RADIOTRONICS

4

Vol. 29, No. 4 April, 1964

IN THIS ISSUE

AN AWV PUBLICATION

REGISTERED IN AUSTRALIA FOR TRANSMISSION BY POST AS A PERIODICAL.

LOW-NOISE UHF TRANSISTOR AMPLIFIER

By W. A. Pond (WA2JXO), P. E. Kolk, and T. J. Robe

RCA Electronic Components and Devices

The recently announced 2N2857 npn silicon transistor opens new possibilities in the construction of extremely low-noise UHF transistor receivers and receivers and converters for mobile and fixed-station operation.

The 2N2857 utilizes a new miniature electrode structure which provides a very low noise figure (4.5 db max at 450 megacycles), high power dissipation capability (200 milliwatts at 25° C free air temperature and 300 milliwatts at 25° C case temperature), very low leakage at high temperatures, and very small variation in noise figure with temperature (±0.5 db from –40° to +100° C). Under typical operating conditions in 30- or 60-megacycle intermediate-frequency amplifier applications ($V_{CC} = 6$ volts, $I_C = 1$ milliampere, and $R_G = 400$ ohms), the noise figure of the 2N2857 can be as low as 2 db. A 15-db gain and 7.5-db noise figure can be realized in 450-to-30 megacycle converter service.

Designed for UHF, specified for UHF, and 100%-tested for UHF, the 2N2857 can be operated as a common-base oscillator to 1,500 megacycles, and as an amplifier to 1,000 megacycles.

Among the characteristics of the 2N2857 at 450 megacycles are its unneutralized wide-band (approximately 50-megacycle) power gain of 8 db, its neutralized narrow-band (approximately 8-megacycle) power gain of 15 db, and its low noise figure of 4.0 db.

Originally, a single unneutralized common-emitter rf stage was the main unit of demonstration. In addition, a single-stage self-oscillating converter using the 2N2857 was utilized to facilitate detection by a commercial communications receiver at 29 megacycles.

Figure 1 shows the two basic chassis connected. The single-stage amplifier chassis is at the left, and the converter is in the small chassis at the right. A bottom view of these chassis is shown in Figure 2. The tuning inductors in the amplifier stage are lengths of thin copper ribbon curved to approximate a semicircle. These strips, which represent approximately 20 nanohenries of inductance, are relatively high-Q coils. This condition does not mean that the over-all Q of the circuit is high, but only that there are negligible losses in these elements. In fact, in view of the level of reactance chosen (20 nanohenries), and the low parallel input and output resistance of the device at 450 megacycles, the loaded Q of the input tuning circuit is extremely low and that of the output circuit moderate. Accordingly, the input tuning should be used primarily for match-

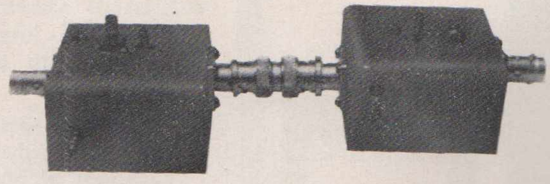


Fig. 1—Authors' Low-noise UHF transistor amplifier showing two basic chassis (single-stage amplifier, left, and converter, right) as combined unit.

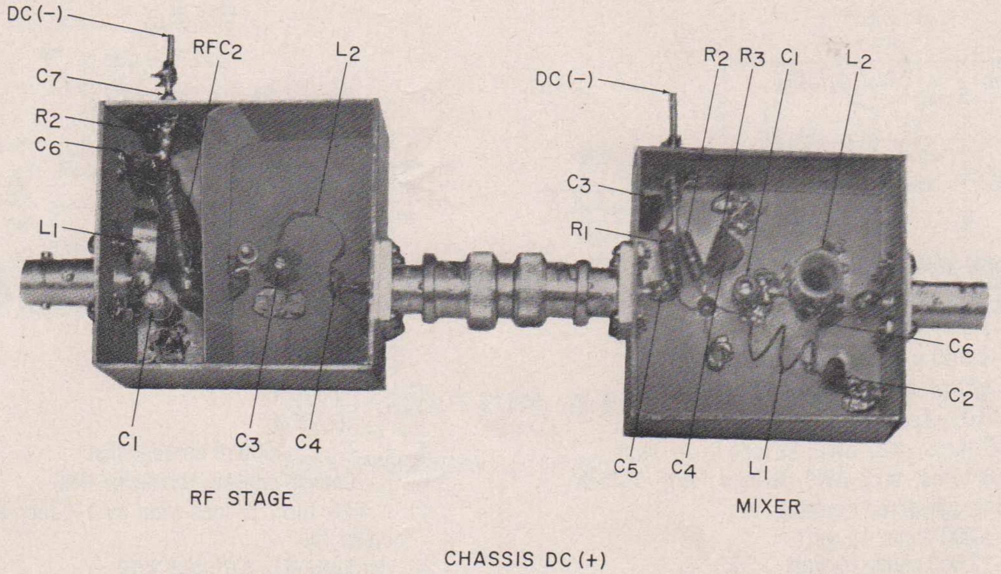


Fig. 2—Bottom view of single-stage amplifier chassis, left, and converter chassis right.

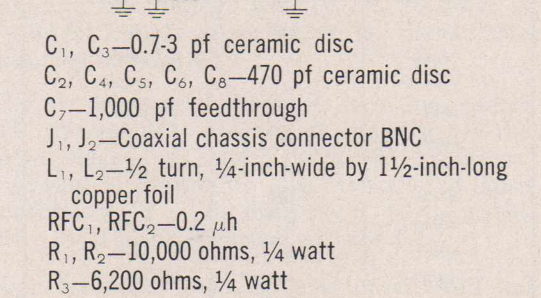
ing the device to the antenna or source impedance The output tuning of the stage sets the selectivity by choice of appropriate reactance level, i.e., the reactance of the parallel tuning capacitance or inductance at resonance.

Figure 3 shows the single-stage amplifier, which uses a pi-matching network at the input consisting of the parallel tuning capacitor, the series inductance copper strip, L_1, and the parallel input capacitance of the transistor. The output is simply a tuned tank circuit having the inductance tapped to match the parallel input resistance of the following stage. An alternate method of matching to the next stage is to place a small variable capacitor (0.8-8 picofarads) in series from the collector side of the tank to the next stage. It should be realized that this approach, in effect, places additional capacitance in parallel with the tank inductance and, consequently, may require a smaller value of inductance, L_2, to resonate at the desired frequency. The parallel input capacitance of the converter is tuned out as part of the over-all tank capacitance of the previous stage.

Figure 4 shows the self-oscillating mixer employing the 2N2857. This circuit oscillates because of the capacitance feedback within the transistor, and is frequency-dependent on the L_1-C_1 tank circuit. C_2 has small reactance compared to L_1 at the radio frequency, but resonates with L_2 at the intermediate frequency.

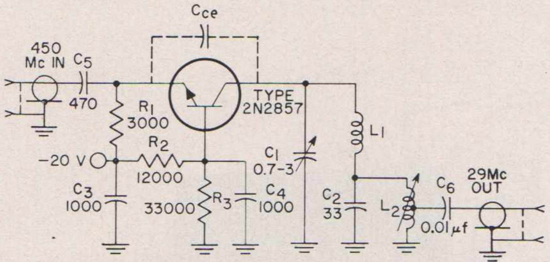
UHF gain up to 19 db can be obtained from the 2N2857 in the 450 megacycle neutralized circuit shown in Figure 5—if the neutralizing capacitance, C_4, is carefully adjusted. The feedback coupling loop, L_3, is a piece of No. 12 AWG copper wire running parallel to and approximately $\frac{1}{4}$ inch from L_2. One end of L_3 is connected to the grounded shield; the other end passes through a hole in the shield to the neutralizing capacitor. It is important that the ground end of L_3 be placed adjacent to the signal end of L_2 to achieve the phase reversal necessary for neutralization.

All of the circuits described have standard mica-filled phenolic transistor sockets designed to accommodate leads arranged in 0.1-inch pin circle. A suitable socket is the Elco 3307 or



C_1, C_3—0.7-3 pf ceramic disc
C_2, C_4, C_5, C_6, C_8—470 pf ceramic disc
C_7—1,000 pf feedthrough
J_1, J_2—Coaxial chassis connector BNC
L_1, L_2—½ turn, ¼-inch-wide by 1½-inch-long copper foil
RFC_1, RFC_2—0.2 μh
R_1, R_2—10,000 ohms, ¼ watt
R_3—6,200 ohms, ¼ watt

Fig. 3—Schematic diagram and parts list of unneutralized rf stage.



C_1—0.7-3 pf ceramic disc
C_2—33 pf ceramic disc
C_3—1,000 pf feedthrough
C_4—1,000 pf ceramic disc
C_5—470 pf ceramic disc
C_6—0.01 μf ceramic disc
L_1—2 turns, #22 AWG, 1/4 inch by 5/8 inch
L_2—8 turns, #22 AWG, 5/32-inch form, 1/2-inch long, powdered iron slug
R_1—3,000 ohms, 1/2 watt
R_2—12,000 ohms, 1/2 watt
R_3—33,000 ohms, 1/2 watt

Fig. 4—Schematic diagram and parts list of self-oscillating mixer.

equivalent. The transistor leads should be cut to about 1/4 inch for best operation. All components connected to the transistor should be mounted as close as possible to the socket to reduce the effects of stray reactances.

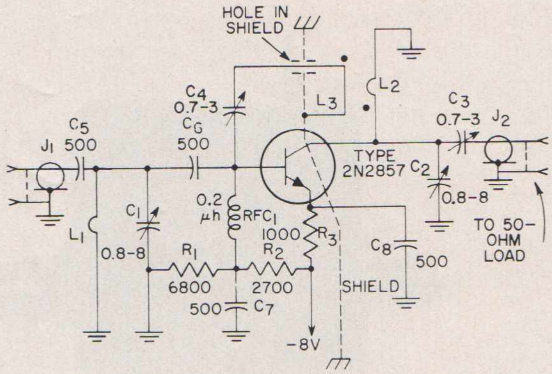
(With acknowledgements to RCA)

! ATTENTION HAMS !

Interested in a handy guide of metric-system terminology? You may find the following table a useful addition to your literature reference file.

Metric System Unit Prefixes

Prefix	Abbreviation	Meaning
pico-	p	10^{-12}
nano-	n	10^{-9}
micro-	μ	10^{-6}
milli-	m	10^{-3}
centi-	c	10^{-2}
deci-	d	10^{-1}
deca-	da	10
hecto-	h	10^{2}
kilo-	k	10^{3}
mega-	M	10^{6}
giga-	G	10^{9}
tera-	T	10^{12}



C_1, C_2—0.8-8 pf
C_3, C_4—0.7-3 pf
C_5, C_6, C_7, C_8—500 pf ceramic disc
J_1, J_2—Coaxial chassis connector BNC
L_1, L_2—1/2 turn, 1/4-inch-wide by 1 1/2-inch-long copper foil
L_3—1/2-turn, #12 AWG Bus wire
RFC_1—0.2 μh phenolic core
R_1—6,800 ohms, 1/4 watt
R_2—2,700 ohms, 1/4 watt
R_3—1,000 ohms, 1/4 watt

Neutralization Procedure:

1. Connect a 450-megacycle signal generator (with Z_{out}=50 ohms) to the input terminals of the amplifier.
2. Connect a 50-ohm rf voltmeter across the output terminals of the amplifier.
3. Apply the supply voltage (−8 volts) and, with the signal generator adjusted for 10-millivolt output, tune C_1, C_2 and C_3 for maximum output.
4. Interchange the connections to the signal generator and the output indicator.
5. With sufficient signal applied to the output terminals of the amplifier, adjust C_4 for a minimum indication at the input.
6. Repeat steps 1, 2, and 3 to determine whether re-tuning is necessary.

Fig. 5—Schematic diagram and parts list of neutralized rf stage.

2N2857 NPN Silicon Transistor
Electrical Specifications

BV_{CBO}	at $I_C = 1\,\mu a$	30 volts min.
BV_{CEO}	at $I_C = 3\,ma$	15 volts min.
BV_{EBO}	at $I_E = 10\,\mu a$	2.5 volts min.
I_{CBO}	at $V_{CB} = 15$ volts	0.01 μa max.
h_{FE}	at $V_{CE} = 1$ volt, $I_C = 3$ ma	30—150
h_{fe}	at $V_{CE} = 6$ volts, $I_C = 5$ ma, f = 100 Mc	10—19
G_{pe} (neut. power gain)	at $V_{CE} = 6$ volts, $I_C = 1.5$ ma, f = 450 Mc	12.5—19 db
N.F. (Noise Figure)	at $V_{CE} = 6$ volts, $I_C = 1.5$ ma f = 450 Mc	4.5 db max.

WIDEBAND TRANSISTOR PROBE

By G. SHENTON, B.E.

AWV Semiconductor Division

Summary

This note describes a high-impedance probe which uses commercially-available transistors. The probe was designed for use with a laboratory oscilloscope, to increase the sensitivity of the oscilloscope by a factor of ten.

Design

High-impedance probes for use with oscilloscopes may be classified into two basic types, passive and active. In the case of the passive type of probe, the signal undergoes some degree of attenuation, and this may be a disadvantage. For the observation of low-level signals, the active probe has the advantage of maintaining or amplifying the signal level. This is an important factor from the point of view of final signal-to-noise ratio and oscilloscope sensitivity. The compactness of semiconductor circuitry makes the use of transistors ideally suited for such an application.

The probe described here is a video amplifier, the design of which is based on an approach developed by Cherry and Hooper[1,2]. The main feature of this approach is the cascading of non-interacting single stage feedback elements, whose transfer characteristic is well defined over the useful frequency range of the transistors. Such an amplifier is well stabilised against parameter variations, and a near-maximum gain-bandwidth product may be realized.

A high input impedance may be obtained by the use of a voltage feedback pair. Although this may lead to a slightly under-damped transient response, it is possible to obtain a reasonable performance by ensuring that the loop gain is not too high.

Circuit Description

The probe described here is divided mechanically into two components. One is the probe itself, and the other is the battery compartment. The unit is so arranged that the battery compartment is used adjacent to the oscilloscope, and is connected to the probe itself through flexible cables. One cable carries the energising voltage for the probe, whilst the other carries the signal to the oscilloscope. The arrangement is shown in the circuit diagram, Fig. 1.

For the observation of signal frequencies above 20 Mc, and for fast pulses, it is desirable that the signal cable be terminated at one end. In this case, the receiving (oscilloscope) end of the cable seemed the more convenient, and was the method adopted.

Transistors T1 and T2 form the voltage feedback pair mentioned previously. The voltage gain of this pair is given approximately by R6/R8. Transistor T3 is a series feedback stage, which provides a high load impedance for the previous pair, so as not to impair their high frequency performance. The voltage gain of the T3 stage is given by R13/R12, where R13 is the signal-cable terminating resistance.

The use of negative feedback from the emitter of T2, through R2, provides dc stability for the first two stages. In setting up the dc conditions, this resistor is adjusted to give the required emitter current in T1. The third stage, T3, is stabilised by the 150-ohm emitter resistor R12.

High frequency peaking is achieved with the capacitors C8 and C9, which are in shunt with the respective emitter resistors. The feedback resistor R6 should be peaked for the same time

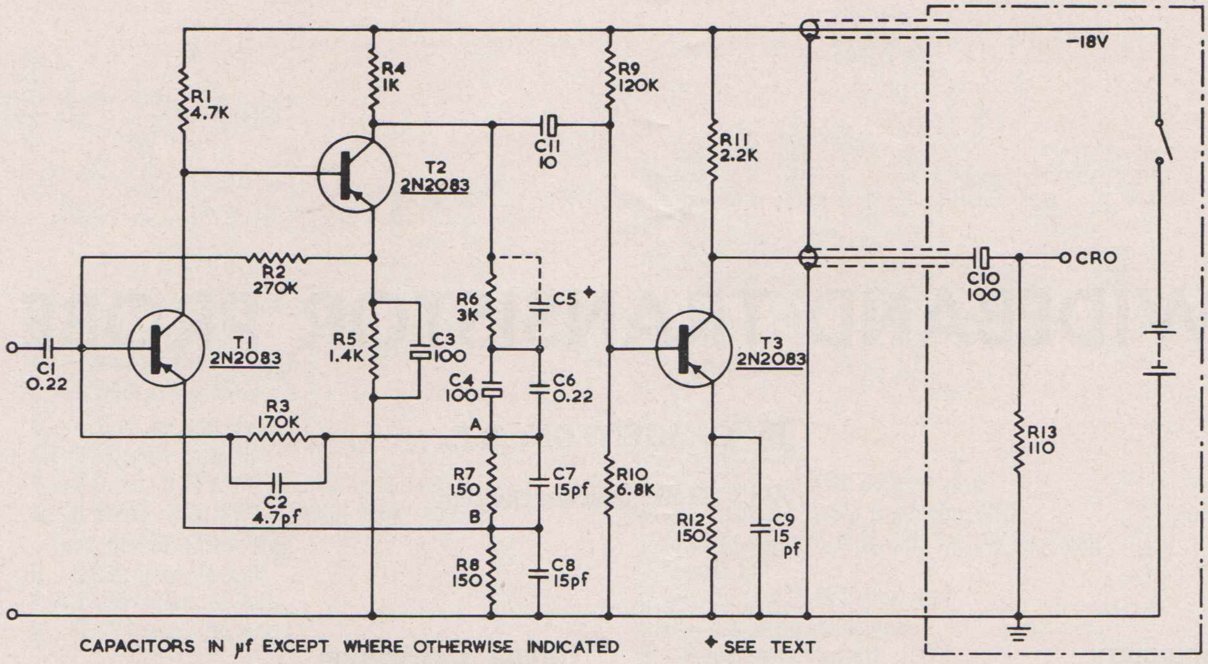


Fig. 1—Circuit diagram of the transistor probe, showing mechanical division into two sub-units.

constant as R8C8, but this means a value for C5 of about 1 pf. The inclusion of the small capacitor C5 may improve the response slightly however, and can be tried in the final testing. Capacitor C4, 100 microfarads, is for dc isolation, and is bypassed for high frequencies by C6.

The input impedance of the feedback pair T1 and T2 is increased by means of positive current feedback, an idea used variously in other applications, and suggested for this purpose by D. Money[3]. The 150-ohm resistor, with a 15 pf capacitor in shunt, which appears in the feedback path is to provide a point where the voltage is approximately twice the emitter voltage of T2. That the point "A" fulfills this requirement can be seen by considering the feedback current in Z_f.

Here i_f is approximately equal to $\beta T2.i_e/4$, where i_f is the signal feedback current, i_e is the emitter current of T1, and the beta of T2 will be typically 80 at 5 ma. Hence $i_f = 80.i_e/4, = 20i_e$, so that the voltage at point "A" will equal that at point "B" within 5%.

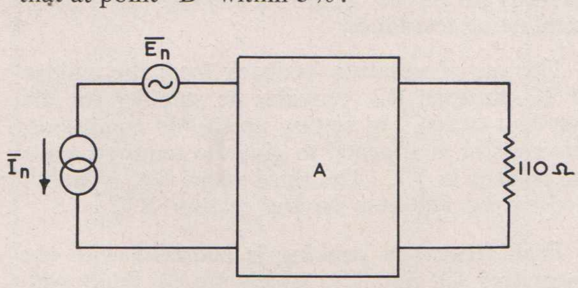


Fig. 2—Equivalent circuit used in specif ying the noise performance of the probe.

The high input impedance achieved with the voltage feedback pair of approximately 270,000 ohms may now be increased by the application of positive current feedback from point "A" to the base of T1. The adjustment may be made experimentally, and the desired input impedance obtained. The flexibility of this technique lies in the fact that the amplifier response is not affected by the adjustment.

Transistors and Operating Conditions

The three transistors used in this probe were all AWV type 2N2083, which is a drift-field germanium transistor classified as a converter in the 2N1177 family. The operating conditions for the three transistors are as follows:

T_1	$I_E = 2.5$ ma	$V_{CE} = 6.0$ volts
T_2	$I_E = 4.6$ ma	$V_{CE} = 7.4$ volts
T_3	$I_E = 4.8$ ma	$V_{CE} = 6.8$ volts

Circuit Performance

The frequency response of the final circuit measured between the 3 db points runs from below 20 cps to 24 Mc. The response on the model showed a gradual rise from 5 Mc to a peak at +2 db at 10 Mc, referred to the 100 Kc point, and then a gradual fall off to –3 db at 24 Mc. The frequency at which the hump occurs can be altered by the adjustment of capacitor C5, within the limits of the desired transient response.

Page 81 Please

THE ART OF HIGH FIDELITY

By B. J. SIMPSON

One of the questions I am most frequently asked is "what is high fidelity?" To avoid misunderstanding, it will be necessary at the outset to say that I have no intention of trying to define it, partly because others better qualified than myself have declined to do so, and partly because I feel more and more that it cannot be defined in the sort of terms that the questioner obviously expects.

It may be thought easy, for example, to define the subject in terms of performance figures. Many attempts to do so have been made, but have failed through lack of agreement or for other reasons. There is reason to suppose that any attempt to define the subject in precise scientific terms will be doomed to failure, if only because the final analysis of a system is subjective. We know, for example, that a system will sound different in different rooms, because the characteristics of the room will affect the subjective performance.

If the aim of high fidelity is considered, then it may be described as an attempt to reproduce in the home, or elsewhere, something that approximates as closely as possible to a live performance. We know from the outset that the perfect achievement of this aim is not capable of being realised, for a great variety of reasons. What is finally achieved is a compromise, and for this reason there are some purists who feel that the whole exercise is therefore not worthwhile. But life is full of compromises, and whilst we know that the results are not perfect, they can at the same time be very acceptable, and bring us a great deal of pleasure.

The same sorts of argument have been directed against stereo since its introduction. Here we are admittedly trying to create an illusion, and it can be done with great success. Too many people, unfortunately, have become overconscious of those records that plagued us when stereo was first introduced, featuring ping-pong balls and railway locomotives careering through the house. The directional effects of stereo are only a small part of the overall illusion that we are attempting, and a comparatively unimportant part. It must be admitted that many people who condemn stereo have not had the opportunity of hearing and evaluating a good system, or resist the progress of the art because they have a large collection of mono records.

This is very understandable. I have a large number of treasured mono records myself. I would say, find out for yourself what stereo can do for you, and remember that on a suitable stereo system, treasured mono records will sound better than you have heard them before. At the same time it will open up a new phase of enjoyment for future purchases.

Because the word "art" was used in the title, we can use an analogy here between mono and stereo performances. If one imagines two pictures side by side in an art gallery, both of the same scene, but from a different viewpoint, the effect of stereo can be described. Let us assume that the scene is a stretch of coastline under the magnificent Italian sky. In one case, the painting is really an interior, and we get a glimpse of the scene outside through a partly-open shutter. The outside scene is very beautiful, but we see only a part of it. When we turn to the next picture, we find that this time the artist has moved his easel out onto the balcony of the room, and this time we see the whole glorious sweep of the bay, with all its background; as far as the view is concerned, we see the whole picture. This, in my feeling, is what stereo offers us, and I feel that to reject stereo is to reject one of the most important advances ever made in the history of faithful reproduction.

HiFi An Art-Form

What we are really trying to do with high fidelity is to emulate the more "photographic" types of painters, and produce a close likeness within the limits of the resources available to us. Unlike the painter, however, who will often interpret the scene in his own terms, and to whom "photographic" art is anathema, it is the task of the electronic artist to achieve the best likeness possible.

Like any other artist, the electronic artist must have a sound appreciation of the various media in which he is working, and must in addition know how the performance he is reproducing would have sounded in the original context. All this calls for an appreciable degree of knowledge and experience outside the direct field of electronics. Admittedly, he has available to him large quantities of facts and figures related to the equipment he is using, but in the final analysis, which is subjective, these become of much less importance than may generally be supposed.

To put this another way, we can define some of the basic requirements of high quality reproduction in reasonably precise terms, but the mere provision of equipment that meets these requirements will not necessarily produce the required results. Having provided the equipment, we then have to call on the disciplines of acoustics, music and psychology, to quote the most obvious ones, in order to produce the illusion that we are striving for.

I feel that if one forgets the attempt to define high fidelity in precise electronic terms, and takes the broader view of using all available means to create an illusion that is as good as possible for the money spent, then better overall results will be obtained and greater pleasure result. Let us face up to the fact that perfection is presently unattainable, and that all our scientific approaches are finally evaluated in a purely subjective way. High fidelity is an art rather than a science.

Buying HiFi

Possibly the second most-frequent question that comes my way concerns the relative merits of two or more pieces of high fidelity equipment. This is a most difficult question to answer, because although a comparison of the performance figures can easily be made, and incidentally may tell us very little, this is not usually what the questioner wants to know. What he really means, whether he realises it or not, is how would they compare with his system in his listening environment.

There are some indications that an acceptable solution to the problem is becoming available, in the form of knowledgeable experts who know the market, and are willing to use that knowledge on behalf of the would-be purchaser. There is a tendency to call in one of these experts, and commission him to make the purchases, based on a predetermined budget and on the understanding that he will produce what is in his opinion the best system available at the price, having regard to the owner's tastes, listening habits, listening room, and so on.

This may seem an unusual way to operate, but it has the advantage that one secures the assistance of a very knowledgeable helper at a fee which is a small proportion of the sum being spent. It could be argued that this is good insurance that the money spent will be spent wisely. The situation here is very much like that of an insurance broker, who, with his intimate knowledge of the market, gets his customer the best deal he can in relation to the customer's needs and circumstances.

Incidentally, I dislike the term "expert", but it has been used here as it seems to indicate what is wanted. In my experience, these men have no connection with trade houses selling the products, and are able to make an unbiassed assessment of the equipment available. It is true that many people who are interested in getting themhelves a hifi system have many friends who press advice upon them. Some of these friends may be technically qualified on the subject, and able to give some good advice. On the other hand, many of them will not be so knowledgeable, and taking their advice could lead to disappointment.

Attempts to formulate advice of a general nature for would-be buyers of hifi equipment always fall by the wayside because of the large number of factors involved. It can in no way substitute for evaluation and discussion of Mr. A's problem as opposed to Mr. B's problem. In general, however, it is first necessary to determine how much money is available for the system. When that has been done, a rule of thumb which I often use is to divide the money, 50% for the two speakers, 25% for the amplifier, and the remaining 25% to the turntable and pickup.

It must be stressed however, that this is only a thumb-rule, because circumstances will alter every case. It does give, in my opinion, some idea of the way the money should be apportioned. It also stresses that, in general, the speakers are the weakest link in the chain of reproduction in the home. The amplifier, on the other hand, is generally the strongest by far. For example, it is comparatively easy to make an amplifier which has a response flat within 2 db (or even less) from 30 cycles per second to 20,000 cycles per second, but the manufacture of a speaker with the same performance is a difficult task, and the speaker would be correspondingly expensive.

Properly chosen and properly installed, hifi equipment can bring a world of enjoyment that would otherwise remain a closed book. For music-lovers, whatever type of music they prefer, the system will bring them their favourite works with a richness, depth and clarity that has to be heard to be believed.

WIDEBAND TRANSISTOR PROBE

(Continued from page 78)

Turning to the transient response, the measured rise time is 25 nanoseconds, with an overshoot of approximately 30%. The input impedance of the probe has two components, resistive and capacitive. The resistive component was measured at a frequency of 10 Kc, and with an input signal level of 100 mv peak-to-peak; the value is 1.4 megohms. The capacitive component was measured at 1 Mc, with the following results: without capacitor C2, 7 pf; with C2 equal to 3 pf, the input capacitance was 4 pf; and for C2 equal to 4.7 pf, the value was 2.5 pf.

The noise performance of the probe may be fully specified in terms of a constant current generator and a constant voltage generator at the input, as shown in Fig. 2. The noise performance then becomes 2 na and 15 μv. Distortion in the probe was not measured, but it is anticipated that the distortion would be small due to the large amount of negative feedback employed in the design.

Construction

The probe was built on a $\frac{7}{8}''$ wide by $3\frac{1}{2}''$ long strip of matrix board, and encased in a 1″ diameter aluminium tube. In the layout, the usual precautions of short leads, separation of input and output, and component placement to minimise undesirable stray capacitances were observed as far as possible.

Two 9-volt batteries were used for the 18-volt supply, and were encased in an aluminium box fitted with a uhf connector for attachment to the oscilloscope. A second coaxial cable, in addition to the signal cable, was used to carry the dc current to the probe.

Notes

1. E. M. Cherry, "An Engineering Approach to the Design of Transistor Feedback Amplifiers", *Proc. I.R.E.E. (Aust.)*, May, 1961.
2. E. M. Cherry and D. E. Hooper, "The Design of Wide-band Transistor Feedback Amplifiers", *Proc. I.E.E.*, February, 1963.
3. A.W.V. Application Laboratory.

RF RATINGS FOR TV DEFLECTION VALVES

Requests are received at fairly regular intervals for information relating to the use of TV deflection valves in audio and radio-frequency service, usually in "Ham" equipment. It has therefore been decided to publish the accompanying data here in order to render it more readily available to those who are interested.

We are presenting here data on the use of types 6DQ6, 6GW6, 6DQ5, 6GT5, 6JB6, 6GX5, and 6JE6, and their 12-volt and 17-volt versions where applicable, in various conditions that may interest "Hams" and others with similar ideas. The conditions quoted are those most likely to be required, and are: rf power amplifier and oscillator in class C telegraphy, rf power amplifier in class FM telephony, plate-modulated rf power amplifier in class C telephony, and class AB1 audio power amplifier and modulator service. All the ratings given here have been established on an ICAS (intermittent commercial and amateur service) rating, and are absolute maximum values.

It will be seen that no sets of typical operating conditions have been quoted. In cases such as this, it is the responsibility of the user to ensure that the conditions meet the requirements of his licence, or other requirements with which he may be faced.

It must be noted that TV deflection valves are not controlled or tested for rf operation; whilst they may function satisfactorily, operation above 60 Mc cannot be recommended. Care must be taken to see that the heater voltage and current ratings are not exceeded; these are, for 6-volt types, 6.3 volts ± 10%, for 12-volt types, 0.6 amperes ± 6%, and for 17-volt types, 0.45 amperes ± 6%.

A maximum temperature rating for the valve envelope has been quoted instead of plate and screen input ratings, or various peak envelope power ratings for specific applications. A control on bulb temperature should control operating dissipations.

TYPES 6DQ6, 6GW6, 6GT5, 6JB6

RF Power Amplifier and Oscillator—Class C Telegraphy

and

RF Power Amplifier—Class FM Telephony

Maximum Ratings, Absolute Values:	**ICAS**
DC Plate Voltage	750 volts
DC Grid No. 2 (screen) Voltage	250 volts
DC Grid No. 1 (control grid) Voltage	–150 volts
DC Plate Current	140 ma
DC Grid No. 1 Current	3.5 ma
Grid No. 2 input	3.0 watts
Plate Dissipation	20 watts
Peak Heater-Cathode Voltage:	
Heater Negative with Respect to Cathode	135 volts
Heater Positive with Respect to Cathode	135 volts
Bulb Temperature (at hottest point on bulb surface)	240°C

Plate-Modulated RF Power Amplifier—Class C Telephony

(carrier conditions per valve for use with a maximum modulation factor of 1.0)

Maximum Ratings, Absolute Values:	**ICAS**
DC Plate Voltage	600 volts
DC Grid No. 2 (screen) Voltage	250 volts
DC Grid No. 1 (control grid) Voltage	–150 volts
DC Plate Current	115 ma
DC Grid No. 1 Current	3.5 ma
Grid No. 2 input	2.0 watts
Plate Dissipation	15 watts
Peak Heater-Cathode Voltage:	
Heater Negative with Respect to Cathode	135 volts
Heater Positive with Respect to Cathode	135 volts
Bulb Temperature (at hottest point on bulb surface)	240°C
Maximum Grid No. 1 Circuit Resistance	33,000 ohms

AF Power Amplifier and Modulator—Class AB1

Maximum Ratings, Absolute Values:	**ICAS**
DC Plate Voltage	750 volts
DC Grid No. 2 (screen) Voltage	250 volts
Max. Signal DC Plate Current	125 ma
Max. Signal Grid No. 2 Input	3.0 watts
Plate Dissipation	20 watts
Peak Heater-Cathode Voltage:	
Heater Negative with Respect to Cathode	135 volts
Heater Positive with Respect to Cathode	135 volts
Bulb Temperature (at hottest point on bulb surface)	240°C
Maximum Grid No. 1 Circuit Resistance	0.1 megohm

TYPES 6DQ5, 6GX5, 6JE6

RF Power Amplifier and Oscillator—Class C Telegraphy
and
RF Power Amplifier—Class C FM Telephony

Maximum Ratings, Absolute Values:	**ICAS**
DC Plate Voltage	750 volts
DC Grid No. 2 (screen) Voltage	175 volts
DC Grid No. 1 (control grid) Voltage	–150 volts
DC Plate Current	280 ma
DC Grid No. 1 Current	3.5 ma
Grid No. 2 Input	3.5 watts
Plate Dissipation	32 watts
Peak Heater-Cathode Voltage:	
Heater Negative with Respect to Cathode	135 volts
Heater Positive with Respect to Cathode	135 volts
Bulb Temperature (at hottest point on bulb surface)	250°C
Maximum Grid No. 1 Circuit Resistance	33,000 ohms

Plate-Modulated RF Power Amplifier—Class C Telephony

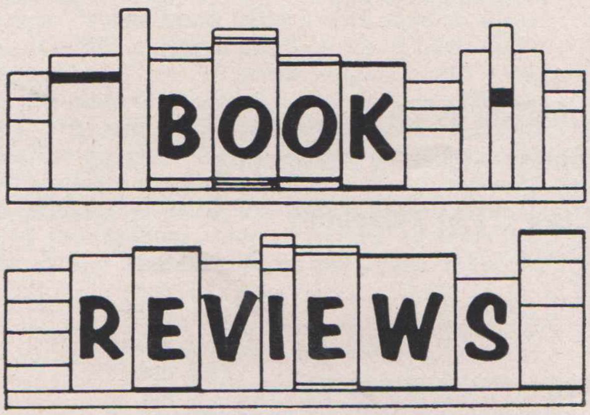
(carrier conditions per valve for use with a maximum modulation factor of 1.0)

Maximum Ratings, Absolute Values:	**ICAS**
DC Place Voltage	600 volts
DC Grid No. 2 (screen) Voltage	175 volts
DC Grid No. 1 (control grid) Voltage	–150 volts
DC Plate Current	230 ma
DC Grid No. 1 Current	3.5 ma

Grid No. 2 Input	2.3 watts
Plate Dissipation	21 watts
Peak Heater-Cathode Voltage:	
Heater Negative with Respect to Cathode	135 volts
Heater Positive with Respect to Cathode	135 volts
Bulb Temperature (at hottest point on bulb surface)	250°C
Maximum Grid No. 1 Circuit Resistance	33,000 ohms

AF Power Amplifier and Modulator—Class AB1

Maximum Ratings, Absolute Values:	**ICAS**
DC Plate Voltage	750 volts
DC Grid No. 2 (screen) Voltage	175 volts
Max. Signal DC Plate Current	280 ma
Max. Signal Grid No. 2 Input	3.5 watts
Plate Dissipation	32 watts
Peak Heater-Cathode Voltage:	
Heater Negative with Respect to Cathode	135 volts
Heater Positive with Respect to Cathode	135 volts
Bulb Temperature (at hottest point on bulb surface)	250°C
Maximum Grid No. 1 Circuit Resistance	0.1 megohm



"ELECTRONIC DESIGN CHARTS", N. H. Crowhurst, Gernsback Library Inc., size 8½ x 11″, 128 pages.

Norman Crowhurst is one of those people who has achieved such a reputation in the audio field that it would probably be true to say that any new book bearing his name will not only be a worthwhile contribution to the art, but will also gain wide acceptance. This title is a comprehensive collection of nomographs which will save the engineer and technician many hours of tedious calculation. Their large size and clear presentation greatly reduce the usual criticism that is levelled against such charts, that they give approximate answers only. Many of the charts appear to be quite new both in conception and design, whilst the detailed explanations and sample problems in the text make them very easy to use and follow. There is a total of no less than 59 charts, bound in heavy-duty covers with a strong spiral binding which allows any chart to lie flat whilst being used.

"TRANSISTOR INVERTERS AND CONVERTERS", by Thomas Roddam. Iliffe Books Limited. 240 pages, including 201 text illustrations.

The rapid development in recent years of portable transistor equipment has brought in its train the need for a light and efficient means of providing both ac and a range of dc voltages from low voltage dc sources. The transistor inverter and converter between them satisfy these requirements: the inverter, which changes dc to ac being used either alone, or as the heart of a converter which can supply as many voltages as may be needed.

Much has been written about transistor inverters in the world's technical literature and hundreds of circuits have been published, with almost as many theories to explain their operation. But this is the first definitive book to be published on the subject, and in it the author has succeeded in producing a single theory to cover all the various types of transistor inverter circuits available.

This title contains many well-tried designs contributed by leading manufacturers, as well as original designs by the author, and will be found an invaluable source of information both by the electronic engineer with no previous experience of inverters and by the established designer who wishes to widen his knowledge of the subject.

"ULTRASONIC DELAY LINES", by C. F. Brocklesby, J. S. Palfreemen, and R. W. Gibson, Iliffe Books Limited. 297 pages, including 168 text illustrations, and 8 pages of plates.

For many purposes it is necessary to be able to delay the passage of electrical signals for predetermined periods of time. Modern ultrasonic delay lines are capable of introducing delays of up to several milliseconds and are therefore capable of acting not only as timing elements but also as information storage devices. They thus find important applications not only in radar, for which they were first developed, but also in radio and television, electronic computers, pulse-forming networks, correlation techniques and multichannel communication systems. In addition they have applications in fields not originally envisaged, such as acoustic interferometry and in measuring the transmission properties of acoustic media.

In spite of the many references to these devices in the technical literature of the world, this is the first book to be devoted specifically to them. The authors, headed by C. F. Brockelsby, are members of a team who have been working on the subject for many years. They are therefore in a unique position to write this book which contains a great deal of original matter not to be found elsewhere.

Basically an ultrasonic delay line consists of two transducers, one to convert the electrical impulses into an acoustic wave train which is converted back by the second into the electrical signal after traversing a path of suitable length in an acoustic carrying medium. A method so simple in outline is not without attendant practical problems, and it is therefore essential first to understand the underlying physical and mathematical principles. Though the book is written mainly for engineers and physicists actively engaged in the subject, it will be found of absorbing interest by scientists and technologists working in other fields.

NEWS AND NEW RELEASES

RCA HIGHWAY WARNING SYSTEM

The use of RCA "Ve-Dets" electronic detectors to set up a trail of warning lights behind a travelling auto was demonstrated at the American Bridge, Tunnel and Turnpike Association Convention in Montreal in October last. The demonstration employed 12 "Ve-Dets" attached to sensing circuits embedded in a scale-model circular roadway.

The demonstration unit depicted how a series of multi-colour lights would be flush mounted in the pavement at 25-foot intervals. As the vehicle moves forward, the three lights directly behind it glow red. The next three lights are amber, while the three farthest from the car are green.

In a full scale installation, the detectors would operate from a 50-foot wire loop in the roadway. A vehicle passing over the loop causes circuit changes, and the resulting signal is picked up by the detector unit at the roadside. The signal serves to actuate the light system.

Thus a motorist would quickly calculate his distance to the nearest car ahead and the speed with which he was overtaking it, even during heavy fog or rain. In addition, the system provides white lights to indicate that there are no vehicles in the control sector, 225 feet ahead.

The "trail of lights" is an outgrowth of electronic highway experiments at the RCA Laboratories in Princeton, N.J. The experiments led to a demonstration in 1960 in which specially equipped cars were made to move around a test track, and to accelerate, brake, and come to a stop with no one at the wheel.

T948 INSTRUMENT CRT

A new 5-inch cathode ray tube has been developed by EEV for use in wide-band, high speed oscilloscopes. The special features of this tube are deflection and sensitivities in the Y and X directions of 3 v/cm and 9 v/cm respectively, excellent brightness enabling high writing speeds to be employed, and good sensibility due to the small spot size (typical line width 0.4 mm). These features are achieved by the use of a post deflection accelerator mesh positioned a few millimetres from the phosphor screen, and an improved gun design. Since the region between the mesh and the screen in which the beam is accelerated is short, raster distortion is kept to a minimum while an improved X deflection sensitivity is achieved by having a large X plate to mesh spacing. A further advantage of this position of the mesh is the improved stability in X and Y deflection sensitivity with changes of temperature. The deflection sensitivity of the tube makes it particularly suitable for use with deflection circuits employing transistors.

SCIENTIFIC FISHING BY MARCONI DEEP-SEA TELEVISION

The Fishing Laboratories of the Ministry of Agriculture and Fisheries at Lowestoft (U.K.) are to use a Marconi television camera to study the general behaviour and breeding habits of fish as a step towards understanding their movements and the way in which they may be caught.

The equipment is the new Marconi Series 321 camera which is completely automatic in operation, the ON/OFF switch being the only control used in the entire channel once the equipment has been set up.

The camera can be enclosed with its control unit in a pressure casing at the bottom of the ocean; in all previous under-sea television work the camera control unit has been installed in a boat and has been connected by cable, and hence the maximum operating depth has been limited to about 1,000 feet due to the delay imposed on the essential synchronizing pulses which control the camera but which are generated in the control unit.

A single supply of electrical power is all that is needed to run the entire channel and the output television signal is in a final form which can be carried over an almost unlimited length of cable from the sea bed to experts on the surface, who will be able to study the fish and the operation of the trawl nets on a 21-inch Marconi monitor screen as much as 12,000 feet away from the ship.

The great depth at which the study can be made is possible only because of the extreme stability of the camera channel in unattended operation and its ability to give excellent pictures at very low light levels. The control unit automatically produces a constant, high definition picture controlled electronically over variations in scene illumination of over 1,000 to 1 at any given lens aperture. Usable pictures can be obtained with as little as 0.1 foot candles of light falling on the vidicon tube face plate.

40216

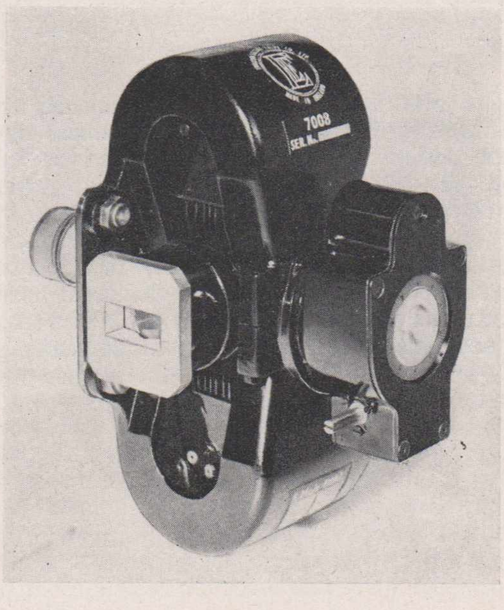
This new silicon controlled rectifier is characterized for high-speed pulse duty at currents to 900 amperes and voltages to 600 volts. The new device, intended initially for radar pulse modulator applications, can fill a broad range of requirements where extremely fast turn-on of high currents is important. Principal areas of application will probably be in the range of 200 to 900 amperes with a pulse width of 4 to 16 microseconds at repetition rates of 500 to 3,500 pulses per second. The high-current performance of type 40216 is a direct result of a unique and coaxial design. Because of this construction, current spreads radially across the junction surface and through successive layers almost instantaneously. This phenomenon permits exceptionally short rise times from zero current to peak value. The standard method of plotting the slope of the rise curve from 10% to 90% of peak value is inadequate to describe the switching speed of this silicon controlled rectifier. Performance of the unit requires a new concept based on turn-on dissipation rather than turn-on time.

2N2857

One of the outstanding features in manufacture of the 2N2857 transistor is consistent production of devices with a noise figure of 4 db at 450 Mc, at least 2 db below the best of previous commercially available silicon transistors. This new double-diffused epitaxial planar transistor has a maximum operating temperature of 200°C higher than comparable germanium transistors. It is now being used in receivers operating up to 1,000 Mc, including military receivers for the 200-400 Mc range. Other major applications for the device include receivers for radar and telemetering equipment as well as navigational aids and missile testing apparatus.

EEV MAGNETRON 7008

The EEV 7008 is a tunable magnetron with electrical characteristics similar to those of the well established 4J50A series. The 7008 has a typical peak output power of 220 Kw and a frequency range of 8,500 to 9,600 Mc. It has a duty cycle of 0.001 with a pulse width of 0.20 to 2.75 microseconds at a peak anode current of 27.5 amperes.



NEW EEV IMAGE ORTHICONS FOR COLOUR TELEVISION

EEV has in development an image orthicon incorporating the new multi-alkali photocathode which has a "blue" sensitivity some 3 to 4 times higher than contemporary tubes. When used in conjunction with a suitable blue filter it gives up to 2 lens stops improvement in the blue channel of a three image orthicon colour camera. It is well known that television studio lighting has a predominantly red content, and that when productions are made in colour using a R-G-B three component system, extreme difficulty is experienced in obtaining an adequate "blue" signal. For this reason the pick-up tube in the blue channel needs to have maximum sensitivity, and it is for this application that this new tube is particularly suitable.

The chemical processing inherent in the formation of the multi-alkali photocathode destroys the normal functioning of the conventional glass storage target and a new target material has therefore been incorporated. This new material is equally suitable for use in tubes having other types of photocathode and has none of the disadvantages of the recently announced oxide films. It retains most of their benefits, including the advantage of reduced image retention. It is intended to use this material at some future date.

NEW "OVERLAY" TRANSISTOR

A new uhf transistor for space communications with a 400% increase in power output over semiconductor devices previously reported has been developed by the ECD Industrial Tube and Semiconductor Division of RCA. Called an "overlay" transistor, the device's first applications are expected in military and satellite transmitters, lightweight radar, and microwave relay equipment for television and telephone communications.

The new silicon device promises significant advances in the design of more compact equipment with greater reliability and efficiency at a lower cost than with other devices, and will open uses in uhf areas previously unattainable by transistors. Some units have produced as much as 5 watts at a frequency of 500 Mc. Prior to the development of this overlay transistor, the maximum power output achieved by transistors was significantly less than 1 watt from a 500-Mc power amplifier.

The "heart" of this unique transistor is a tiny checker-board structure, far smaller than the head of a pin. It consists of a mosaic made up of 156 individual high frequency transistors which are microscopic in size. These units are integrated through use of a new overlay structure and applied on a silicon wafer by a photo-etch process.

EEV RUBY LASER FLASH TUBES

EEV has introduced two new Linear Quartz Flash Tubes, types XL604 and XL605, which are primarily intended for the excitation of Ruby Lasers. These tubes are filled with a gas mixture which, when triggered, gives a light output spectrum similar to the absorption characteristics of ruby laser crystals. The maximum input energy per flash of the XL604 is 1250 joules with a nominal duration of 1.0 ms. Maximum operating voltage is 3 Kv. It has an arc length of 5.5 inches and a typical flash rate of 2 per minute. Maximum input energy of the XL605 is 5000 joules per flash with a nominal duration of 3 ms. Maximum operating voltage is 3 Kv. Flash rate is typically 1 every 2 minutes and length of arc 6.5 inches.

LASER CRYSTALS

Widened quests to explore fully the characteristics and applications of semiconductor and solid-state materials are daily yielding new data to serve as the basis for an ever-increasing flow of new products.

One of these new products is an amazing industry development that challenges the imagination and moves the pages of science fiction into the realm of everyday reality. Known as "light amplification through the stimulated emission of radiation" or, more simple, "laser", this latest advancement presages an era in the not-too-distant future when super-powerful light beams will be used to perform the most delicate surgery, weld and machine the most difficult refractory metals, vaporize hostile ballistic missiles in flight, guide space vehicles, detect submarines lurking in the ocean deeps, and communicate between planets.

Already scientists are in the process of evolving a laser communications system that in theory may use a beam of light to carry all the radio, TV, and telephone broadcasts now being transmitted throughout the world. Other current research involves development of a laser computer that operates at amazingly high speed.

How did this remarkable "breakthrough" come about? What are the principles on which it operates? Investigation of higher spectra as a means for transmitting intelligence was initiated primarily for two reasons: the growing concern of Government and private industry over increased crowding of communications channels; and the limitations of existing communications methods which became evident during recent orbital space flights.

Research into the higher frequency bands, which include infrared radiation and visible light, seemed to offer the logical answer, but many drawbacks were present.

Ordinary light, for example, is composed of varied colours in the visible spectrum and radiation in the near-visible regions, each of which represents a separate frequency. A light beam for communications, on the other hand, would have to consist of a single frequency. Furthermore, this light beam would have to be capable of amplification and be "coherent"; that is, among other characteristics, it should have the capacity to travel over enormous distances without appreciable "spreading".

The answer to these problems has been found in a device built around a new RCA type of laser crystal of superior optical quality. In the new device, the desired amplification is achieved by shining ordinary light, consisting of many different frequencies, upon a crystal, some of whose electrons are thereby stimulated to emit light at only one of those frequencies. By silvering both ends of the crystal—one partially and the other completely—most of the emitted light is reflected back and forth, inducing still other electrons to emit. The effect is cumulative until the highly directional beam of coherent energy radiating from the partially silvered end is more intense than light at the surface of the sun.

Because laser beams concentrate tremendous amounts of energy into tiny diameters of amazing coherence, power loss due to spreading is relatively slight over great distances.

The new laser crystal is distinguished from other reported materials in that it reduces by 10 times the amount of energy required by other types to generate powerful beams of infrared light. Moreover, such emission is triggered by a very broad band of light energies stretching across the entire visible spectrum. In a relatively short time scientists expect this device to operate continuously, activated only by a 100-watt bulb. By contrast, most solid-state lasers currently give only pulsed output and require the intense power of a xenon flash lamp to operate them.

THE LASER

DR. H. R. LEWIS

RCA Laboratories, Princeton, N.J.

In discussing lasers, an anology might be made: When the transistor was announced, its applicability was immediately evident. It was clear from the start that this device could perform the function of a vacuum tube and thus replace it for many purposes. The laser, on the other hand, is an entirely new tool looking for work. So far, it has been considered primarily as a replacement part in systems already in operation using lower-frequency generators. It is to be hoped that in time it will more and more interest creative engineers who will invent entirely new applications, particularly suited to its novel properties. This paper provides a brief insight into those properties, as an introduction to the several papers on this field that follow.

Progress in technology usually consists of a series of small improvements in well-known techniques. Making these improvements requires a great deal of hard work and ingenuity. Moreover, one may expect the effort expanded per unit improvement in any one field to increase as time passes because the easy inventions have all been made. Thus, the uncovering of an entirely new technique is greeted with considerable excitement.

Those who are most excited are, of course, the scientists and engineers who can see in the new development an easier road to other new achievements. Ultimately, when the initial flurry dies down, the real achievements can be separated from the sham, and the importance of the new invention can be properly assessed. That time is still a year or more away for one of the most recent technological innovations—the optical maser, or as it is also called, the **laser.** Yet, one can feel even now that most of the attention the laser has received to date is justified for at least two reasons: (1) it performs an entirely new function: the generation of coherent electromagnetic energy in the visible and infrared portions of the spectrum where coherence was previously unattainable and (2) it uses physical principles which were not exploited for practical purposes until very recently. A serious discussion of these two points must necessarily make large demands on the reader, the editor and the author Fortunately, this is unnecessary here for the literature contains several detailed articles on lasers and masers[1-3] which the dedicated can read at their leisure. Here, we need only state how the laser differs from the old, familiar light sources, indicate why these differences may be significant for applications, and give a general notion of the operating principles involved.

Coherence and its Significance

In what way is the output of a laser significantly different from the output of, for example, a high intensity mercury arc? The answer lies in a careful description of the nature of the electromagnetic radiation characterized as light. Normal light sources—the mercury arc, or an incandescent light for that matter—produce an electromagnetic field which is irregular and unpredictable. The field at any point in space has a sinusoidal time dependence only for times much shorter than a microsecond. Then, an abrupt change occurs, and a new sinusoidal variation begins. This is in contrast to the situation for radio waves where the regular sinusoidal variation continues for long periods of time. This regularity is known as **coherence.** The laser output differs

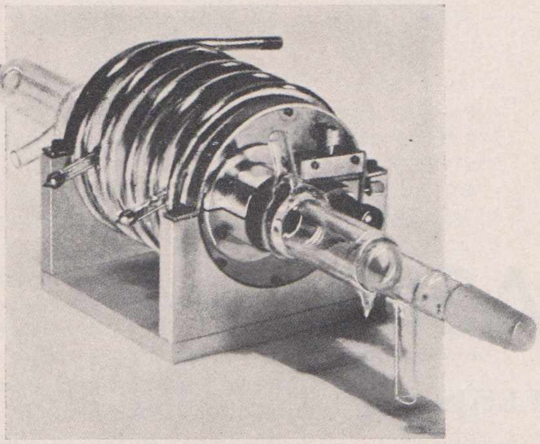


Fig. 1—An elliptical cavity for testing continuously operating solid-state lasers. The emitting crystal is placed on one focus, and the "pump" lamp is placed along the second focus of the elliptical cylinder. The glass tubing is a dewar which may be used to circulate a liquid coolant. The emitted radiation emerges along the axis of the dewar.

from that of conventional light sources by virtue of the high degree of coherence it displays. In fact, the laser produces electromagnetic waves that rival radio waves in their regularity.

Why is the coherence of laser radiation so important for certain applications? Crudely speaking, one can relate the coherence of a generator to the width of the frequency band which contains a significant portion of the energy emitted by the generator. (Here we are speaking of the character of the radiation **before** modulation.) The relation is inverse: that is, the greater the coherence, the narrower the emitted band. Thus, one can change the question to read: Why is the spectral purity of the laser so significant for applications? There are three, simple, important answers. First, the spectral purity allows one to filter out noise in the receiver of any communications or radar system. To give an example, the filter for a typical laser need only be approximately 1 kc wide (or the width determined by the modulation rate if that is larger), but a filter designed to accept most of the energy in the "sharp" green line of a mercury arc must be 10^{10} kc wide. Clearly, the receiver must accept much more noise if the conventional source is used. A related point is that conventional heterodyning techniques may be used with the coherent laser, while they are ineffectual with normal light sources. Heterodyning is a convenient technique for limiting the bandwidth of the receiver, and the local oscillator adds power that helps in other ways to overcome noise. Finally, the coherence of laser radiation enables one to form the radiation into beams which may be as narrow as the diffraction produced by the largest optical element involved in the system. (The usual example: A laser on earth using a 4-inch lens will illuminate an area only two miles in diameter at the moon.) By way of contrast, in a system using a conventional light source, the beam angle increases as the area of the emitter increases; thus, one cannot easily increase the intensity of radiation received at a distant point by increasing the area of such a source. The same coherence properties of a laser which provide such a narrow beam permit a condensing lens to focus the energy into an area with dimensions of a few wavelengths of the light, thus producing energy densities and electric field strengths orders of magnitude larger than those previously available. The technological and scientific consequences of this feature may well prove to be the most important of all.

How the Laser Works

Finally, we come to the question of how the laser works. (The general principle underlying the maser is the same.) It may clarify the situation to compare and contrast the operation of lasers to the familiar process of fluorescence.

In fluorescence, individual atoms in a gas, liquid, or solid absorb energy from some source (frequently ultraviolet light) and then re-emit the energy, usually at a longer wavelength. Each of the atoms, and there may be 10^{15} to 10^{19} of them per cubic centimeter, emits independently and spontaneously; the light thus produced emerges

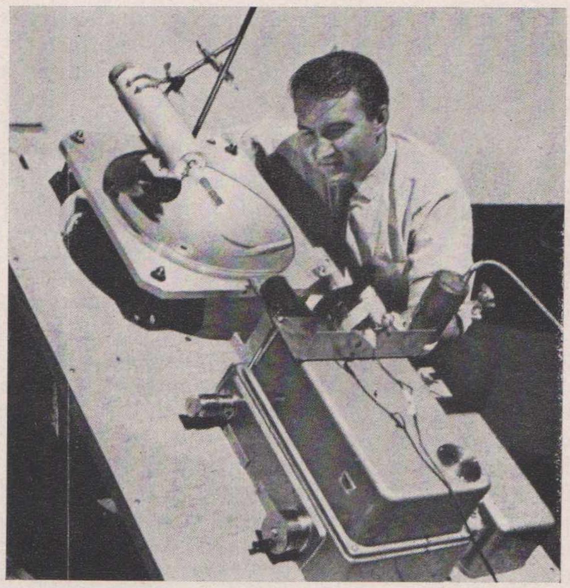


Fig. 2—Dr. Z. J. Kiss and the sun-pumped laser. The emitting crystal is mounted in the tip of the dewar, and the dewar is adjusted so that the crystal lies just beyond the focal point of an elliptical reflector directed at the sun. The emitted beam travels along the axis of the dewar into a detector.

in all directions in a broad frequency region. However, an atom can also emit its energy because of stimulation by an electromagnetic field of the appropriate frequency (i.e. the same frequency at which the atom would eventually emit spontaneously.) Thus, the emission of light by one atom can cause the emission of light by another atom thereby amplifying the electromagnetic field. Providing reabsorption and other losses do not overcome the gain produced by the stimulated emission, we can then visualize a growing electromagnetic wave propagating through a fluorescing material. This amplification process, caused by a kind of co-operative fluorescence of many atoms, can be converted into a self-triggered oscillation —a laser—in the conventional way, that is, by introducing feedback and a resonant circuit. In a laser, the feedback and resonant circuit may be produced by placing the emissive material between two parallel mirrors. Useful power is coupled out by making one of the mirrors semi-transparent (Fig. 1).

Lasers of this kind have now been made using solids (ruby, calcium fluoride, or calcium tungstate, suitably doped with fluorescing centres; semiconductor diodes) and gases (helium-neon mixtures, cesium, etc.). Some are excited optically, some by radio-frequency discharges, some by passing DC currents through semiconductor diodes. They deliver energies in the range of 1 milliwatt to 1 watt at frequencies ranging from the ultraviolet to the near infrared.

RCA Laboratories has made a number of contributions of its own to the development of solid-state lasers. It has developed several new lasers including[4,5] Er^{3+} in $CaWO_4$, and Tm^{2+} in CaF_2. A relatively high power, continuously operating laser has been produced,[6] using $CaF_2:Dy^{2+}$, and a continuous laser using sunlight as the pump source has been demonstrated by RCA Laboratories—the first device of its kind.

Conclusion

Despite this progress, much improvement in lasers is still needed if this new field is to measure up to its advance publicity. The chances that such improvements can be made still seem large after several years of work in this area.

Bibliography

1. A. L. Schawlow and C. H. Townes, "Infrared and Optical masers," *Phys. Rev. 112,* 1940 (1958). *This is the basic reference on the theory of lasers.*
2. A. Javan, "Negative Temperatures in Gas Discharges," *Phys. Rev. Letters 3,* 87 (1959). *A discussion of the possibility of making a gaseous laser.*
3. J. Weber, "Masers," *Reviews of Modern Physics 31,* 681 (1959). *A survey of masers containing many valuable references.*
4. Z. J. Kiss and R. C. Duncan, Jr., "Optical Maser Action in $CaWO_4:Er^{3+}$," *Proceedings of the IRE,* June, 1962.
5. Z. J. Kiss and R. C. Duncan, Jr., "Optical Maser Action in $CaF_2:Tm^{2+}$," *Proceedings of the IRE,* June, 1962.
6. Z. J. Kiss and R. C. Duncan, Jr., "Optical Maser Action in $CaF_2:Dy^{2+}$," *Proceedings of the IRE,* June, 1962.

(With acknowledgements to RCA)

Editor .... **Bernard J. Simpson**

Radiotronics is published twelve times a year by the Wireless Press for Amalgamated Wireless Valve Co. Pty. Ltd. The annual subscription rate in Australasia is £1, in the U.S.A. and other dollar countries $3.00, and in all other countries 25/-.

Subscribers should promptly notify Radiotronics, P.O. Box 63. Rydalmere, N.S.W., and also the local Post Office of any change of address, allowing one month for the change to become effective.

CLOISTER PRESS (W. SHORT), 45 George Street, Redfern

AWV