The Editor does not necessarily endorse opinions expressed by his correspondents

Electronic Organs

AS one who has made a modest contribution to the literature on this subject, I have no intention of commenting on the electrical design of Mr. Towers' organ; but I feel that he might have been a little more expansive on the constructional side. As president of the Electronic Organ Constructors' Society I have probably seen more of the difficulties confronting the amateur than most people, and I would draw attention to the need for ensuring that there is ample movement of the keytails to operate the signal contacts, since these must make firm contact with the busbar when off and move sufficiently to give some wiping action to the gold wires when on. Some keyboards may not have enough leverage so be careful when buying this item.

In the correspondence columns in the August issue Mr. Palmer mentions the possibility of using the expression "electrophonic"; this was in fact proposed by the council of the Royal Musical Association many years ago, but found no favour. Mr. Kirk mentions in the same issue the use of rotating Leslie speakers. This method is in wide use as a means of dispersing the sound which, in a pipe organ, comes from a multiplicity of point sources covering a large area. It was originated by the Allen Company and is used in Mr. Bourn's organs under the name Rotophon. And since Mr. Bourn mentions in his August letter tuning, and Mr. Towers considers it a relatively simple matter, I append a table which shows the way to set about it.

Starting with a tuning fork for C_{25}, this will give 261.62 c/s. Then proceed as follows, remembering that the beats are all produced by *flattening* the note, not sharpening it. A little tedious, but well worth the trouble as I can testify that Mr. Towers' oscillators are very stable.

Hold notes	Musical interval	Approx. beats in 10 seconds	Remarks
C_{25} & G_{32}	Fifth Up	9	Tune G to zero beat then flatten till correct
G_{32} & D_{27}	Fourth down	13	Tune D to zero-beat then flatten
D_{27} & A_{34}	Fifth up	10	A as above
A_{34} & E_{29}	Fourth down	15	E as above
E_{29} & B_{36}	Fifth up	11	B as above
B_{36} & $F\#_{31}$	Fourth down	17	F# as above
$F\#_{31}$ & $C\#_{26}$	Fourth down	13	C# as above
$C\#_{26}$ & $G\#_{33}$	Fifth up	9	G# as above
$G\#_{33}$ & $D\#_{28}$	Fourth down	14	D# as above
$D\#_{28}$ & $A\#_{35}$	Fifth up	11	A# as above
$A\#_{35}$ & F_{30}	Fourth down	16	F as above

A quick check can be made on the above by holding C_{25} and F_{30}; the C should be flat to the F by approximately 12 beats in 10 seconds. If it is too fast, the intervals have been tuned to too slow a beat.

The above bears out Mr. Bourn's statements about the necessary departure from perfect intervals and is a fact. The maximum "out of tune" is required in a small organ having only one set of generators and only one waveform basically.

In conclusion, I would like to point out that the firm of Ernest Holt mentioned by Mr. Towers has been incorporated into that of Kimber-Allen Ltd., of London Road, Swanley, Kent, from whom all previous Holt supplies can be obtained.

Nottingham. ALAN DOUGLAS

MR. BOURN suggests in his August letter that tempered scale distortion, consisting of the approximate equalizing of beat frequencies produced by fourths and fifths, make a distinctive key character when changing key (disregarding the actual change of pitch). I feel that there may be some confusion here between the somewhat bizarre effect experienced when changing key on a badly tuned key board instrument, and the phenomenon known as key colour or character.

The beats heard when sounding a perfect fourth must be quicker than those from a fifth otherwise the object of equal temperament would be lost. If the tuning process is not performed accurately the errors incurred are cumulative, and as such, a large error would be realized at the end of the tuning cycle. In other words, using middle C as a starting point with G above it forming the initial interval (a fifth) the tuner, proceeding through the scale finishes with C and F (a fourth). Obviously any errors "picked up" whilst "laying" the scale would result in a rather gruesome fourth, unless the tuning errors were self cancelling, in which case the scale would be internally distorted (which is equally objectionable). An organ tuner takes considerable care when fine tuning to "prove" each note of a stop by sounding alternately the fourth, fifth, and octave below the note. On a powerful stop the beats are very prominent and one can compare the beat frequency produced by the fourth with that produced by the fifth. The equally tempered scale must, therefore, be a geometric progression with a common ratio of $\sqrt[12]{2}$, and to prove it multiply 261 c/s (middle C) by $(\sqrt[12]{2})^9$ and we get 440 c/s (middle A)!

Axminster, Devon. B. W. DANIELS

"The Engineer Shortage"

EVER since the shortage of candidates for the profession of engineering aroused comment—for example in the words of your August Editorial: "The root cause of the training problem is that engineering in general does not appear an attractive occupation to boys at school considering their future careers"*—I have been puzzling over it. For when I was a student, more than 40 years ago, the reverse was true. "Pure scientists" were regarded with something approaching pity or contempt, as concerned

* The motivations affecting choice between the "arts" side and the science and technology side in the schools are being studied by the Committee on Manpower Resources for Science and Technology (which includes several representatives of the electronics and electrical industries) and also by a Working Group of the Council for Scientific Policy. In the February 1966 interim report of the last-mentioned Group, "Enquiry into the Flow of Candidates in Science and Technology into Higher Education" (Cmnd. 2893, H.M.S.O., 3s) there is an extensive bibliography and a list of research projects under the heading "Factors influencing choice" in the Appendices.—ED.

only with academic abstractions, whereas it was engineering that had the glamour, with its control of power, machines, and especially the mysteries of electricity—all the things to appeal to boys. What has happened to reverse this?

I confess I am not at all sure. One reason given is that schoolmasters—and, even more, schoolmistresses—are predominantly arts biased, and of those who teach science very few have much real knowledge or understanding of engineering. Do school leavers pay so much more regard for their teachers' advice nowadays than they used to? And are their outlooks more bounded by school? I should not have thought so. There are far more sources of information about engineering than there were in 1920.

Do school leavers know about the poor prospects in this country for engineers or even for pure scientists, and choose arts instead? Then surely, if they could so easily be deflected, they would never have made good engineers.

I agree that the introduction of "Chartered Engineer" cuts little ice; any corporate member of the I.E.E. has been entitled for many years past to call himself a Chartered Electrical Engineer if he wanted to.

There does seem to be a stronger case for supposing that there is general ignorance in this country of what engineering is; it seems to be almost a matter for pride among the classical scholars of the establishment. This would explain the attitude of business leaders you describe, and journalists and broadcasters habitually giving credit for engineering accomplishments to "scientists" rather than to engineers. The latter have thereby become associated in the public mind with strikes, wage claims and left-wing politics. This is presumably why, when someone wants to introduce me favourably he usually describes me as a scientist, using the word no doubt as a euphemism to spare me (wholly imaginary) embarrassment.

Is there a cure? No short cut, it would seem. But the process of enlightenment could be accelerated if influential engineers with some gift for modern means of education felt the need sufficiently to devote time and effort to it. The presentation of the case *must* be authentic in every detail, with no flavour of cheap publicity or "talking down." The I.E.E. film "The Inquiring Mind" was good. But there needs to be much more.

Bromley, Kent. M. G. SCROGGIE

Constant Current Circuit

CONGRATULATIONS to Mr. G. Watson on an ingenious and useful constant current supply (August issue). There is a scarcity of published information on such circuits, the only one I can recall being by the same author in *Electronics*, July 6, 1962, p.50.

An alternative approach to the problem is to use

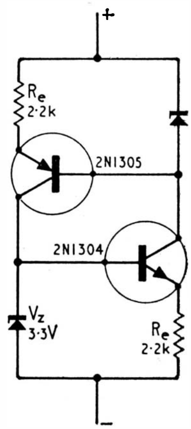
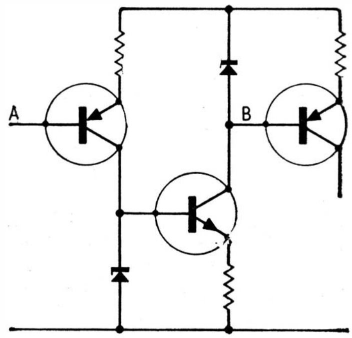


Fig. 1.



ig. 2.

positive feedback in a complementary circuit (Fig. 1). It is fascinating to note the different ways in which circuit designers describe this arrangement when first encountering it. To a "digital" man it is a "complementary bistable with catching Zeners" while an "analogue" man will be more likely to see it simplified as in Fig. 2.

This is how I found the circuit when trying to produce a Zener reference of extreme stability. In an alternating series of constant current and constant voltage sources, each one biases the following so that each is working under conditions progressively approaching the ideal. Breaking at points A, B and joining these gives Fig. 1.

The total current for the symmetrical case is approximately

$$2\ \frac{V_z - V_{be}}{R_e}$$

and temperature stability approaches the ideal when

$$\frac{dV_z}{dT} = \frac{dV_{be}}{dT}$$

As a bistable the circuit can rest in the offset though leakage currents normally ensure switch on. Alternatively a high resistance between the bases provides a starting current. Typical values for low currents are indicated on Fig. 1, but variations on this theme have provided the writer with currents from microamps to amps.

Paisley College of Technology, Renfrewshire. PETER WILLIAMS

LOUDSPEAKER ENCLOSURES

Dr. A. R. Bailey is unable to supply any more long-fibre wool to readers building the loudspeaker enclosure he described in the October, 1965, issue. He says "bonded acetate fibre wadding or fibreglass seem to be the most readily available substitutes. One correspondent has tried wood-wool with success but I have not tried all the alternatives that have been suggested".

Colour Television

I FEEL I must answer the immoderately phrased and biased comment re BBC-2 from Mr. Cox in the July issue.

I am told by a large dealer that "at least" 5% have now got u.h.f. television receivers and that it is just a matter of waiting for receivers to wear out before the audience will "leap."

It has been quoted in the American press that the number of viewers of colour television "does not exceed 10%". Is 5% after a few months a flop, but 10% after 10-odd years a success?

Come now, Mr. Cox. Do you really imagine people are going to queue up for colour sets, even if it is sent out on all channels? Although I am a regular viewer of BBC-2, the prospect of being able to convert to colour at the price of a mini-car does not attract me!

Peacehaven, Sussex. RONALD G. YOUNG

"The Diode-transistor Pump"

I WAS surprised to read in the article "The Diode-transistor Pump" by D. E. O'N. Waddington (*W.W.*, July, '66) that the simple pump frequency discriminator when applied to transistor circuits cannot give a sufficiently linear output and I wonder whether the reason for this pessimistic view might lie in the author's approach to the subject. Having first described the pump integrator, the author considers the case when a resistor is connected across the integrating capacitor (Fig. 1) and then quotes

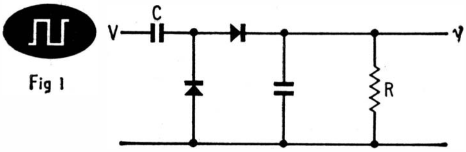


Fig 1

the characteristic of the frequency-to-voltage converter so formed:

$$v=\frac{VCR}{T\left[1+\frac{CR}{T}\right]}$$

This expression shows that the output per volt of input step is very nearly equal to the fractional deviation from linearity and the designer must therefore trade one attribute for the other on these terms or resort to one of the additional linearizing devices described by Mr. Waddington. Incidentally, I was sorry to see the author drop the first of these devices, the emitter-follower bootstrap, in favour of the less elegant isolating amplifier. However, there is no real need to bootstrap or isolate the integrating capacitor since the need for this component does not arise.

Surely the best approach to design stems from the basic requirement to sense the mean level of a train of

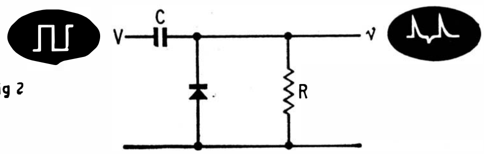


Fig 2

constant area pulses. A good starting point is the differentiator and clamp (Fig. 2). The mean output is:

$$v=\frac{VCR}{T}\left[1-e^{-\frac{T}{2CR}}\right]$$

The second term in the bracket is the fractional deviation from linearity due to tail clipping and the ratio $\frac{T}{CR}$ must therefore be chosen to suit the application. Output has to be traded for linearity, as before, but a good compromise is now easier to achieve. Several published designs apply the basic principle.[1,2,3.]

Although the simple discriminator just described will give good linearity at an output adequate for most applications, a no-compromise solution can be achieved by generating a pulse whose area is absolutely independent of signal frequency. A trigger pulse derived from the limiter can be used to drive a waveform generator of the monostable class to give a train of rectangular pulses at the output. Such discriminators have been built[2, 4] but I would question whether the increased complexity is worth while.

A much simpler constant-area generator has been

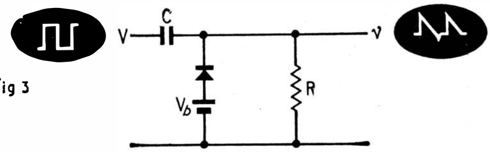


Fig 3

developed by returning the anode of the differentiator clamp to a positive bias V_b (Fig. 3). The exponential tail of the output pulse being caught at V_b is thereby terminated at a point in time independent of signal period. The mean output is:

$$v=\frac{VCR}{T}\left[1-e^{-1}\left(1+\frac{V_b}{V}\right)\right]$$

Putting $\frac{V_b}{V+V_b}=e^{-1}, v\approx 0{\cdot}42\frac{VCR}{T}$ where the limiting value for $\frac{CR}{T}$ is 0·5 (assuming unity mark-space ratio). As V_b is increased, the waveform approaches a linear sawtooth and the output at top frequency becomes $\bar{v}=0{\cdot}25V$ (very nearly). The technique has been applied to both f.m. receiver and frequency meter applications with perfectly satisfactory results.

I hope this brief account might help a little to restore the reputation of this thing they call a pump (but which neither integrates nor counts) and I wonder whether dropping the jargon might help the pulse-rate discriminator student even more.

Lee-on-the-Solent, Hants. A. S. CHESTER

1. Scroggie, "Unconventional F.M. Receiver," *W.W.* April and May, 1956.
2. Baxendall, correspondence. *W.W.*, September & November, 1964.
3. "*Wireless World* Audio Signal Generator," *W.W.*, November, 1963.
4. "*Wireless World* Transistor F.M. Tuner," *W.W.*, July, 1964.

HAVING read Mr. Waddington's article with great interest, I feel that I ought to make some comments on the subject, as I (independently) developed a similar circuit in 1965. The development resulted in the circuit in Fig. 1. The first attempt was to use it for adding successive amplitudes of a semi-periodic voltage (Fig. 2), but I also realized its usefulness as a staircase generator or a frequency divider (Fig. 3). In Fig. 1 the circuit is shown as a frequency divider with a unijunction transistor. As I worked with small pulses and a division by about 20, stabilization of the triggering of transistor Tr2 was found necessary. This is made with the capacitor C_1, driving the first base of Tr2 opposite to its emitter voltage for

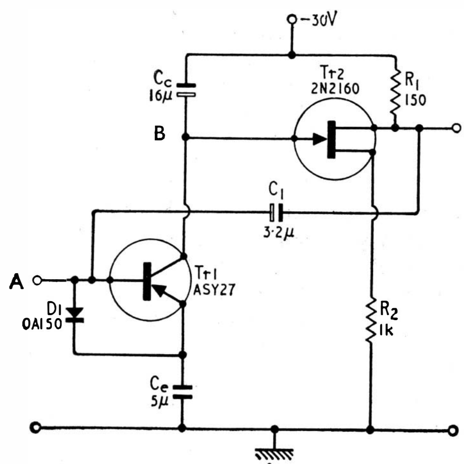


Fig. 1.

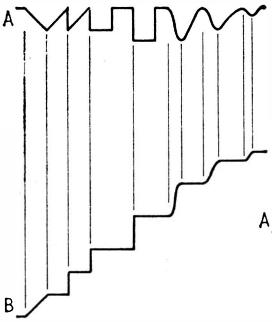


Fig. 2. Circuit adding successive amplitudes.

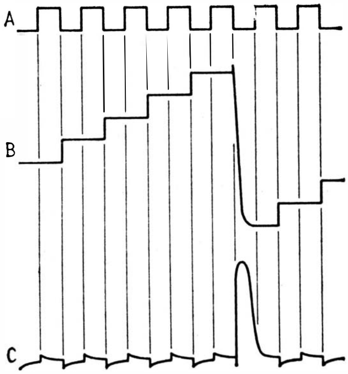


Fig. 3. Circuit used as staircase generator or frequency divider.

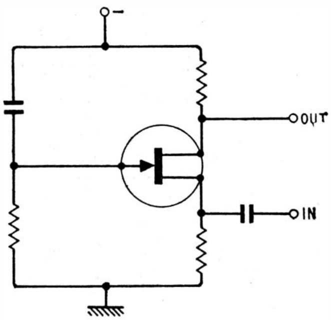


Fig. 4.

each input pulse. Careful design, increased swing in the voltage at point B (determined by the unijunction circuit) and some kind of temperature stabilization would probably allow a stable division by about 30. However, the unijunction transistor frequency divider in Fig. 4 shows, experimentally, a better stability.

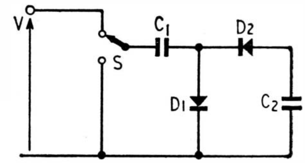
JAN-ERIK SIGDELL
Division of Applied Electronics,
Chalmers University of Technology,
Gothenburg, Sweden.

MAY I make the following observations on the interesting article on diode pump circuits by Mr. D. E. O'N. Waddington in your July issue. Fig. 1 reproduces the simple diode pump circuit, which is the starting point of Mr. Waddington's article.

After every "switch on," the voltage step available to charge the capacitors is not V as stated by Mr. Waddington but $V - V_{D1} - V_{D2}$ where V_D is the forward voltage drop of the diodes. This is also true of the two modified circuits described by Mr. Waddington. In the circuit above capacitor C_2 charges asymptotically to $V - V_{D1} - V_{D2}$ and not to V. And since V_D changes with temperature, the operation of the circuit is somewhat temperature dependent unless V is much larger than $V_{D1} + V_{D2}$ (which is not always easy to achieve).

Fig. 2 shows a slightly modified circuit, which uses an additional supply rail but largely overcomes the temperature dependence of Fig. 1. The voltage step

Fig. 1.



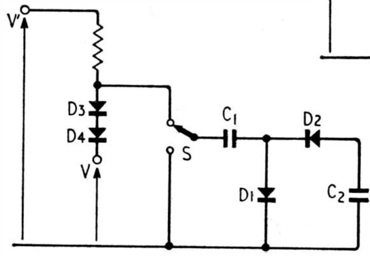


Fig. 2.

now available is $V - V_{D1} - V_{D2} + V_{D3} + V_{D4}$. Even if the actual forward drops of the diodes do not exactly cancel out, their variations due to temperature nearly do.

I have found in practice, using silicon planar diodes, that the forward voltage drops of D3 and D4 almost perfectly compensate for the forward drops of D1 and D2.

Basildon, Essex. S. GHOSH

The author replies:—

I am sorry that my article caused Mr. Chester pain, particularly as the offending sentence contained a misprint. The second sentence originally read, "With thermionic valve circuits it has, generally speaking, proved adequate but with the lower supply voltages usual with transistor circuits, it no longer supplies a *sufficient* linear output." Thus, Mr. Chester is perfectly correct in his contention that the diode pump can provide a very linear output provided that the output is limited to less than 1/10th of the input pulse amplitude. However, with the diode-transistor pump described, the interdependence of the input and output amplitudes is no longer a restriction and it is possible, by suitable design, to obtain a greater output voltage than the input pulse amplitude and still to maintain linearity.

As Mr. Sigdell's letter is concerned mainly with an extension of the technique which I suggested using the unijunction transistor, no comment is necessary. However, the use of forward feed to make the trigger action more positive is interesting.

Regarding Mr. Ghosh's observations, in order to keep the analysis of the action of the circuit simple, I omitted the forward voltage drop of the diodes as, indeed, in Fig. 3 I omitted the effect of beta and in Fig. 4 the effect of alpha. In most applications the temperature dependence of the circuit is not important as the variation in diode voltage is only 2mV/°C. However, Mr. Ghosh's solution to the temperature problem is well worth remembering.

The input waveform in Fig. 8 was inadvertently shown as having half the correct frequency. It should be as shown below.