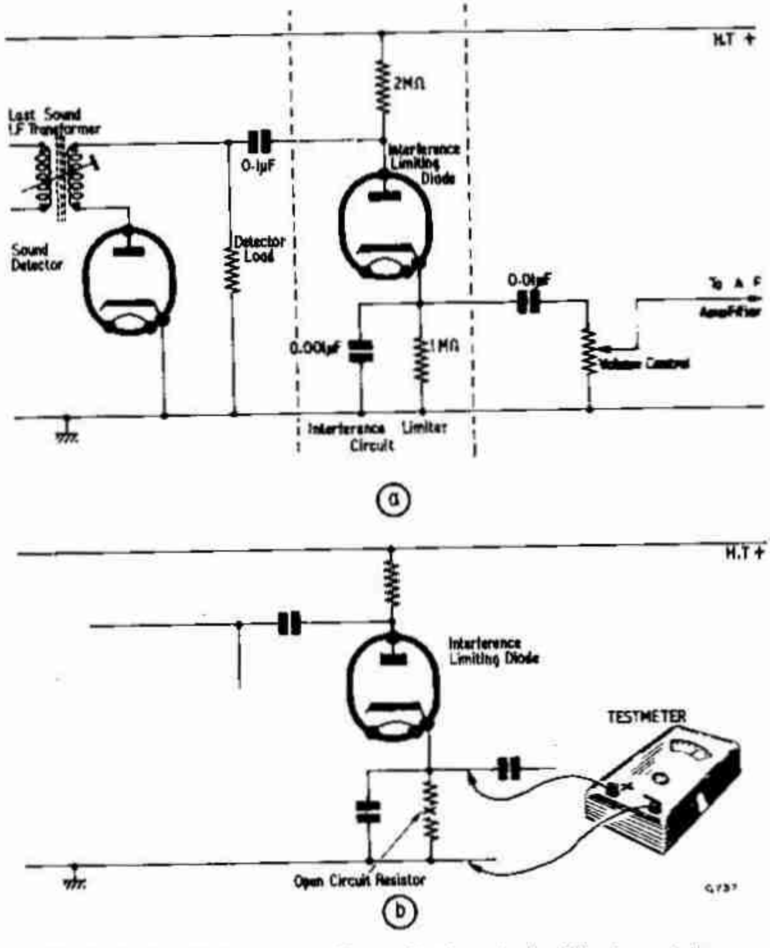


Fig. 3 (a). A typical sound interference limiting circuit with representative values where applicable. Thermionic diodes are shown for reasons of clarity. The sound detector circuit is meant to illustrate the polarity of the rectified signal only, and omits i.f. filter components after the diode (b). If the lower resistor of the pair in series with the interference limiting diode is open-circuit, a moving coil testmeter may not indicate this fact directly. However, applying the testmeter will cause current to flow through the diode and sound to be reproduced by the receiver at normal, or nearly normal, level

The Last Word

He looked round the Workshop, noting the large quantity of successfully repaired receivers stored neatly on the racks.

"Do you know, Smithy," he continued, "I think we've done jolly well today. I reckon we can describe ourselves as representing the apex of this establishment!"

"Apex of the establishment?" said Smithy, puzzled. "I don't get it."

"What I mean," grinned Dick, "is that we're Nine-Oh, Top of the Shop!"

Acknowledgement Fig. 2(e) is taken from *New Product Information—PC97* published by Mullard Limited.

INCREDUCTORS

by

J. B. DANCE, M.Sc.

THE INCREDUCTOR IS A NAME GIVEN TO A COMPARAtively new type of inductance designed in America, the inductance value of which can be altered by changing the magnitude of a direct current passing through one of the windings. Increductors are small devices, comparable in size with the smallest a.f. transformers and are manufactured by C.G.S. laboratories, Inc. of Wilton, Connecticut.

One type of increductor consists of two windings on a toroidal ferrite core. One of these windings is used in the signal circuit and the other is the control winding. Direct current is passed through the latter and produces magnetic flux in the toroidal core, thereby changing the incremental permeability of the material of the core. The inductance of the windings will also be altered, as it is proportional to the incremental permeability of the core material.

Increductors have obvious uses in sweep circuits. For example, if a sawtooth current waveform is passed through the control winding of an increductor, the signal winding of which forms part of the resonant circuit of an oscillator, the oscillator frequency can be made to sweep repeatedly over quite a wide frequency range. Thus the increductor is a very useful component in panoramic work.

A third winding known as the bias winding may be used in addition to the signal and control windings; it enables a desired mean value of inductance to be obtained around which the instantaneous value can be varied by passing an alternating current through the control winding. Increductors with three windings are also useful when the signal circuit is to be controlled by two independent quantities. It is possible, further, to obtain the required control of inductance by moving the pole of a permanent magnet towards the toroidal core.

Inductance Range

The inductance of the signal winding when no control current flows through the control winding is known as the starting inductance. Practical increductors with starting inductances varying from about 0.01 mH to 10 H have been made. These components can be used at frequencies varying from d.c. to about 500 Mc/s.

The "inductance change ratio" is an important parameter in increductor design. It is the ratio of the maximum to minimum signal winding inductance as the direct current in the control winding increases from zero until the core is saturated. Maximum to minimum inductance ratios of 400 to 1 have been obtained using increductors for audio frequency work, whilst ratios of 3 to 1 have been obtained in components suitable for use at 300 Mc/s.

Q Factor

The Q factor of increductors is important. At low audio frequencies the Q may be 80 to 120, but rises to about 250 with frequency, eventually dropping to about 5 at 500 Mc/s. If the signal input is large, the Q may be reduced below the value for a small signal owing to the flux produced in the core by the current flowing in the signal winding.

The control power required varies from about 1/100 watt to 10 watts. The increductor control winding should preferably be fed from a "constant current source", as it is a current controlled device.

Control currents can be used to change the inductance of certain types from 100 mH to 100 H, whilst some types can handle 100 watts at 150 Mc/s. The temperature coefficient of inductance is usually between 0.01 and 0.02% per degree Centigrade. The signal windings have a capacitance of about 50 to 100 pF at audio frequencies and about 1 pF at v.h.f. response speeds in the microsecond region have been obtained.

The control winding resistance may be 100Ω to 2kΩ for control currents of about 10 to 200 mA, but it is always possible to reduce the number of turns and increase the control current providing that the number of ampere turns is maintained.

A typical American type is being produced under the type number 6XBK4 at $13.60 (about £5) and can be used from 3.7 to 216 Mc/s.

One can only wonder whether, in the future, radio receivers (or even transmitters) will be tuned by means of a potentiometer, the resistance of which controls the inductance of increductors in the tuned circuits.