SEPTEMBER, 1974
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electronics TODAY INTERNATIONAL

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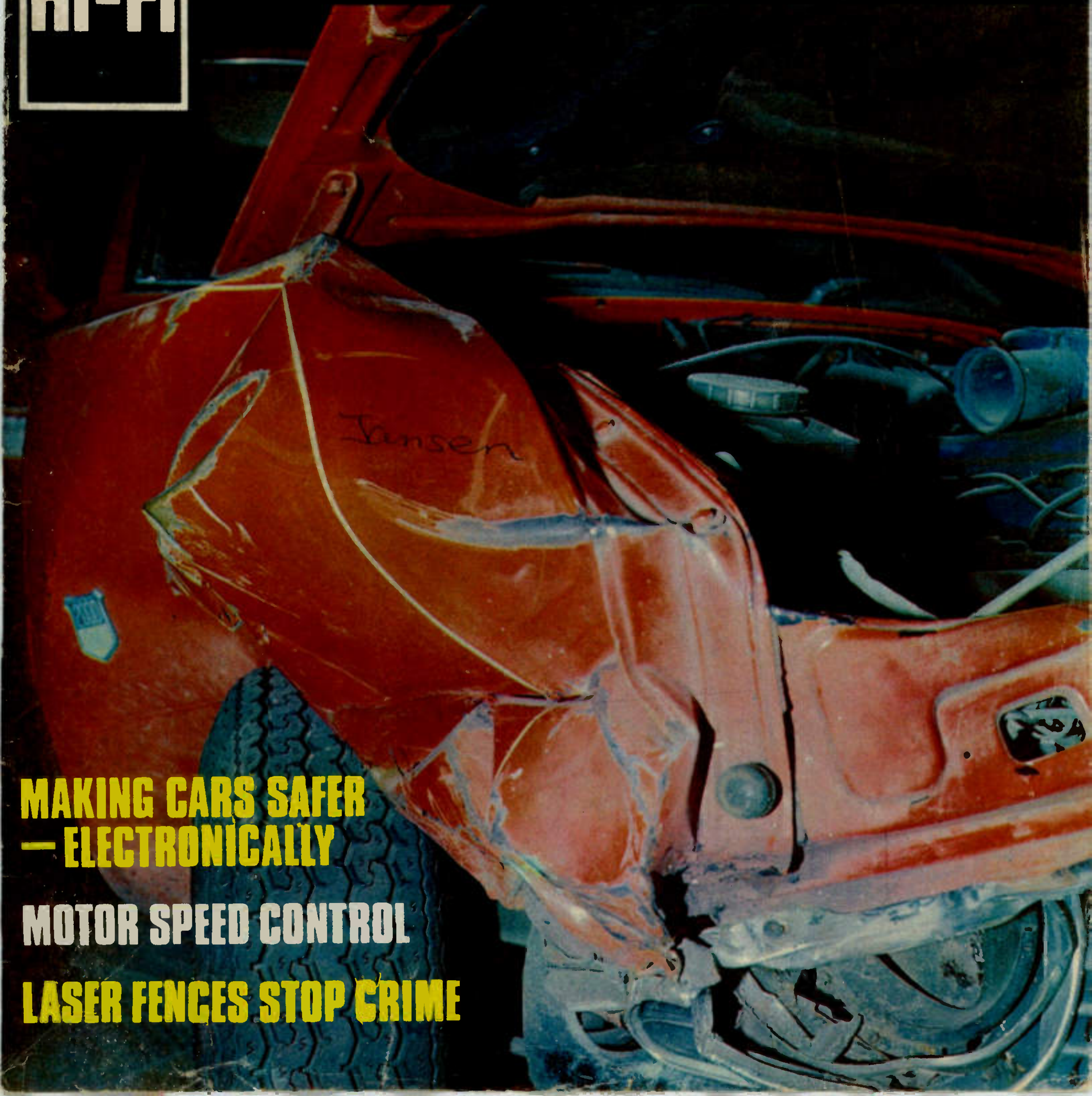

MAKING CARS SAFER — ELECTRONICALLY

MOTOR SPEED CONTROL

LASER FENCES STOP CRIME

electronics TODAY INTERNATIONAL

SEPTEMBER 1974 Vol. 4 No. 6

main features

projects

product tests

reviews

news & information

COVER: Technology not driver education may be the key to accident reduction – so many authorities believe – full story page 34 onwards. Cover picture by staff photographer John Knight.

NEXT MONTH

SPECIAL CONSTRUCTIONAL PROJECTS ISSUE

10 GREAT PROJECTS

INCLUDING

* Room Equalizer
* Drill Speed Controller
* Room Intercom
* Amplifier Rumble Filter
* Electronic Combination Lock
* Car Courtesy Light Delay
* Headlight Reminder
* Three Temperature Controllers

+

FREE 64 PAGE DICK SMITH CATALOGUE

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ROAD ACCIDENTS a realistic approach

LEGISLATORS, road safety bodies, motoring writers — all exhort us to drive ever more carefully. To avoid accidents by skill and restraint.

They have been doing this now for fifty years — and still the number of accidents increases. Still we hear the same weary exhortations.

What rubbish it all is.

There is no evidence whatever that road accidents can be substantially reduced by driver education or driver propaganda. On the contrary, many drivers may well be driving as well as they will ever be able.

People are not uniform. Many will never be safe drivers. Some are nervous or timid by nature, others make errors because of over-confidence. Others lack the aptitude, intelligence, concentration, muscular co-ordination or even-temper so necessary on the roads today. And others may well have brilliant driving technique but have immature or unstable personalities that cause them to drive dangerously just for the thrill.

Some people are careful by nature, they don't have to try to be. Other people are naturally careless, clumsy and/or stupid — they won't suddenly change when they drive a car.

What possible sense is there then in seeking reductions in accident rates only in terms of driver education?

What evidence is there that most people are not already driving as well as they can?

We have been for too long trying for a uniform standard, which, considering the great diversity of human nature, we are never likely to achieve.

In present day traffic a driver has to make a large number of virtually instantaneous decisions as his vehicle progresses through a seething mass of hopefully well-controlled vehicles. But too often speed and the number of changing events are beyond his capacity to react correctly, and in time — and accidents occur.

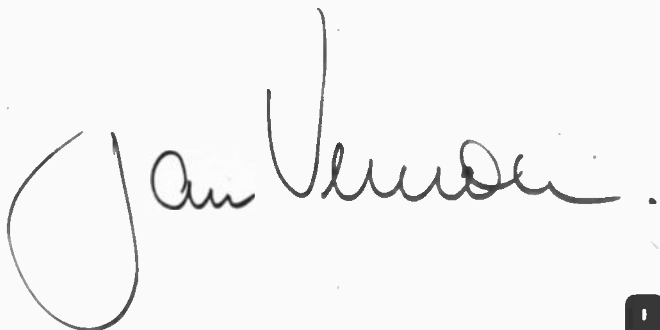
No threats, exhortations or legislation are ever going to change that situation for there is no way in the world in which you can impose uniform standards on non-uniform populations.

This view is now held by a small but increasing number of road researchers.

They accept that for many people, driving skills can only be marginally improved by education. They concentrate instead on making roads and vehicles intrinsically safer.

In this, electronics is playing a major role. Far larger perhaps than many of us realise.

So we sent our special correspondent, Dr. Sydenham, to Britain's Experimental Road Safety Vehicles Exhibition to report. His fascinating story is featured in this issue.



NAKAMICHI:

"The Nakamichi 1000 must surely be considered the Rolls Royce of cassette recorders with its 2 noise reduction systems (Dolby and Philips DNL), variable speed, separate record head for monitoring facilities, IC logic control, and a host of other features."
American AUDIO Magazine, March, 1974.

"We would rank it for now as the best cassette recorder we've tested and one of the best tape recorders of *any* we have ever used."
STEREO REVIEW of U.S.A., December, 1973.

"All told, a unique and fascinating product."
HIGH FIDELITY MAGAZINE, OF U.S.A. August, 1973.

"I found the Nakamichi 1000 and the 700 cassette decks to be aristocrats of the cassette world."
AUSTRALIAN FINANCIAL REVIEW, 31st May, 1974.

3 HEADS

"In conventional cassette machines this narrow head gap cannot be exploited because of the functions of the playback head and the record head are combined in one unit. The Nakamichi machine overcomes this difficulty by using 3 separate heads."
ELECTRONICS TODAY INTERNATIONAL, October, 1973.

". . . there are separate record and playback heads, each can be designed for optimum results. Thus, the gap in the record head is 5 microns but the playback head has an exceptionally small gap of only 0.7 microns!"
American AUDIO, March, 1974.

AZIMUTH ALIGNMENT

"Azimuth Alignment meaning the absolute right angle of the record and playback heads across the tape width. If either head is misaligned one loses high frequency sound."
AUSTRALIAN FINANCIAL REVIEW, 31st May, 1974.

"The knurled screw is then adjusted until the correct indication is given by a pair of light emitting diodes. After one has become familiar with the procedure, the whole operation takes about 6 seconds to perform."
ELECTRONICS TODAY INTERNATIONAL, October, 1974.

REEL-TO-REEL

"The first cassette machine that . . . is equal in every respect to top quality reel-to-reel recorders."
ELECTRONICS TODAY INTERNATIONAL, October, 1974.

". . . its performance is essentially comparable to that of open-reel decks in the same price range."
STEREO REVIEW, December, 1973.

"After the various measurements were taken, recordings were made and they compared very favourable with those made with a standard open-reel machine."
AUDIO, March, 1974.

"Almost incredibly, we could not detect any difference between the Nakamichi and the Nagra . . ."
ELECTRONICS TODAY INTERNATIONAL, October, 1973.

DOUBLE NOISE REDUCTION

"When you want noise reduction in the recordings you're making, the Dolby B system is there: when you want to reduce apparent hiss without audibly affecting the music, the DNL system is there as well. These two can be used simultaneously."
HIGH FIDELITY MAGAZINE OF U.S.A., August, 1973.

IC LOGIC ELECTRONIC CONTROLS

"When you switch from one transport mode to another, this logic system is carefully designed to time the sequencing of events . . . . All this avoids audible start-and-stop wows and switching transients in the monitor circuit."
HIGH FIDELITY MAGAZINE OF U.S.A., August, 1973.

"The control logic . . . has been very carefully thought out to provide click-free operation of the highest professional standard."
ELECTRONICS TODAY INTERNATIONAL, October, 1974.

TAPE DRIVE MECHANISM

"The double capstan system creates a constant, stable, tension between the two capstans. The condition of the tape between the two capstans is not affected by external conditions such as irregular tape up, supply torque, or uneven winding of the tape. The two fly wheels are physically large and the overall performance is further enhanced by a pneumatic damper . . ."
ELECTRONICS TODAY INTERNATIONAL, October, 1973.

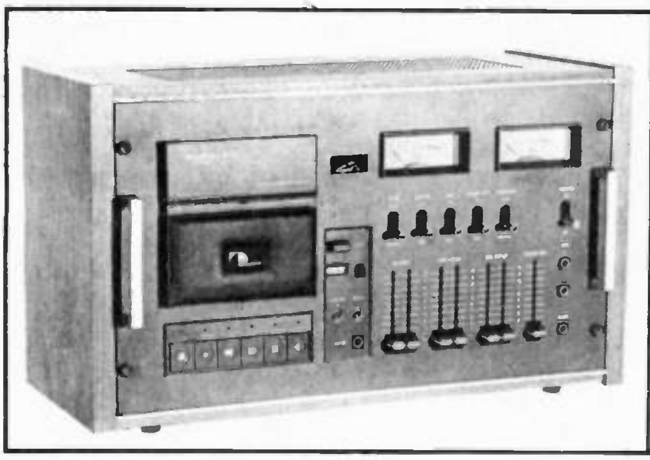
SUMMARY

"We were unable to find any signal source with anything like a normal dynamic range that could not be reproduced on the 1000 so faithfully that we were unable to distinguish between the copy and the original."
HIGH FIDELITY MAGAZINE OF U.S.A., August, 1973.

". . . Nakamichi has achieved results which would have been thought absolutely impossible not so long ago. Not only that, but they have come up with a professional machine that is even simpler to operate than an ordinary domestic recorder!"
American AUDIO Magazine, March, 1974.

MEMO TO NAKAMICHI

"Memo to Nakamichi -- please, do not ask me to return the recorder yet!" George W. Tillett, test authority.
American AUDIO Magazine, March, 1974.



Nakamichi 1 000

Nakamichi 700

The Worlds Best Cassette Deck!!

The Critics Prove It

TECHNICALTEST RESULTS

SPECIFICATIONS	MANUFACTURER	STEREO REVIEW Tested 700	AUDIO Tested 1000	HIGH FIDELITY Tested 1000	ELECTRONICS TODAY Tested 1000
Freq. Response					
CRO^2 Tape	35-20,000 Hz ± 3dB-20vu	30-22,500 Hz	20-20,000 Hz	28 to 19,000 Hz	20 to 20,000 Hz
Low Noise Tape	35-18,000 ± 3dB-20vu	47-20,000 Hz	20-19,000 Hz	40 to 18,000 Hz	20 to 20,000 Hz
Signal to Noise Ratio	Better than 60dB	-62.5 dB	-63 dB	-51 dB	-57 dB
Harmonic Dist.	Less than 2%	1.8%	1.4%	2.2%	1.4%
Erasure	Better than 60 dB		-66 dB	-61 dB	-62 dB
Channel Seperation	Better than 35 dB	Not quoted	Not quoted	Not quoted	Not quoted
Cross talk	Better than 60 dB	Not quoted	Not quoted	Not quoted	Not quoted

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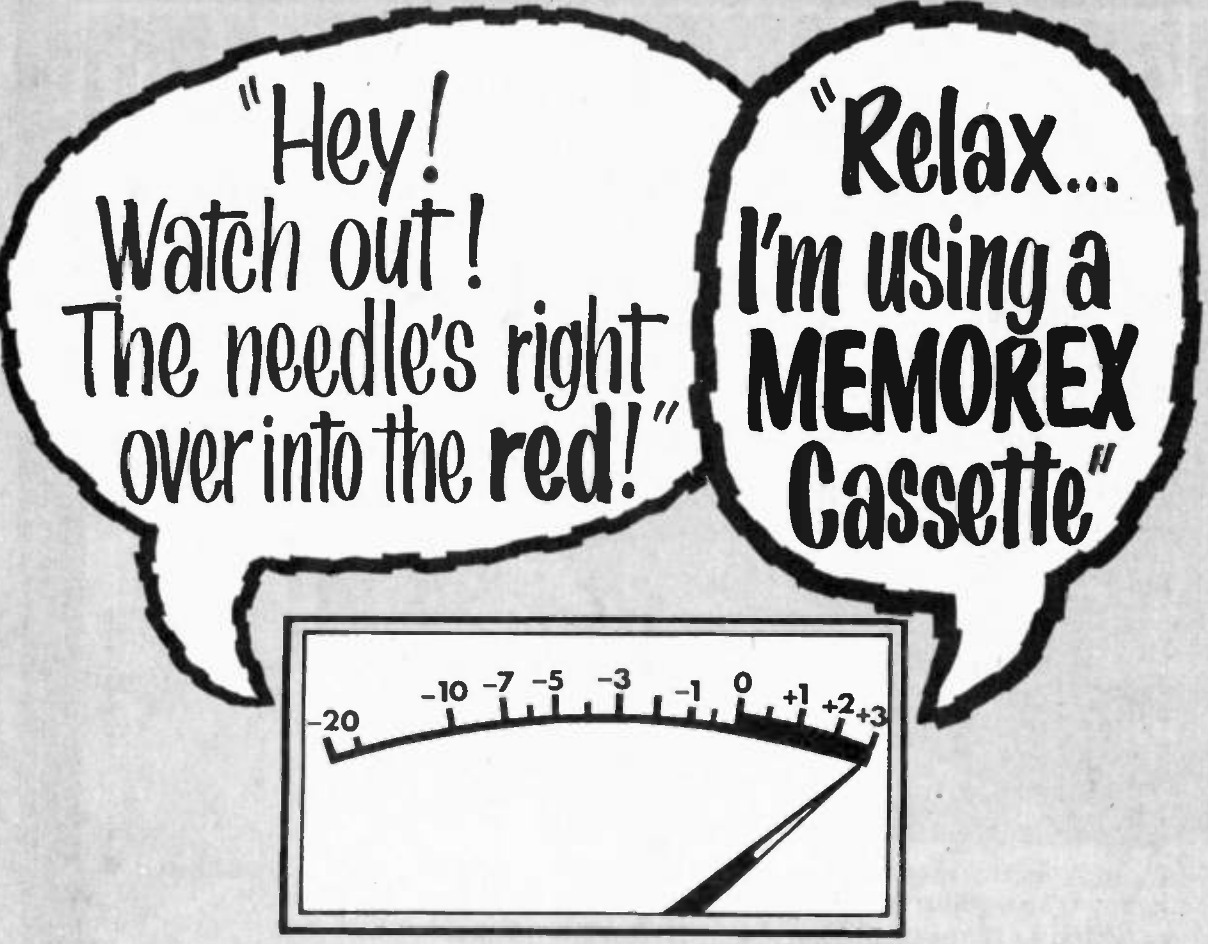

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202 Pelham Street,
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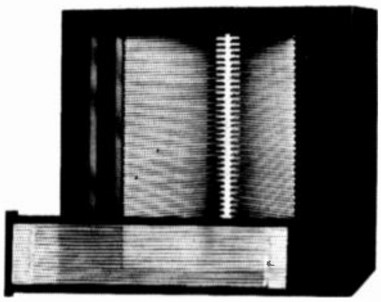
LIGHT YEA

Threadbare though the word "revolution" has become, the ESS amt 1 loudspeaker marks a revolution in high fidelity reproduction through its incorporation of the Heil Air Motion Transformer, developed and perfected by Dr. Oskar Heil, of Heil Scientific Laboratories, Inc., over the last four and one half years. This exciting new device gives the ESS amt 1 the first authentically new approach to sound generation in fifty years.

By utilizing the Heil Air Motion Transformer, the ESS amt 1 breaks completely with sound generating principles that stretch back, unchanged, to the earliest acoustic phonographs. From turn-of-the-century "talking machines" through today's most sophisticated component systems, the air pressures you hear as sound have been created by the direct push of a diaphragm surface moving forward and backward to get air motion. As the diaphragm surface works directly against the air its movement must be as great, and as rapid, as the required air movement — and this holds true for cones, electrostatic panels, piezoelectric crystals, traveling wave transducers and even ionized air devices that have an ionized cloud moving "forward and backward" just like a paper cone.

The Heil Air Motion Transformer, used as the mid and high frequency reproducer in the ESS amt 1, departs dramatically from this traditional concept of sound reproduction. By squeezing air instead of pushing it, it effectively creates *fives times* more air movement than the direct push of an equivalent flat surface and accelerates transducer design light years ahead. The Heil Air Motion Transformer has no "piston" surface, no voice coil, no elastic suspension devices, no significant mass, no "forward-backward" motion, no resonances, and is so light and simple that it carries a lifetime warranty.

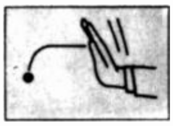
Instead of trying to displace air molecules with the forward-backward motion of a flat or cone surface, the Heil Air Motion Transformer harnesses the power-purchase of a pneumatic "lever" and by applying small squeezing forces over a large surface area produces air movements *five times greater* than an equivalent "pushing" piston surface. And whereas the energy applied to a piston driver is used to push a cone that pushes the air, the Heil Air Motion Transformer squeezes air *directly*. As a



The Heil Air Motion Transformer— The loudspeaker of the future.

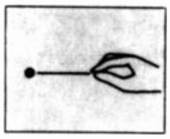
result of this greater, more direct and near massless transfer of energy, the Heil Air Motion Transformer approaches instantaneous acceleration for flawless transients, has no "cone breakup" to create coloration, and shows distortion figures as fine as modern electronics to recreate the sharpest of images, the cleanest of attacks and the highest harmonics with a clarity and immediacy never before experienced.

To form a picture of the completely new technique by which the Heil Air Motion Transformer generates sound, imagine trying to set a cherry pit, a low mass object (air), into motion with a high mass object, the flat of your hand (cone and voice coil).



This is obviously a technique of low effectiveness because the great mass of your arm and hand relative to the small mass of the cherry pit prevents rapid movement and results in a poor transfer of kinetic energy from your arm to the cherry pit. Result: the pit can never move faster than your hand pushes it. Moreover, when trying to accelerate your hand rapidly and stop it suddenly, the great inertial force created by the mass of your arm results in sluggish starts and overhanging stops. All the dynamic drama of music is removed.

And yet for all its shortcomings, this is the way sound has been reproduced since the acoustic phonograph. Now imagine placing the cherry pit between your fingers and squeezing. The result: high effectiveness in the transfer of kinetic energy from your finger to the cherry pit, great movement of



the cherry pit with a small but powerfully effective lever-like movement of only the tips of your fingers.

This analogy describes the ESS Heil Air Motion Transformer's principle. Sound is squeezed into the air instead of pushed toward it. A light small surface only .5 mil thick and made of a recently perfected plastic having enormously high internal molecular damping is formed into multiple interfacing cavities. The volume of these cavities alters in response to electro-magnetic forces generated by a uniformly distributed conduction cortex and projects sound outward with an almost perfect transfer of kinetic energy. The entire moving system is only two inches by five inches and its mass is effectively equivalent to only *three-quarters of a linear inch* of air across its surface — by contrast a conventional cone mechanism is effectively equivalent to one to three feet of air. This permits the moving system to react exactly with the imput signal and results in an incredibly accurate conversion to sound waves, a conversion realized by the listener as vastly superior definition, clarity and spatial proportionality. Music is reproduced to scale with a distinctiveness to each individual timbre that marks the difference between merely satisfactory reproduction and sound as clear as light.

The ESS amt 1 combines the amazing Heil Air Motion Transformer with a newly developed ten inch woofer which has an oversize, deep-drawn frame assembly and a powerful magnet to permit exceptional excursions at the highest possible acceleration. The woofer is critically designed for clean, impactful low frequency response and exciting transient capabilities that precisely complement the open articulation of the Heil Air-Motion Transformer. The ESS amt 1 triumphs over time and space by recreating in all its past, distant grandeur, every nuance of the original performance. Nothing we say, or can say, will adequately prepare you for the ESS amt 1's incredible new aural freedom, clean, clear and airy as light.

RS AHEAD

There are now two models available in the revolutionary new Heil Air Motion transformer speaker systems.

The AMT 1 at $628 per pair, and the AMT 3 at $898. See and hear them at:

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KENT HI-FI PTY LTD.,
Sydney, Phone: 29 2743, 29 6973

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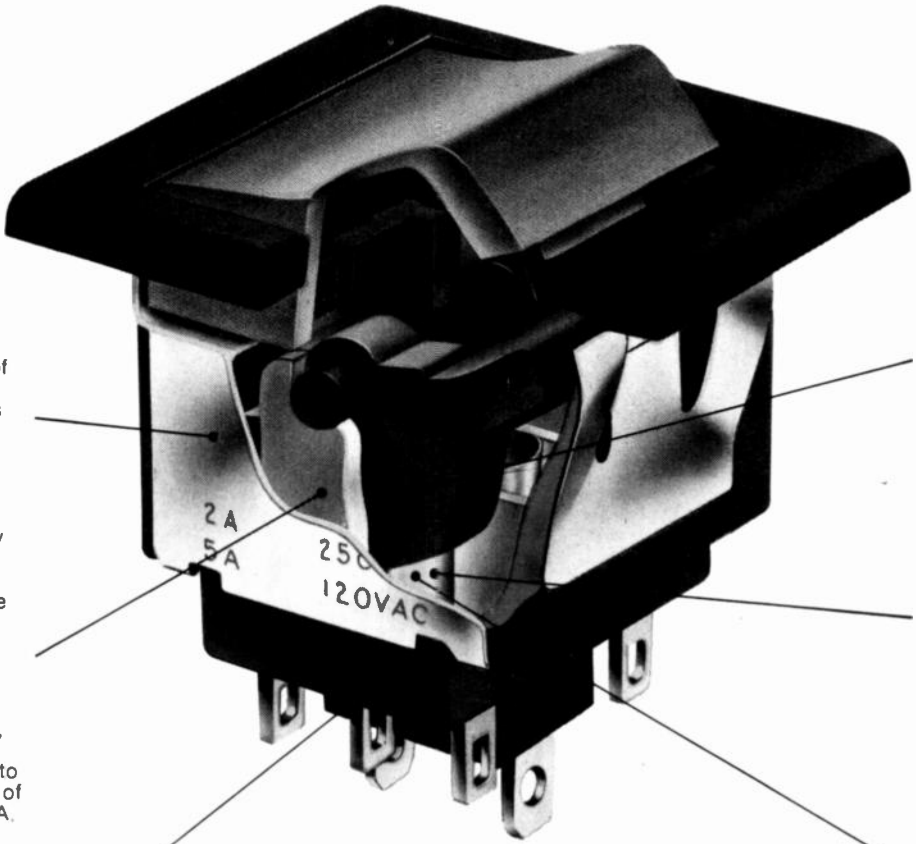
Heil Air Motion Transformer is the registered trademark for ESS loudspeaker systems incorporating design principles invented by Dr. Oskar Heil and licensed exclusively to ESS Inc.



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The tone controls are of the Baxandall type with the frequency determining elements in the feed back loop.

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Attention has been paid to stability into reactive loads and, together with the very low distortion figures obtained gives a sound quality of exceptional standard.

Power Output: R.M.S.	40 watts per channel into an 8 ohm load both channels driven.
Frequency Response:	20 Hz to 20 kHz ±1 dB.
Total Harmonic Distortion:—	Better than .1% (20 Hz to 20 kHz)
Intermodulation Distortion:—	Better than .1%
Hum & Noise:—	Phono 65 dB. Tape 80 dB. Tuner 80 dB. Aux 80 dB.
Sensitivity:—	Phono 3 mV. Tuner 200mV. Aux. 1 200mV. Aux 2 500mV
Scratch Filter:—	6 dB at 12 kHz. 12 dB at 20 kHz
Tone Controls:—	Treble ±15 dB at 10 kHz. Bass ±15 dB at 100 Hz.

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The Timbre A40 carries a two year warranty on all parts and labour.

news digest

MORE ENERGY

A revolutionary new battery for powering heart pacemakers has been developed by this team of scientists at the General Electric Research and Development Center, Schenectady, N.Y. With three times the energy and two-and-a-half times more voltage of conventional pacemaker batteries, the new battery is expected to last as long as the ten-year life now predicted for nuclear power sources. Moreover, pacemakers powered by the GE battery are expected to sell at a fraction of the cost of nuclear pacemakers (now estimated to be US$4,800). Dr. Stephan P. Mitoff, Robert R. Dubin, and Dr. Fritz G. Will (left to right) compare a pacemaker containing the new battery with a conventional pacemaker (left). The latter contains six mercury-zinc cells (shown) that have to be replaced every 24 to 28 months. The new chemical batteries are now being tested by GE's Medical Systems Business Division at Milwaukee, Wisconsin. Human implants are scheduled within two years.

AUSTRALIA WINS BIG COLOUR TV ORDER

The South African Broadcasting Corporation has ordered more than $100,000 of colour television equipment from Philips Vision & Sound, Oakleigh, Victoria.

The equipment comprises 14 colour television relay (re-broadcast) receivers and seven television transmitter test demodulators for use throughout the S.A.B.C. network.

It is the first major export order the Division has received for this type of locally-designed and built colour television equipment. Mr. Paul Long, marketing manager of Philips Vision and Sound, said that the order was awarded only after the South African Broadcasting Corporation had evaluated competitive equipment from European manufacturers.

SOUND PATTERNS FOR READING

A new reader for the blind, called "Stereotoner", translates printed letters from books, magazines or newspapers into stereophonic sound patterns which the user learns to recognise.

The blind person moves a hand-held 150 mm probe over the pages. Photocells inside the probe respond to colour contrast between print and background and change the images to sound patterns. These are reproduced on earphones connected to the probe through the main unit worn on a strap around the neck.

Powered by a rechargeable battery, the Stereotoner allows blind persons to read material ranging from small to headline-size type at speeds up to 60 words a minute (with some practice).

The manufacturer, Mauch Laboratories, Inc., Dayton, Ohio, also developed the "Optacon" which was selected as one of the 100 winning products in 1972 for its ability to convert printed materials to braille characters recognisable by a blind person by touch.

BIG NUMBERS

Two or so years ago the US Unicon company announced production of a trillion-bit laser memory. This extraordinary device operated by burning tiny holes in a thin metal film. At $US1.7 million it was something of a bargain but nobody seemed to need that many bits.

A smaller version of this device has now been announced by Precision Instrument Co. (Santa Clara.). The new device is available with capacities as 'low' as 200 megabytes. Prices begin at US$400,000.

PRESSURE SENSITIVE ELASTOMER

A new variably conductive elastomer has been developed by Dynacon Industries (117, Fort Lee Rd, Leonia, N.J. USA).

The material's resistance varies linearly with pressure over a range sufficiently wide to enable it to be used for many sensor applications.

Cast in sheets of treated metal particles suspended in rubber or plastic, the material has an intermediary semiconducting zone which is claimed to conduct under pressure only along the direction in which the pressure is applied.

The metal particles do not need to be in contact for conduction to take place, stress the manufacturers. Resistance range is very wide — varying from 10 megohms down to less than one ohm.

Like many formulations, Dynaco is a discovery currently in search of a use and because of this it is being marketed in sample-kit form.

Possible future uses include pressure, torque and tension sensors, weighing and levelling devices, strain gauges — even say Dynacon as a pressure sensitive hand for robots.

U.S./SOVIETS USE SATELLITES FOR SEA STUDIES

Scientists from the United States and the Soviet Union, participating in a joint symposium on the Bering Sea, have found that satellite data can be used for the accurate assessment of sea surface and related atmospheric conditions.

The symposium was held in Leningrad May 12-17 to report final results from the joint U.S./USSR Bering Sea Experiment on Microwave Sensing of Atmospheric and Oceanographic Characteristics.

Research aircraft provided by NASA and the Soviet Academy of Sciences obtained data for the study during February and March 1973, working with a U.S. ice breaker and a Soviet oceanographic research ship to study Bering Sea ice cover, surface state, and zones of precipitation.

Two research groups independently surveyed the sea surface under identical atmospheric conditions using microwave radiometry techniques, with comparison data provided by the research ships sailing below. The findings of the two teams were in general agreement, permitting a high degree of confidence in the data collected and in the subsequent interpretation.

The study offered convincing proof that scientists can use microwave measurements from satellites to asses sea ice distribution, motion, and stress, and that multi-spectral observations can permit scientists to determine the content of liquid water and water vapor in the atmosphere above the sea surface.

The same technique, the scientists agreed, could also be used to determine wind speeds above the ocean surface.

A complete report of the Bering Sea findings will be made public following a review by NASA and the Soviet Academy of Sciences.

MONKEY BUSINESS

Nothing to do with electronics, but we couldn't resist passing on this story from a recent 'New Scientist'.

Apparently in an effort to stabilise the diet of a large anthropoid ape, London Zoo authorities put up a large sign outside the cage asking that visitors 'DO NOT FEED THE ORANG — OUTANG'

Dramatically illustrating the relative insignificance of human endeavour the anthropoid promptly ate the sign.

TEXAS WIN BASIC CALCULATOR PATENT

The USA's Texas Instrument company have just been granted a basic patent for a 'miniature electronic calculator'.

The patent (3.819.921) was first applied for in Sept 1967 and relates to personal-sized battery-powered calculators which have their main circuitry in a single LSI (large scale integrated) chip.

As most small calculators are now built this way, Texas' basic patent could well have far-reaching implications for other manufacturers.

The announcement has caught Texas' competitors completely by surprise. Texas say that now the patent has been granted they intend to inforce it by granting licencing arrangements to other manufacturers.

Industry observers feel that Texas may well be able to enforce their patent protection and that retroactive agreements may in fact have to set up.

RFI WRECKS ICS

Catastrophic failure of many semiconductors can be caused by radio interference at levels very much less than previously believed.

Logic state changes have been caused in 7400 series NAND gates at absorbed rfi levels as low as 10 milliwatts. And output changes of several volts have been caused in 741 op-amps at levels of less than 10 microwatts.

Whilst catastrophic failure is less rare, it has been induced in op-amps and logic modules with half-millisecond bursts of rfi of less than 100 watts.

These instances are among many others quoted by the US Naval Weapons Laboratory in a paper presented to the recent IEEE International Symposium on Electro-magnetic Compatibility (July 1974).

Seems we may have to watch those Triac light dimmers even more closely!

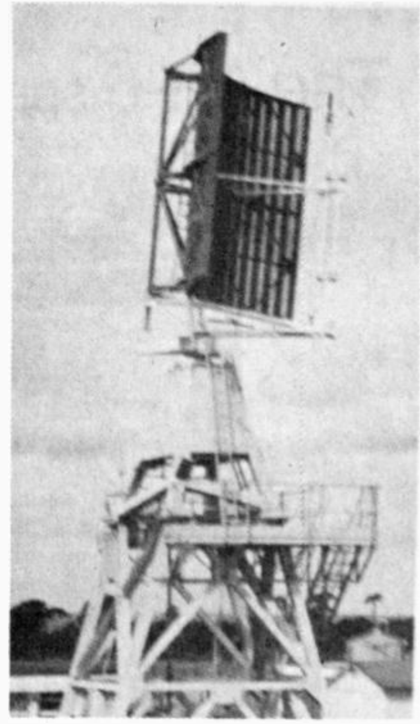
SINGLE ANTENNA RADAR GIVES HEIGHT PLUS RANGE

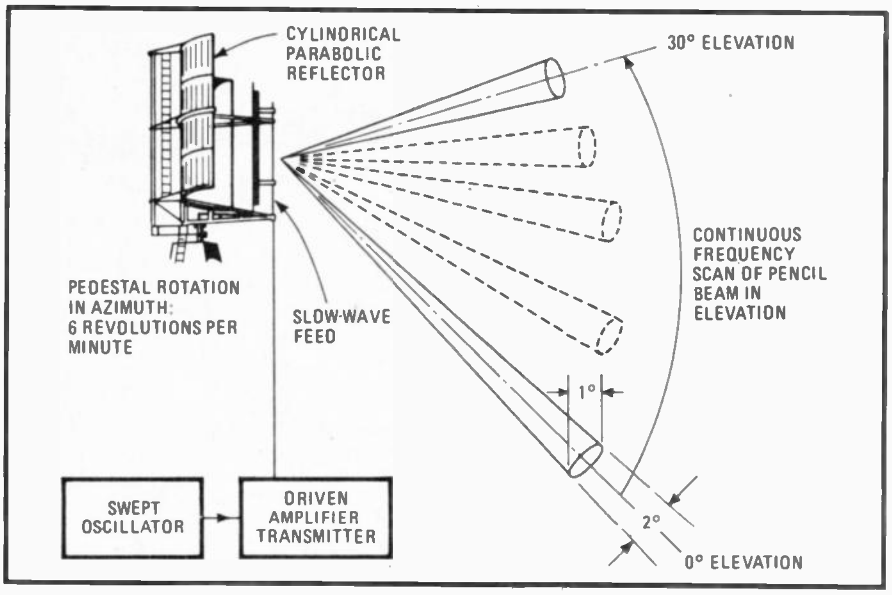
Most radar systems derive range and altitude data by using separate antenna and associated electronics for each parameter.

Another technique is to 'stack-up beams', effectively creating one large antenna from a multiplicity of small ones.

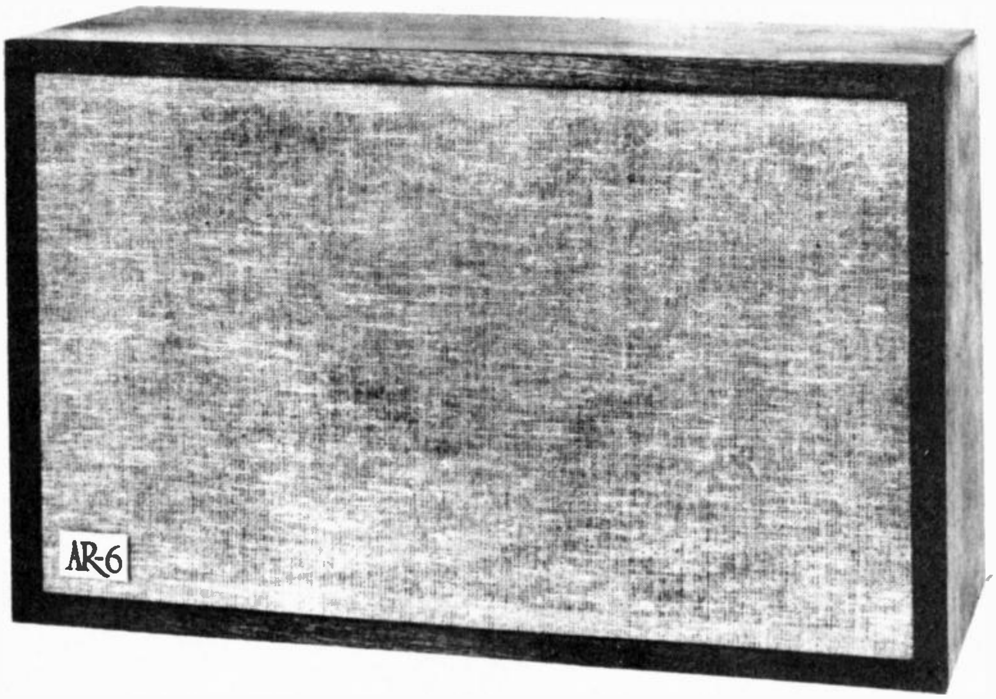
Now a new technique has been developed in the UK by Plessey Radar. The system obtains height information by transmitting a pencil beam which has a 'squint' in the vertical plane. The angle of this 'squint' is proportional to transmitted frequency.

Thus intercepted targets return echoes at frequencies that are directly to target elevation.





The AR-6 speaker system from Acoustic Research.



The least expensive speaker sold by AR (the AR-4x at $249*)is also the most widely sold of all high-fidelity speakers, because it has provided maximum performance per dollar of cost. The new AR-6 offers significantly better performance for $299.* It adds one-third octave of low distortion bass, and also provides superior dispersion and more uniform energy output at high frequencies. The seven inch depth of the AR-6 adapts it ideally to shelf placement, or it may be mounted directly on a wall with the fittings supplied with each speaker system.

Stereo Review says . . .

"All in all, the AR-6 acquitted itself very well in our tests. It was not quite the equal of the much more expensive AR models, whose sound it nevertheless resembles to an amazing degree, but on the other hand it out-performed a number of considerably larger and far more expensive systems we have tested in the same way. Incidentally, the AR-6 shares the AR characteristic of not delivering any bass output unless the programme material calls for it. If at first hearing it seems to sound "thin" (because it lacks false bass resonances), play something with real bass content and convince yourself otherwise. We don't know of many speakers with as good a balance in overall response, and nothing in its size or price class has as good a bass end."

High Fidelity says . . .

"Another great bookshelf speaker from AR . . . a really terrific performer. The AR-6 has a clean, uncoloured, well-balanced response that delivers some of the most natural musical sound yet heard from anything in its size/price class, and which indeed rivals that heard from speakers costing significantly more . . .

The response curves taken at CBS Labs tell a good part of the story. Note that across the largest portion of the audio spectrum and especially through the midrange the AR-6 responds almost like an amplifier . . .

Directional effects through the treble region, as evidenced by the average of 2dB that separates the three response curves, are actually less pronounced than we've seen in some costlier systems. Tests made of the effect of the tweeter level control show that it can vary the response from completely minus the tweeter to a steady increase in tweeter output of about 2 dB across its range. The design in this particular area is just about perfect . . . Pulse tests indicate virtually no ringing; in fact the AR-6 seems better than average in this regard too.

. . . a pair of AR-6s would be an excellent choice."

The workmanship and performance in normal use of AR products are guaranteed from the date of purchase; 5 years for speaker systems, 3 years for turntables, 2 years for electronics. These guarantees cover parts, repair labour and freight costs to and from the factory or nearest authorised service station. New packaging, if needed, is also free.

The AR catalogue and complete technical data on any AR product are available free upon request.

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BUBBLE MEMORIES

Japan's Ministry of International Trade and Industry are subsidizing a number of Japanese companies in their quest to produce bubble memories.

Hitachi have developed a 17 k memory on a 6.5 by 4.4 mm chip and NEC-Tohoku Metals have produced a 2400 bit chip.

Ultimate aim of the project is to produce a chip suitable for a mass filing system with 10 megabit capacity and 0.1 ms access time. To do this successfully chip size will need to be about 100 000 bits.

DOUBLE-SIDEBAND DMINISHED-CARRIER TRANSMISSION

With the increasing use of the v.h.f. bands for land-mobile radio, every idea must be tried to economise on channel spacing and to reduce interference. Research workers at Bath University (School of Electrical Engineering University of Bath, Claverton Down, Butt, England) consider that double-sideband diminished-carrier (dsbcd) transmitters will help. They have justified their claims in papers published recently in the Proceedings of the Institution of Electrical Engineers.

The design of a dsbdc mobile transmitter poses problems. Old designs either applied the modulation at a low power level and used a linear amplifier, or applied screen modulation to tetrode valves in a push-pull final amplifier. These methods are inefficient or power hungry, and do not suit modern mobile applications, in which semiconductor components are usually used. The new approach used at Bath University is to combine low-power-level angle (phase) modulation with high-level amplitude modulation to generate the required dsb signal.

The transmitter built on this principle operates in the 82 – 103 MHz band and delivers 15 W pep when operated from 12 V and 38 W pep when the supply voltage is increased to 18 V.

The microphone signal is amplified and then 'clipped' to increase the average speech power, and the bandwidth of the audio signal is restricted to 3 kHz. The phase modulation is produced by applying the audio signal to a zero-crossing detector, and the amplitude modulation is generated by full-wave rectification of the amplified audio signal.

The rf section of the transmitter is fairly conventional, with the addition of a balanced modulator used to phase-switch the carrier.

The output stage of the transmitter presents 35 dB of attenuation to the phase-modulated carrier – and angle-modulating functions is maintained at approximately 0.5°.

The design approach could be extended to transmitters of higher power ratings. With dsbdc the low average dissipation reduces heat-sink problems, making possible very compact designs.

THE GOOD OIL?

Advertising creeps in everywhere! Try this one on your pocket calculator.

426 46407 divided by 3, then multiplied by 5.

Now turn the calculator upside down!

SIMPLE PULSE MONITOR

A 'Pulse Watch' strapped to a patient's finger, monitors his pulse rate and reports the findings on a meter and with sound and a flashing light.

The Pulse Watch, (Model PW-404), manufactured by the Whittaker Corp, Waltham, Massachusetts, accurately measures a patient's pulse rate by optically sensing blood flowing in and out of a finger tip. Earlier systems required fastening electrodes to a patient with paste, restricting his movements.

The Pulse Watch is easily attached to a finger with a strap. The patient is free to move with the battery-driven device. Because a continuous reading can be obtained rapidly, the device is useful in hospital emergency rooms and to monitor changing rates during physical fitness programmes.

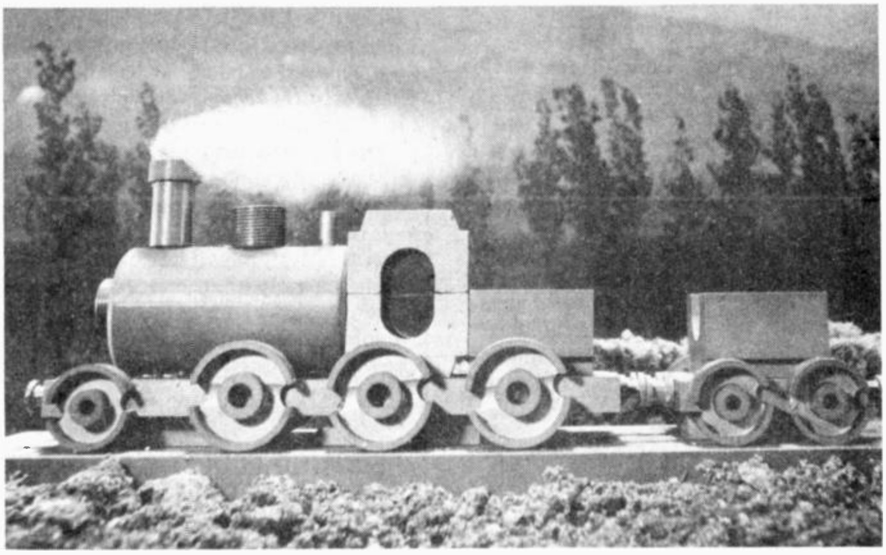
FOG METER

The ability of a driver to see in fog depends upon background light level as well as fog density.

Consequently both parameters must be checked in any fog monitoring system.

Instrumentation that does just that has been developed in the UK by Plessey Radar under contract to the Home Office Police Scientific Development Branch.

news digest



IRON HORSE

This small railway locomotive was built solely from ferrite cores by an ambitious model maker. Siemens manufactures several thousand different types of these components from magnetic materials containing iron (Siferrit). They are used for chokes, coils and transformers in practically all fields of electrical engineering and electronics. The pot cores used for the locomotive wheels, for example, are available with diameters of 3 mm to 80 mm.

NEW AM BROADCASTING FORMAT

Increasing mutual interference between AM broadcasting stations on medium and long waves is depreciating their main advantage – that of long-range reception. Even after the wave-plan conference planned for 1974/75, no great improvement can be expected in receiving conditions with double-sideband (DSB) amplitude modulation – the oldest method of radio broadcasting. Moreover, hopes for the single-sideband system (SSB) faded after the 1972 session of the European Broadcasting Union in Brussels.

Consequently, the independent sideband (ISB) system suggested by the Hamburg Institute for Radio Engineering has the best chance of success because it offers the same advantages as the SSB system with regard to bandwidth utilization, fading and interference. It could also be introduced without international agreement. Furthermore, the number of programme channels is doubled for the same number of transmitters.

ISB programmes cannot be received however, with present-day radio receivers. For this reason Siemens, on the basis of fundamental system studies and experiments, has developed two new module design concepts which involve compatibility of component technology and circuit design.

ISB programs require special receivers which isolate the two sidebands by at least 40 dB in the main range of audibility between 150 and 4000 Hz. A compression of the dynamic range of 30 dB is considered appropriate at the sending end. The two suggestions made by Siemens for an ISB receiver differ basically only in the method used for supressing the unwanted sideband. One method utilizes a thin-film 90° phase shifter (0.1% tolerance), operating in the range from 150 Hz to 4 kHz in one type of receiver, and in the range from 150 Hz to 2 kHz in the other type.

Since an ISB receiver is subjected to higher overall demands than a conventional receiver, there would be nothing to prevent the reception of SSB and DSB signals. Considerably improved DSB reception would at once be obtained owing to the possibility of selecting the side-band with less interfernece. This and a number of other features would induce an increasing number of listeners to make greater use of the short, medium and long-wave bands again. Also, the growth in the number of listeners might persuade broadcasting companies to offer additional programmes on AM, which would undoubtedly benefit the introduction of an ISB system.

For further information contact Siemens Industries Limited, Melbourne, Sydney, Brisbane, Perth, Newcastle and Wollongong.

PATIENT MONITOR DEVELOPED FROM NASA TECHNOLOGY

Remote medical monitoring techniques developed primarily for manned space flight and the technical know-how of a NASA Biomedical Applications Team have led to the development of a new, portable device able to monitor continuously the vital signs of high-risk patients in small hospitals, nursing homes or rehabilitation centres.

Now available commercially, the 1.8-kilogram device, called Vitasign Attendant Monitor, is designed to operate from existing patient call systems and conventional electrical outlets.

The device makes available at moderate cost the continuous patient monitoring techniques previously found only in the intensive care limits of large hospitals.

To operate the device, three electrodes are placed on the patient's chest. These monitor his ECG (electrocardiogram) and respiration rate. A loss or sudden change in the ECG signal or changes in the normal respiratory cycle automatically switches on an alarm light on the unit and activates a signal at the central call station to alert medical attendants.

Initial development work on the monitor was carried out by the NASA Biomedical Application Team at the Southwest Research Institute, San Antonio, Texas. A prototype was built and successfully tested at the Caruth Memorial Rehabilitation Center in Dallas.

Drawing on this technology, and working closely with the Southwest Research Institute, a medical instrumentation firm named Modern Medical Methods, Inc. (P.O. Box 4824, Wonderland Station, San Antonio, Texas 78285), designed and built a commercial version of the device.

The Vitasign Attendant Monitor is expected to be particularly useful in monitoring patients with cardiac diseases, muscular dystrophy, cerebral palsy, tuberculosis, emphysema and cystic fibrosis.

300 WATT FET'S!

High-power field-effect transistors have been successfully developed by Japan's Yamaha company.

The devices were originally invented by Prof. Jun'ichi Nishizawa of the Electronic Telecommunications Research Laboratory of Tohuku University.

A prototype audio power amplifier

news digest

using the new devices has already been demonstrated by Yamaha and plans are well in hand to produce a production version early next year.

The output stage of the prototype unit have high power FET's rated at 300 watts. Voltage amplification of the output FET's is 5, breakdown voltage over 200V, and drain current is 10 amps.

Some details of the prototype unit have been released. The brief specifications are — output 150 watts per channel into 8 ohms over full 20 Hz to 20 kHz bandwidth. Total harmonic distortion at 100 watts is less than 0.01% (at 1 kHz), frequency response is 5 Hz to 100 kHz within 1 dB.

Amplifiers using power FET's have also been produced by Pioneer, Toshiba, JVC and Sony, but we understand that Yamaha are the only company so far to have overcome problems of high current dissipation — apart from which they appear to hold all the patents.

DOLBY CRO2 PRE-RECORDED CASSETTES

The Advent Corp. (Cambridge Mass.) have just announced that they are producing Dolbyized pre-recorded chromium dioxide cassette tapes.

Programme material is from Nonesuch Records and also the Connoisseur Society's catalogues.

At the time of closing for press it was not known if these cassettes will be available in Australia.

NEW BIG CASSETTE

As reported in ETI last month, BASF are believed to be about to launch a new cassette format for high quality hi-fi and professional use.

The cassette, which is about the size and shape of a paper back book uses ¼" professional quality tape.

It now seems that almost certain that this system will be commercially available early next year. AIWA have recently shown a prototype cassette recorder designed specifically for this new BASF 'Unisette' system.

REDUCING ACOUSTIC FEEDBACK IN PUBLIC ADDRESS SYSTEMS

Acoustic feedback caused by microphone proximity to public address amplifiers and sound gain clashes with room frequency resonances, is significantly reduced by a frequency shift system developed in Britain by Millbank Electronics (Bellbrook Estate, Ackfield, Sussex)

Consisting basically of a plug-in power board, the device uses integrated circuitry and incorporates an upward shift of the frequency spectrum by 5 Hz. It operates over the audio wave band from 35 Hz to 20,000 Hz and is of modular construction.

The principle of shifting the frequency spectrum during the amplification process so that, for example 50 Hz becomes 55 Hz, means that the sound reinforcement 'spillage' picked up by the microphone differs by a few Hertz from the original sound. Thus feedback takes place at a much higher reinforcement sound output and is determined more by the room resonances than by any other factor.

The small frequency shift does not affect normal speech and music applications and goes some way to eliminating the effect of room acoustics upon the actual sound being reinforced. The manufacturer states that by using amplifiers incorporating the new system, improvements in the effective loudness of a sound reinforcement installation can be as much as 6 dB.

NOISE REDUCTION SYSTEM FOR RECORDS

Perhaps the first really serious rival to the Dolby Noise Reduction system is Dbx Inc's dbx record encoding system.

Whilst Dolby has so far been used primarily with cassette tapes, dbx is intended for use with gramophone recordings.

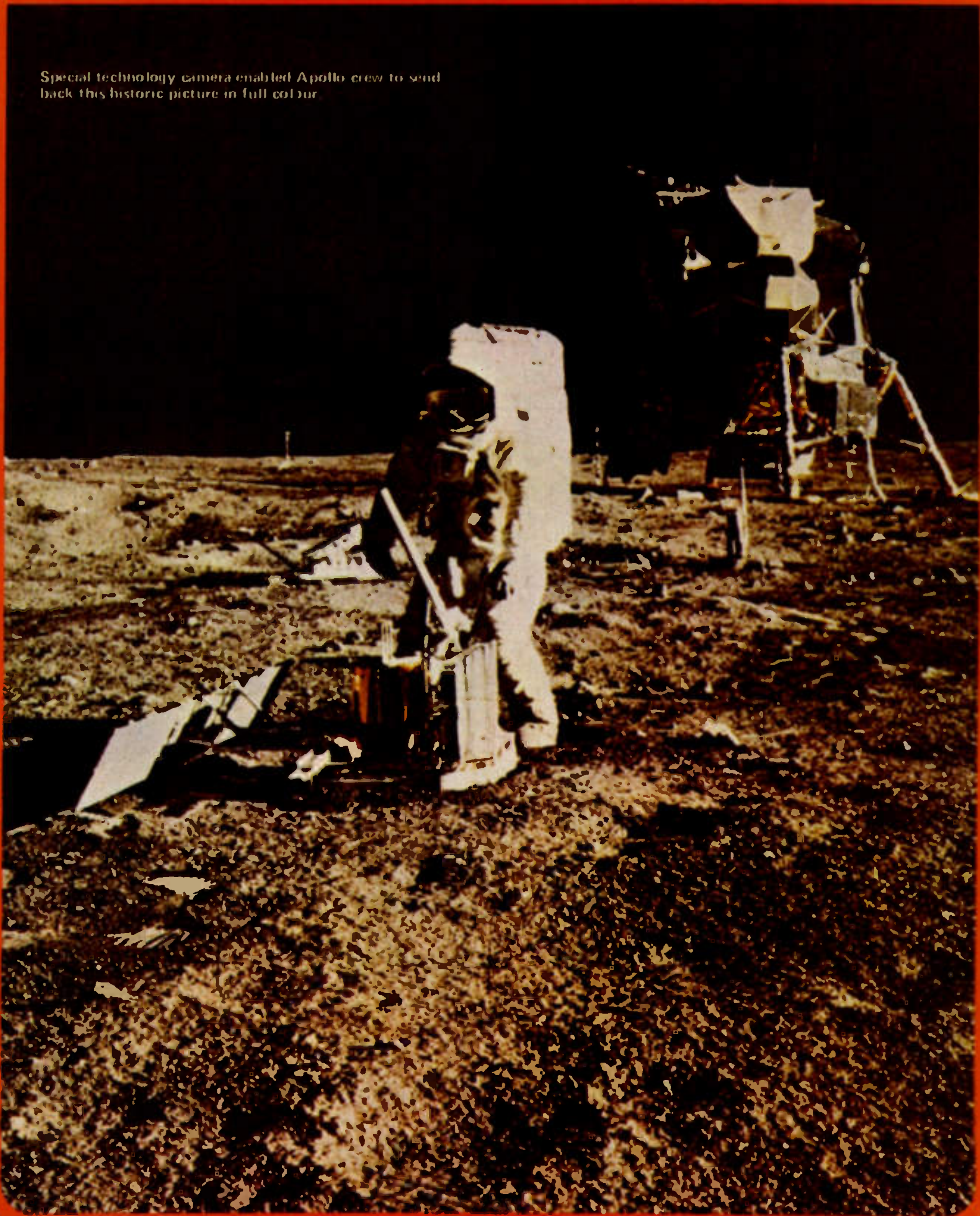
Basically dbx is a process of recording gramophone discs in such a way that the signal is electronically compressed by a factor of 2:1. It is then expanded by a 1:2 factor on playback. The nett effect is to reduce noise. Dynamic range is also increased.

The system is very effective and dbx-encoded records heard so far have quality close to that normally only heard on studio master tapes.

As with four-channel sound, the technique will only catch-on if record manufacturers are prepared to produce dbx-encoded material. Present indications are the recording industry are at least seriously considering the system and dbx-encoded demonstration discs have been produced by Klavier and Creative World.

PICTURE TO SIGNAL

TV camera tubes have come a long way since Baird. Here's how they work.



Special technology camera enabled Apollo crew to send back this historic picture in full colour.

WHEN WE USE OUR eyes to look at any scene, there are two features in particular which the eyes convert into signals to pass to the brain. These are hue and brightness.

The hue is what we can describe as the colour; the eye not only detects this but also the degree of *saturation* of the colour, how pure it is or how mixed with white to make a pale colour.

The brightness information is more important, for it tells us more about the shape of the object, and can operate at lower light levels. All this information is received by the eye as light waves which come in diverging paths from any object.

What happens to the light rays inside the eye is of considerable interest, not only to specialists in the eye but also from the point of view of the electronic engineer, since television systems operate in ways which must match the action of the eye.

In each case, there has to be an imaging system — a lens, which makes the diverging light rays from an object *converge* to form an image. That image must be formed on some sensitive layer which can convert the light intensity and hue into electrical signals for transmission.

In the eye, this is done in the retina, and the signals are transmitted along countless nerves to the brain.

In a television system, the job of converting image to signal is done in the camera tube, but we cannot have countless channels; the information must eventually end up as one electrical signal to be transmitted. It is because of this last restriction that the camera tube is so unlike the eye in detail.

BREAKING UP THE SIGNAL

To transmit picture information in any way other than as light, involves splitting up the picture into pieces. There is always more information than we can cope with.

Even light is itself not a continuous wave but stops and starts irregularly in groups called *quanta*, but these bits are too small for our purposes; we must break up the picture into a number of bits which we can handle.

The eye does this by having the retinal surface made of sensitive fibres, the 'rods and cones', so that the number of rods and cones determines the number of bits into which the picture is broken. Each sensitive portion has a 'wire' (the nerve) linking it to the brain, so that an image is broken into bits, and the hue and brightness information on each bit is taken to the brain at the same time.

As we said earlier, we cannot have a separate channel for each piece of information, so we cannot transmit all the bits of our picture at the same time. The only way in which we *can* transmit all the pieces of a picture is by transmitting them in sequence: this is the process of scanning.

If the picture is scanned in sequence at the transmitter and each piece of information transmitted as it is scanned, then a similar sequence at the receiver should reconstruct the picture. This is the heart of the television system, and a television transmitting tube must therefore be able to convert an image into an electrical signal and then to scan it so that only one bit of information at a time is transmitted.

PICTURE TUBE PROBLEMS

The early mechanical systems of television carried out the scanning by means of perforated wheels, but totally electronic television camera tubes have now been with us for as long as high definition television.

High definition means that the picture is broken into a large number of pieces, so that fairly fine detail can be seen, not simply the outline of shapes.

The development of such tubes has occupied men of great inventiveness and intellect and has resulted in the remarkable achievements which we take for granted today, but in every case the operation of these tubes involves a number of compromises in order that the system as a whole can work.

For example, the number of bits into which the picture can be broken, which determines the resolution of the picture, is affected by several parts of the whole television system. The normally favoured scanning system is into lines, and the resolution of the picture is affected by the number of lines. But we cannot simply decide to have more lines so that we may have more resolution. The scanning spot of the receiver cathode ray tube may be too large to show a number of closely spaced lines as separate parts, as also may the scanning spot of the transmitting tube. In addition, the greater number of lines means taking up more channel width, so that we can have fewer transmissions. Similar conflicting factors affect every part of a television system, so that the camera tube must be tailored to fit the remainder of the system, and be at least of a comparable performance.

On the face of it, we need only two sections in a camera tube, one to convert the image on the face of the tube into an electrical signal, another to scan the electrical signal and "read out" the information on each picture bit to the transmitter. This we find to be insufficient.

The conversion of light image to electrical signal is not an efficient business, and the materials used convert only a small fraction of the energy of the light into electrical energy — with different efficiencies at different colours. What is more, the signal coming out carries no colour information. The result is that using the electrical signal direct from the conversion of light to electrical signal gives us insufficient energy, so that early television worked only under lighting of ferocious power. For this reason, all camera tubes incorporate the idea of storage.

At each part of the picture, light energy is converted into electrical energy, but the electrical energy is stored, and built up until it is scanned and removed. The electrical output is not therefore that present during the microsecond or so that the scan spent on that part, but the amount built up between scans, which is a very much longer time, several thousand times longer.

The use of this principle has resulted in the high sensitivity obtainable today; but materials are still not available to enable the scanned signal to carry colour information, though some ingenious recent tubes have achieved colour coding inside the tube. In most cases, the colour information has to be gathered by having separate tubes working on separate colours, and we are fortunate that only three 'primary' colours, red, blue and green, are needed to re-create any colour found in nature, (and a large number which are not). Since the colour information does not involve any difference in the camera tube (except in the case of the specialised tubes mentioned), we need not mention it further, but will look at the types of

Portable colour TV camera from Toshiba.

PICTURE TO SIGNAL

tubes used in television camera work.

THE VIDICON

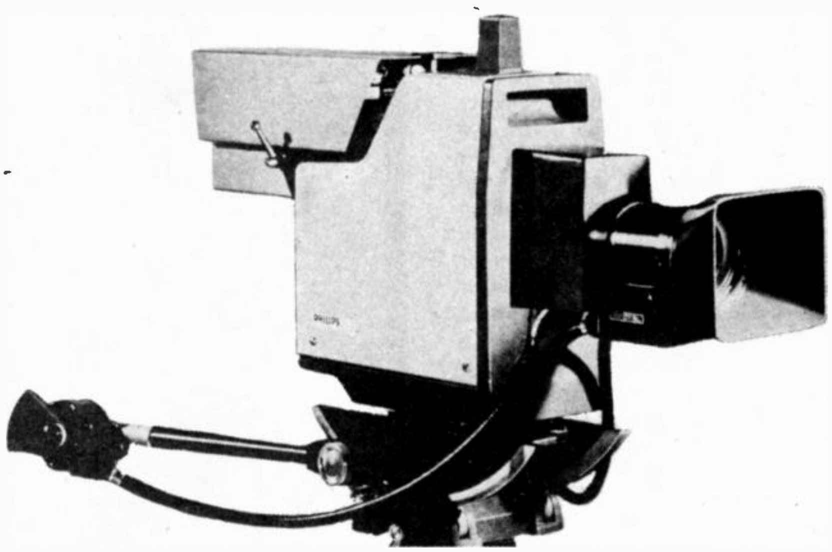
This tube is considerably smaller than other types, and exists in a number of types according to the material used for light sensitivity. Since the tube works in the same way, we need not bother too much about this at the moment, but the differences are of importance later.

The conversion of light information into electrical signal is performed by a photoconductive material, whose electrical resistance changes with the amount of light falling on it. It is very high (in the region of megohms) in the dark, and low when illuminated, the amount of the resistance depending directly on the light level.

In the "traditional" vidicon, this material is antimony trisulphide, in the more modern type of vidicon, a form of lead oxide is used. This material has a dual role, since it acts also as the means of storing the electrical information. These substances will polarise in an electric field, meaning that if they are sandwiched between conducting plates with a voltage across them their molecules will charge so that one part is negative and the other end positive. This is the familiar action of a capacitor, and normally we use insulators for this job; there is no reason for not using conductors except that they would lose the charge too quickly. If we use poor conductors, then the charge will be lost only slowly, and as it turns out, this is ideal for our purpose.

Imagine then, a glass plate which has been treated with stannous chloride at a high tempeature. This treatment makes the glass a conductor along the treated surface, so that it transmits light and can have an electrical contact made to it. On the conducting side there is now deposited a thin film of photoconductor, antimony trisulphide or lead oxide (Fig. 1).

Suppose now that we make contact with the photoconductor, and connect the glass to a positive voltage of about 40 V. With no light falling on the glass, the photoconductor does not conduct, so that the glass side remains at 10 V and the other side remains at zero volts. If some light now shines on this sandwich, the photosensitive material conducts, and some of the 10 V present on the glass appears on the other side. How much? It depends on the resistance of the connection we have made, which can be kept constant, and on the level of light. What is more, the material will act as a capacitor, and the voltage will build up with time, giving us the storage which we need. The whole assembly acts as a capacitor shunted by a resistor whose value depends on the light intensity.



This model LDH 20 colour TV camera from Philips is equipped with three + 25 mm plumbicon tubes — adaptors enable it to be used with vidicons if required.

SCANNING

Reading the information from this sandwich is done by a scanning electron beam. The beam must have a very small spot size, since this directly affects the resolution. Fortunately this is not difficult to achieve, but some care has to be taken that the beam current is not cut down too much to achieve a small spot, otherwise the signal out will be very small, and the signal-to-noise ratio will be poor.

The beam has then to be caused to scan so that it arrives at the sandwich structure, the target just described, at right angles to the surface and scan across and down in the familiar TV pattern. This task is made easier by the small size of the vidicon; it is always easier to achieve precise scanning of a small area than of a large area. As it scans the target, hitting the surface of the photosensitive material, it acts as a high-resistance contact connecting the target surface with the electron-gun cathode wherever it touches. As it does so, any voltage built up on the surface of the target at that point is discharged, as would be a capacitor.

This action does not depend on the resistance of the material; it is the action of a capacitor, and it causes an equal amount of current to flow in the contact to the glass (Fig 2). The amount of current is that needed to charge the target up again to its original level (zero volts on the gun side, 10 V on the glass side), and is proportional to the amount of charge, which in turn is proportional to the amount of light which discharged the target between scans. The current which flows to the glass contact in this way is the signal current, and it can be amplified in the usual way.

THE COMPLETE ACTION

Consider now the complete cycle of action at any piece of the target while a scan is being televised. An image of some scene is focused on to the glass side of the target, so that some areas are brightly lit, and others are darker. Imagine one portion, neither fully lit nor totally dark. On the glass side of the photoconductor, the voltage is maintained at +40 V by the power supply. Assuming that the scan has just passed, the action of the photoconductor is to allow the voltage on the electron gun side to rise towards 40 V.

The rate of rise depends on the capacitance between the two sides of the photoconductor, which is fixed by the type of material and the thickness of the layer, factors which remain constant after manufacture, and also on the resistance, which depends on the light level.

The portion which we are looking at is therefore rising in voltage at a rate which depends on the light level. If there were no scan, it would continue to rise (though not at a constant rate) until it reached +40 V. Because of the scan, however, it rises only part of the way when the beam scans across, the capacitance is recharged down to zero volts, the current flows in the glass contact, and the action of that part of the target starts again.

The vidicon relies so heavily on the properties of the material and for its target that it is not surprising that the choice of material is very critical to its operation. When antimony trisulphide is used, the main problem is "vidicon lag", which is a problem of storage, causing a changing picture to appear smeared, as if the previous image were not wiped clear before the next one appeared. This is, in fact, exactly what is happening, and it is most troublesome when the vidicon is operated at low light levels with moving subjects.

This problem became acute with the advent of colour television. The cameras used had three vidicons, one for each colour, and each individual vidicon thus dealt with less than at the total light.

As a result, development of lead oxide surfaces was speeded-up, and this work, due to Philips, has resulted in much improved vidicon behaviour. Nowadays the lead oxide type of vidicon is used almost in all colour cameras.

Work on vidicon target materials is not complete, and the most promising recent reports have been on silicon photodiode arrays. A sheet of dots of silicon, each a miniature photodiode, forms the target for this type of vidicon. The construction follows the familiar methods used for integrated circuit construction, and the advantages spring from the greater control over the process, and from the fact that each miniature diode is isolated from its neighbours rather than being part of a sheet of material. So far, the difficulty has been that of creating a sufficiently large target surface free from defects, since one faulty diode can be detected as a spot in the final picture.

IMAGE ORTHICONS

Despite the large number of lead oxide vidicons in use in colour cameras, the image orthicon is still the most used camera tube world-wide. The principles of the image orthicon are totally different from those of the vidicon; it is a tube which has "grown up" with television itself, as it can trace its ancestry back to the earliest types of camera tube.

The image orthicon can be divided, for the sake of understanding its action, into three distinct parts. These are the image section, (Fig. 5), where the light image is turned into an electrical signal, the target section (Fig 6), where the electrical signal is stored in the form of charge, and the scanning section, where the charge signal is scanned and the information extracted from it and amplified within the tube.

THE IMAGE SECTION

This part of the tube consists of a thin film of photo-emissive material deposited on a glass plate. The film is made from a complex mixture of materials, the metal caesium and the semiconductor antimony being the most prominent. When light shines on

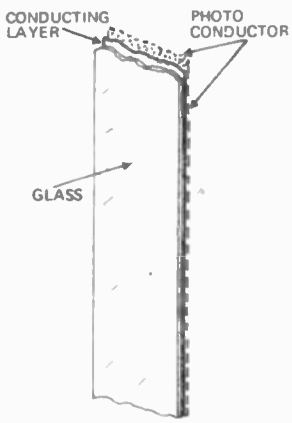


Fig. 1. Magnified cross-section of Vidicon target.

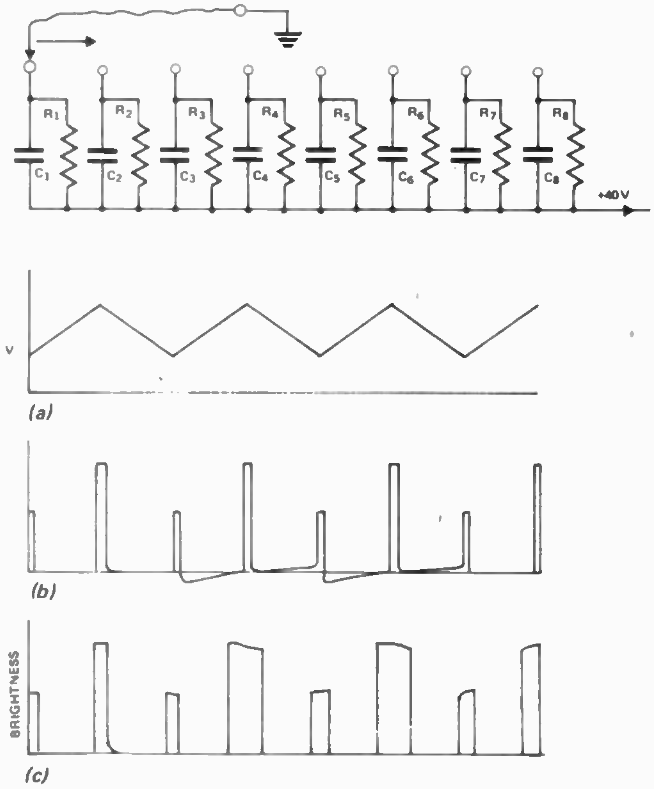


Fig. 2. Action of target. The equivalent circuit is of a set of capacitors with variable resistors (controlled by light intensity) in parallel. The beam scanning action is to earth one side of each capacitor in turn and then disconnect. As each capacitor is scanned, its beam-side plate is clamped to zero volts. The voltage will rise as the capacitor discharges through the resistor in parallel. The amount of the rise achieved in one scan time depends on the value of the resistor. (a) Typical voltage waveform for light and dark areas. (b) Current flowing in common circuit as capacitors are discharged. (c) Brightness pattern on the tube face.

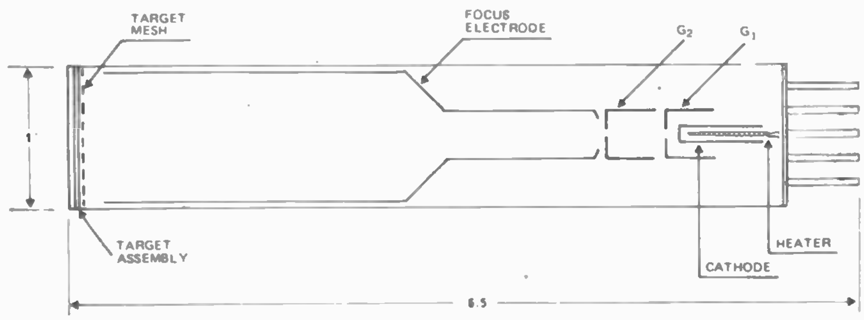


Fig. 3. Complete vidicon assembly. The target mesh exists to act as an anode for electrons which do not land on the target.

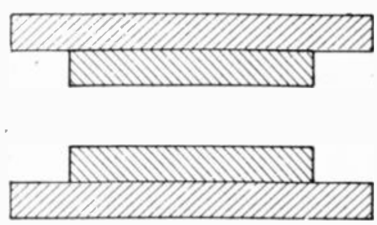


Fig. 4. Scanning/deflection coil cross-section. The coil assembly fits over most of the length of the vidicon.

such a material (which must be formed and kept in a vacuum), electrons are released, and the current which can be drawn from the surface depends on the intensity of the light. To draw this current, an accelerating voltage must be used, and this must be in the region of 1000 V. By using electrodes of carefully designed shape, the electrons leaving the photocathode, (as the film of photoemissive material is known) can be made to keep the relative positions which they had as they left. In this way, an 'image' of electrons exists at any plane parallel to the photocathode, and electrons landing on any surface on such a plane should recreate an image in the form of electric charge, since each electron is a unit of electric charge.

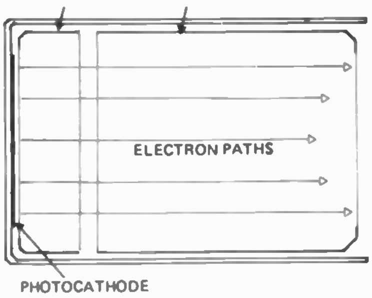


Fig. 5. Image section of Image Orthicon. The photocathode releases electrons in numbers which depend on the light level, and the electrons are accelerated by the G6 and target cup towards the target.

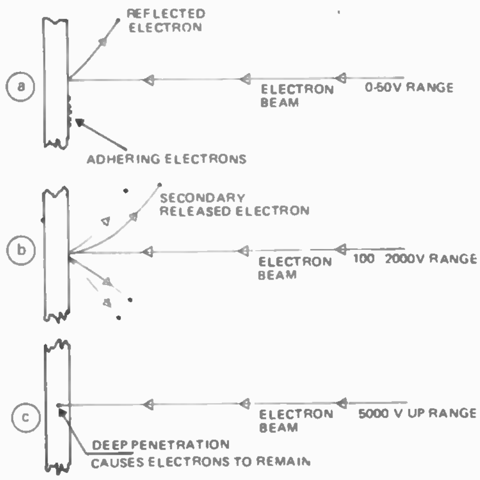


Fig. 7. Secondary emission. (a) At low accelerating voltages, the electrons stick to the surface or reflect. (b) At higher accelerating voltages, more electrons come off the surface than reach it, so that an insulator surface becomes steadily more positive as the electrons hit it. It cannot become any more positive than the most positive electrode near it. (c) A very high accelerating voltages, electrons penetrate so deeply that there is no return, and an insulator becomes steadily negative.

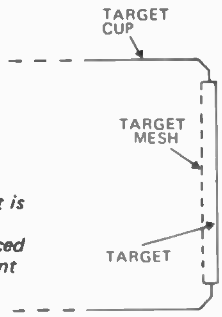


Fig. 6. The target assembly. The target is of glass, the target mesh of copper spaced about 0.001" in front of the glass.

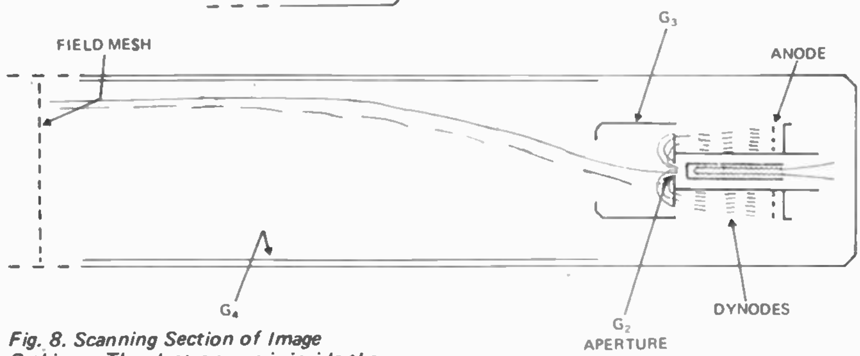


Fig. 8. Scanning Section of Image Orthicon. The electron gun is inside the dynode assembly, and projects a beam towards the target. The beam is focused and scanned by the coil assembly. The electrodes, particularly the field mesh, are arranged so that the beam approaches the target at a low speed and at right angles to the target surface. The return beam hits the G_2 surface, which is also the first dynode, releasing large numbers of electrons, which are then multiplied in turn by the remaining dynodes. The final signal is obtained from the anode connection.

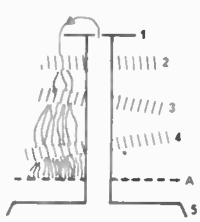


Fig. 9. Dynode assembly. The dynode consists of fine metal vanes and mesh coated with the metal Caesium, which is a good secondary emitter.

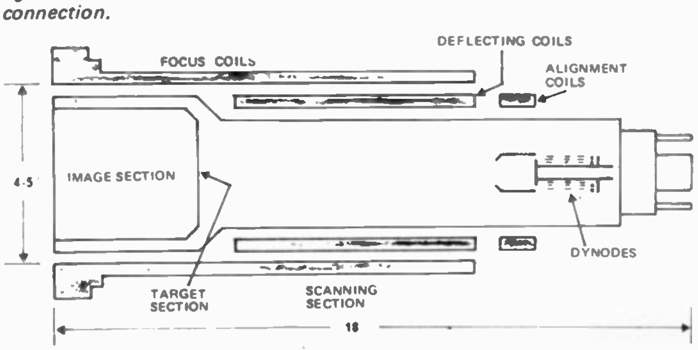


Fig. 10. Overall section of Image Orthicon. Note the complexity of focus, scan and beam alignment coils.

THE TARGET SECTION

The target of the image orthicon is a thin film of glass which is slightly conducting. This is no ordinary glass, but a material which is able to conduct by flow of electrons through it, and it is made as a very thin film, less than a thousandth of an inch thick.

Two properties of this material are used. One is the now-familiar idea of charge storage, using the glass as one plate of a capacitor to store charge, the other plate being the target mesh. The second property is 'secondary emission', a property of all substances but little known outside this field of electronics.

When a surface is hit by electrons, the way in which it is affected depends on the speed of the electrons. Very slow electrons, accelerated by only a few volts, simply remain on the surface or bounce off. The electrons which remain cause the surface to be charged negatively, unless there is a conducting path to discharge it. When faster electrons are used, accelerated perhaps by several hundred volts, the energy of the electrons can cause the target material to release some of its *own* electrons. For each electron that surfaces, there may be more than one released, so that the surface, if it is an insulator, charges *positively*, as it is losing *negative* electrons.

The voltage which exists between the photocathode and the target is enough to ensure that this condition exists, so that the electrons striking the target from the photocathode leave more than their fair share of charge behind them. If the electrons from the photocathode have retained their relative positions so as to form an image, they will leave an image of charged areas on the target after the secondary emission process has taken place. The formation of a true charge image can take place only if no electrons return to the target; as the target is positively charged by the secondary emission process, this is likely to happen unless there is a more positive surface to attract the electrons. This, however, must be able to distinguish the secondary emitted electrons which must be trapped from the electrons from the photocathode, which must be allowed to pass through with as little impediment as possible. This rather difficult task is performed by a metal mesh of very fine texture (750 lines per inch in each direction) which is spaced close to the target on the photocathode side and which also acts as a capacitor plate. The rapidly moving electrons from the photocathode pass through the holes in the mesh, though a rather large fraction (about 40 per cent) is intercepted. The mesh is held at about 2 V positive, and the slow-moving secondary electrons are readily trapped.

This established the charge image on the target, it only remains to scan it and take the signal out.

THE SCANNING SECTION

One of the peculiar advantages of the image orthicon, over earlier tubes, is that the target is scanned from the opposite side from the photocathode, so that there is some degree of isolation between the photocathode imaging magnetic fields and the scanning fields. This is possible because the target is made of a glass which conducts slightly through the thickness of the film, but very little across the surface. Because of this, the positive charge which appears on the photocathode side appears also on the scanning side of the target. The resistance of the glass is so high though that we cannot make use of a beam current to the target to form a signal.

Instead, the beam which scans across the target from the electron gun is made to strike the target at such a low speed that the main part of the beam returns down the tube to the gun. How much of the beam will return depends on the conditions at the target. If the beam is scanning over a positive portion of the target, the electrons of the beam will land on the positive target until the surface is discharged. If the beam is scanning over a more negative portion of the target, most of the beam will return, as there is much less charge to replace. The return beam therefore carries the charge information, being dense where the beam has scanned a more negative target area (low light level at the photocathode) and thin where the beam has scanned a more positive area (high light level at the photocathode). Unfortunately, because the spot size of the beam must be small, the beam current is very low, and amplification of such a small signal would be difficult and would give signals of very poor signal-to-noise level.

The solution is to amplify the beam current variations noiselessly within the tube itself.

On the way back to the gun, the return beam strikes a surface called the first dynode; a surface of metal at a high voltage (about 500 V) and coated with a material which is a good secondary emitter. Four or five secondary electrons are released, for each electron of the return beam landing on the first dynode. This represents an amplification of the beam signal four or five times.

This does not finish the process, though, for the secondary electrons can be accelerated in turn to a second dynode so that each one releases another four or five, and the process may be continued to five dynodes before the final anode at which the total current of the amplified beam signal is available. Because no other electrons are involved, this process of multiplication, as it is called, adds practically no noise to the signal, and enables a usable signal output to be obtained from a beam signal too small to be used at the light levels now common. Each dynode must, of course, be run at a voltage rather higher (several hundred volts) than the previous one to ensure that the electrons released from one dynode are attracted to the next.

OVERALL ACTION

The overall action is as follows; assume an image of half light, half dark across one line. The image on the photocathode causes electrons to be emitted — in large numbers on the bright side, very few on the dark side. These electrons are accelerated, without changing positions, to the target. The electrons from the bright side of the photocathode cause the target to have a voltage of several volts positive (relative to the gun cathode) and the electrons, few in number, from the dark side leave the target at its natural voltage close to the voltage of the gun cathode. Because of the conductivity of the cathode, the voltages appear also on the other side of the target. On this other side, the electron gun scans with a fine-spot beam across the target. As the beam scans across the half which is positive, (corresponding to the bright side of the photocathode), the beam lands, and very little of the beam returns. On the other half of the scan, where the target is at low voltage (corresponding to the dark portion of the photocathode), the beam is almost totally reflected. The return beam, whose current depends on the state of the target, has its fluctuations amplified by the dynodes. Finally the signal emerges as a current signal at the final anode. Note that the action of scanning has left the target on the scanning side at a uniform voltage, and the time between the scans is available for charging up the target again, so giving the storage action required.

PROBLEMS AND DEVELOPMENTS

The target action has proved to be the greatest headache in image orthicon design and used for the conductivity of the target is most critical.

If the conductivity is low, then the scanning beam will be unable to wipe off the signal from the photocathode side, and the target will be 'sticky', meaning that a scene will remain, giving an output signal after the tube has been pointed at another scene or capped up; this, of course, makes the tube useless for scenes having movement.

If the conductivity is too high, the charges may move sideways on the target and so cancel each other out, giving a low signal output.

Before the invention of the electronically conducting target, due mainly to Peter Banks of E.E.V., problems of this sort were endemic, and it was accepted that the life of an image orthicon would be a short one due to target deterioration.

The new types of target have changed this dramatically, and excellent working is achieved provided that the target is run at the correct temperature — since its conductivity varies with temperature. Cameras for image orthicons have always incorporated thermostatically controlled heaters and blowers to keep the target of the tube at a constant temperature.

The main development of recent years concerns the use made of the beam. It is rather illogical that the return beam should be most dense in the part of the target corresponding to low light, for a large return beam density means greater noise in the signal just where the signal is small and can least afford greater noise. The image isocon is a development of the image orthicon, which makes use of the different type of reflections of electrons at the target to separate the signal-carrying electrons from the remainder which make up the steady beam current. This gives an enormous increase in signal-to-noise ratio, enough to enable the isocon to be used in applications where the light level is too low for normal vision. Such tubes are even more of a precision job than the image orthicon, and so are not in quantity production, but have undoubted applications.

SUMMING UP

The camera tubes used for television purposes are remarkable achievements in electron beam technology, and at the moment there seems nothing likely to replace them from the "solid-state" stable. The scanning operation is the most difficult to replace, an operation which is comparatively simple to carry out on an electron beam presents most formidable difficulties in a solid array; the problem is not impossible, and has been solved after a fashion for low definition pictures, but its extension to the high-definition picture to which we are accustomed is fraught with difficulty. It seems likely that we shall be living with the vidicon and its larger cousin, the image orthicon, for a long time to come.

After you don't believe the way the brand new decks sound, you won't believe the way they're priced.

The beauty of Pioneer's cassette decks is the way they reproduce high fidelity sound from unbelievably tiny cassettes. In fact, no others on the market with prices comparable to Pioneer's new CT-5151, CT-4141A, and CT-3131A give you so much sound for the money. Take, for instance, CT-5151, the top-notch among the three featured here. With a frequency response range from 30 to 16,000Hz, a built-in Dolby* noise reduction unit, and long life ferrite solid tape head, you're going to want to compare CT-5151 with most of the expensive reel-to-reel decks. CT-5151 is, indeed, loaded with a lot more features like normal/chromium dioxide tape selector (bias/equalizer independently switchable), full-automatic stop mechanism, tape running pilot light, peak level indicator, over-level limiter, electronically controlled DC motor, and even a memory rewind switch. If you've ever doubted the sound quality of cassette tape, now's the time to hear it all over again. On the CT-5151, CT-4141A, and CT-3131A, just a few of many quality high fidelity products made by Pioneer. To see and listen to them, please contact your nearest Pioneer Dealer.

Dimensions:	15⅝(W) × 9½(D) × 3¾(H) inches.		
Weight:	CT-5151	10 lb.	9 oz.
	CT-4141A	10 lb.	6 oz.
	CT-3131A	9 lb.	11 oz.

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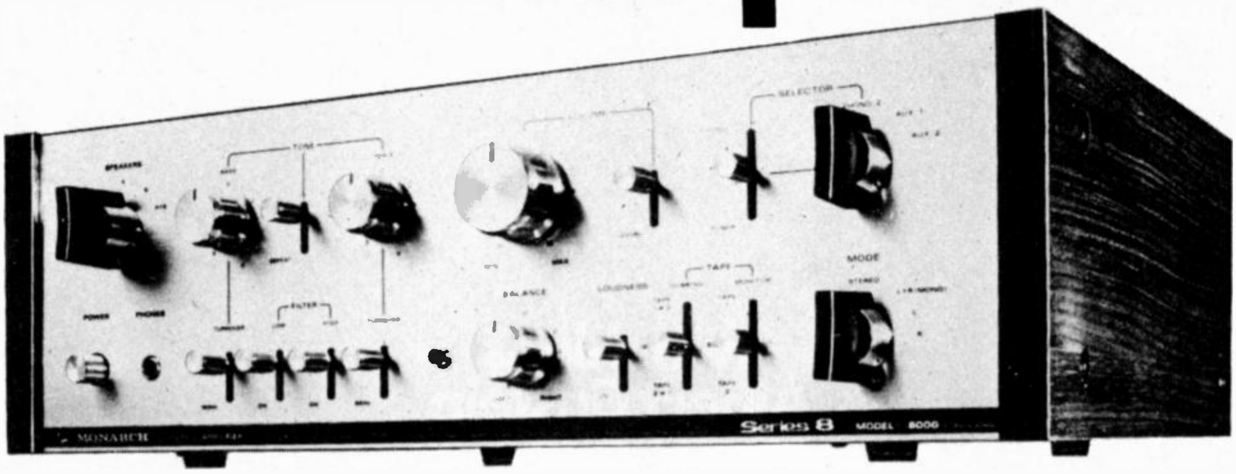

When people already think of one name as the best value for money, they naturally expect every new model to maintain the same high standards — or improve on them. So, Monarch's brilliant new Series 8 amplifiers will come as no great surprise.

No surprise — even though we've created a superb new amplifier, top-of-the-range Monarch 8000 to bring you continuous RMS power of 55 watts per channel at 8 ohms, with distortion of less than 0.1%; even though we've included tape dubbing and turnover controls; even though we've produced a frequency response of 10 Hz to 60,000 Hz; even though we're presenting three other new Monarch amplifiers — the 80, 88 and 800, which feature dramatic improvements in power and efficiency. It's no great surprise — because you *expect* Monarch to be the best . . . And it is, so all Monarch amplifiers remain "kings" on a power-to-performance-to-cost rating.

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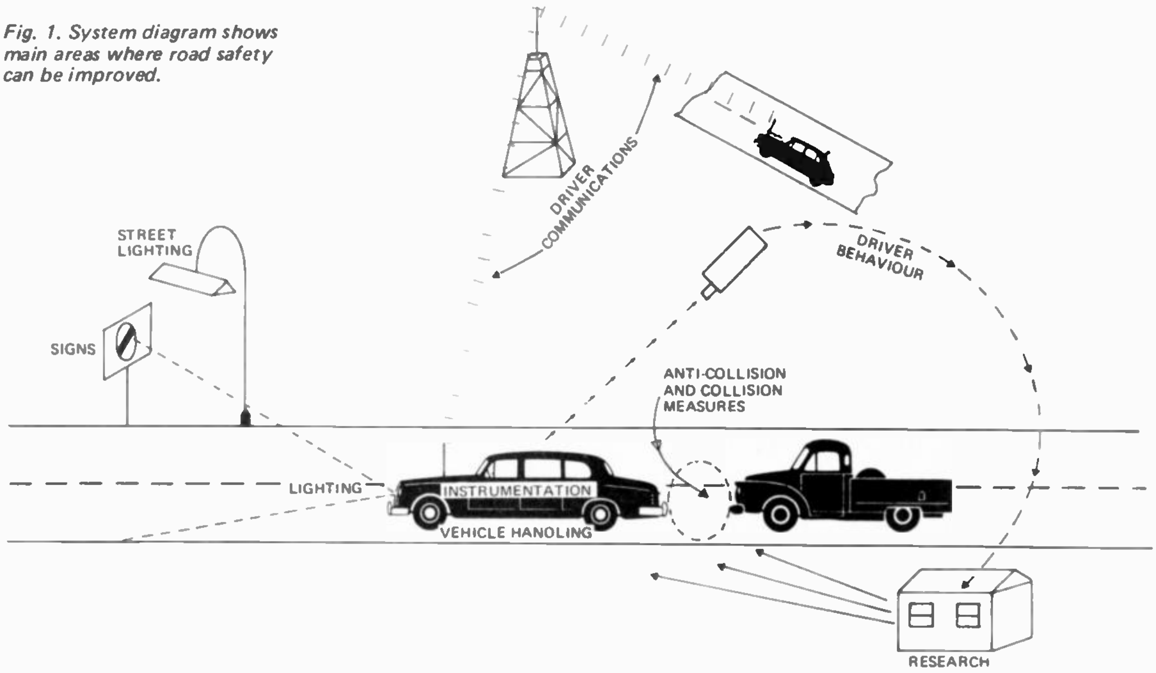


Fig. 1. System diagram shows main areas where road safety can be improved.

An Experimental Safety Vehicles and associated Road Safety Exhibition has just been held at Britain's government sponsored Transport and Road Research Laboratory.

Electronics Today's special correspondent Dr. Peter Sydenham went along to report.

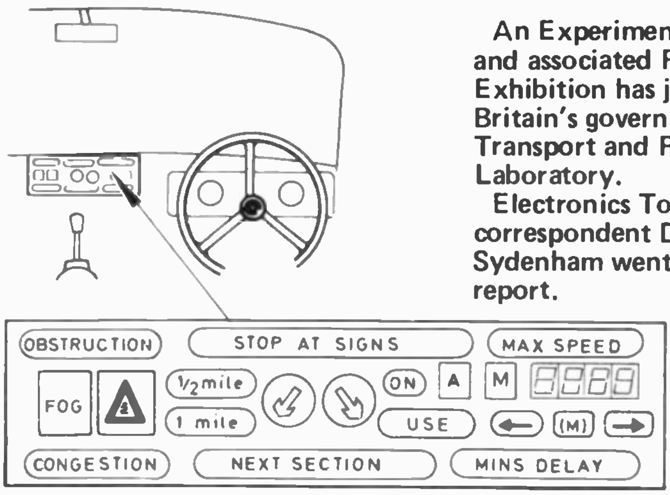


Fig. 2. Indicating panel of advance warning equipment 'AWARE'.

SOME road accidents may well be inevitable, believe many road research workers.

A driver has to make too many virtually instantaneous decisions as his vehicle progresses through a seething mass of hopefully well-controlled movement. Too often speed and the number of events are beyond his capability to react correctly and in time — and accidents occur.

Hence, any economic method of improving the available data will help the driver improve quality of decisions — and this will improve safety.

But the driver cannot take in up-dated data at a rate faster and more distant than his senses can perceive. Better communications are required.

Radio is an obvious way to improve communication and the BBC are working on a plan that will provide motoring information at all times, rather than relying on disk jockeys who give it at present.

The proposal is that network groups of single frequency stations be created at 50 km separations working on an exclusive medium-wave frequency to ensure easiest reception.

Time-multiplexing the stations in a group will put sixteen of them on the air together at any one time, sending a thirty second message. This way a vehicle will receive data at eight minute intervals and the problems of interference will be largely avoided.

An override control will enable a central transmitter to speed up the interval time to cope with more urgent messages. These groups would be repeated with minimum distances of 200 km between identical transmitters to reduce mutual interference.

There is also talk of an international motoring service that would extend the concept beyond Britain into the all European community. As the reception is at a single frequency the receivers would be inexpensive.

The use to which the system can be put is widespread. A traveller in each group area can be informed of bottle-necks to avoid and of approach into fog or rain; police messages can be sent more readily and so forth.

The system provides communication in the macro road system but would

approach

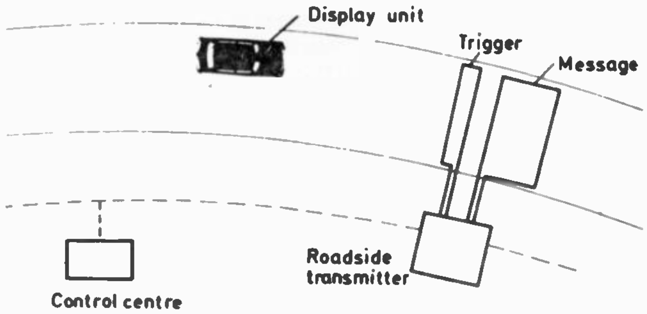


Fig. 3. Loops set into the road trigger the AWARE panel in the vehicle.

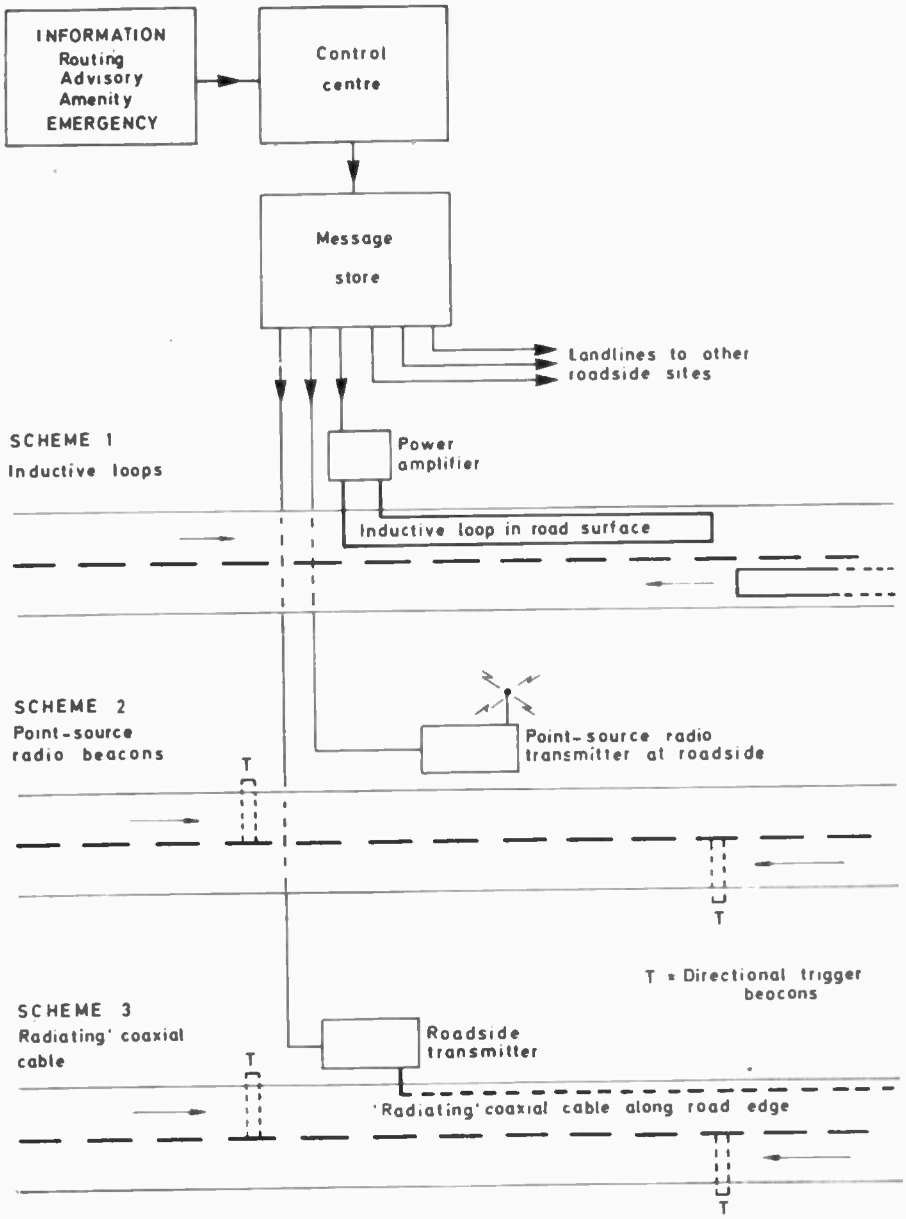


Fig. 4. Alternative schemes under study as means to provide driver communication.

be unable to provide for the very immediate needs of the driver. This would be catered for by other systems now in development. Firstly let us look at "AWARE".

ADVANCE WARNING EQUIPMENT

The design aim is to provide the driver with a number of valuable tit-bits of information as well as danger warnings. On the dash panel will be a display — shown in Fig. 2 — that normally appears opaque.

The rear mounted signs will illuminate selectively to compose a message. For example, to warn of a hazard or delay ahead it would show for about one minute.

"CONGESTION 1 MILE 20 MINS DELAY"

It can also be used to suggest alternative routing and the nature of the road hazard. (The displays exhibited have now passed through four different physical forms. The next stage is said to be rear projection to bring the message into a single line but obviously an LSI light emitting diode matrix will come with time to reduce the area needed and the cost of the display).

The next requirement is that the display be set up by some means that is external to the vehicle as it travels.

Inductive loop and ferrite-cored coil sensing is proposed in the manner shown in Fig. 3. Alongside the appropriately serviced road is a system to excite the message loop (after the unit in the car is triggered on).

At present, 108 bits of data can be sent. Fourty four control the message, thirty two carry the variables of the message and five are used for checking. A trigger loop is included to provide the necessary directional data ensuring that the driver gets data for what lies ahead, not behind.

This is an EEC development, and is intended for use on the European road network in general.

Allied to the same concept is RITA (road information transmitted aurally) which gives the driver similar information via the ear rather than the eye.

There are many reasons for pursuing this alternative and it is yet unclear which is the best as both have their respective pros and cons.

Language variation across Europe is an obvious problem for aural systems whereas visual distraction and changing illumination levels go against visual counterparts.

Three alternatives are under study for RITA — inductive loops, point-source radio beams and radiating coaxial cable. The alternatives are shown in Fig. 4.

It remains to be seen which system of communication will be adapted but certainly any is better than the present virtually non-existent services.

The potential of this work is great for it paves the way to automatic vehicle guidance and navigation.

LIGHTING

Lighting is one area where electronic methods are increasingly being considered.

Headlights need to be used as effectively as possible with as little glare to oncoming drivers as is

ROAD SAFETY

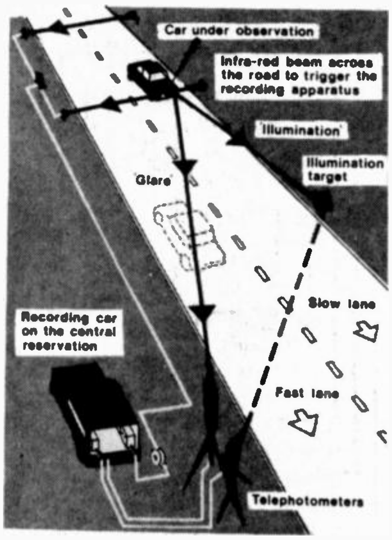


Fig.5. Telephotometers are used this way to monitor glare.

practicable. Designers need to ensure that the vehicle warning lights are efficient in all conditions that may exist. Also there are the probable improvements that can be made to street lighting.

Reducing headlight glare.

There exist a number of possible solutions: one design aim is to ensure that the headlights point correctly regardless of vehicle attitude.

Research has shown that modern vehicles tilt significantly with varying load application – 30% of private vehicles tilt from the design position by 0.5 degrees and 7 percent by up to 1.0 degrees.

These changes cause a normally well-adjusted beam to generate severe glare.

Several solutions have been tested by the TRRL and they each use some form of automatic arrangement that swivels the lamp in its bearings.

The Cibie method use hydraulic actuation, the Martin-Vaughan prototypes are entirely mechanical in principle. Road tests have shown that one feels somewhat divorced from the self-levelling lights at first, a sensation that eventually becomes acceptable.

Having provided means to keep the lights pointing correctly, it is then necessary to make actual measurements of beam distribution of the moving vehicle to decide how to reduce glare.

Figure 5 shows the TRRL set up used to monitor an on-coming car's headlights.

The recorders are triggered on by infra-red beams that are intercepted by the car. Two telephotometers (narrow viewing-angle light meters) set up (60m ahead) record the illumination level seen by the on-coming driver.

This equipment has been used to compare the British cum/American Standard with its Continental counterpart for each differs somewhat in respect to the beam distribution in space.

Research has shown that dipped lights are often annoying to other drivers in well lighted streets and that the driver cannot accurately decide whether to use them dipped or to use side lights only.

In Britain it is normal to use only side and tail lamps when driving through cities at night. This appallingly dangerous practice still continues despite many accidents directly attributable to it – one in particular, occurred about twenty years ago when a bus ran down and killed nearly 30 people.

A decade ago suggestions were made to use two-level dipped lights the effect being produced with a series resistor that dropped the lamp voltage to about 60 percent of maximum supply.

It was called the dim-dip system. The ability of drivers to use this system correctly was doubted so the TRRL designers pressed on to automate the idea.

The system specifications needed were that it be insensitive to other vehicle lights, have variable dim range (not just switched high-low), be slow to dim but fast to brighten and that no dimming should occur in daylight fog.

Basically the first TRRL system made use of the light level of the modulated content of street lights (at 100 Hz). A schematic of the system is shown in Fig. 6.

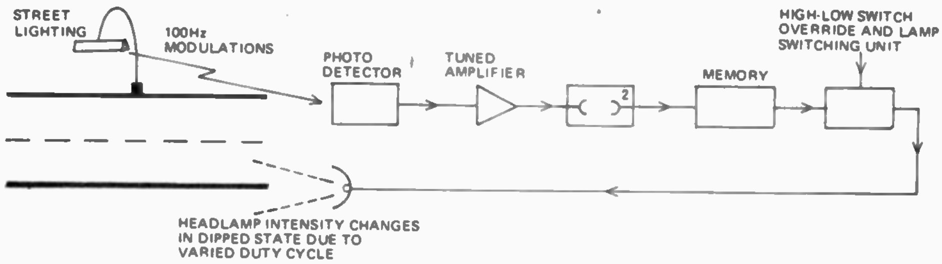


Fig.6. Schematic block diagram of TRRL automatic dimming system.

A detector is coupled to an ac amplifier which peaks selectively at 100 Hz. The output from this initial stage is proportional to light level of the 100 Hz signal.

In daylight the stage provides zero output as no 100 Hz signal is present. The ac output is then fed to a circuit that generates a square wave as long as the peak value exceeds a minimum reference value.

The variable mark-space ratio of the square wave conveys the required intensity level to a circuit that charges

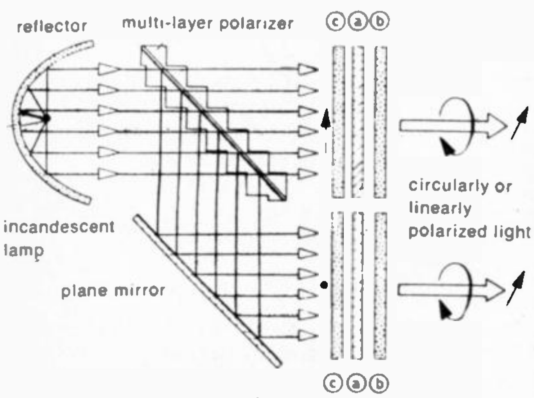


Fig.7. The Bosch polarized headlamp

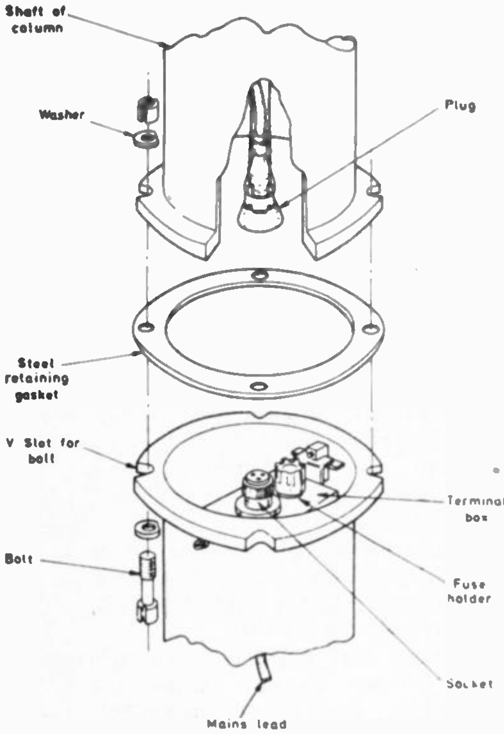


Fig.8. Breakaway column joint incorporating disconnecting plug.

a capacitor memory, providing the time constant needed, plus an output that is inversely proportional to street light level.

Headlight intensity is adjusted using this signal by on-off switching, with on periods varying from 120 to 1.2 ms, and a fixed 2 ms off period.

The switch is controlled by the voltage existing on the memory capacitor. Intensity range swing is about 75 per cent.

Another way to reduce glare is to vary the centre road-side cut-off angle of the undipped beam so that it does not shine with full amplitude into the on-coming driver's eyes.

As far back as 1969 Lucas designed a system called "Autosensa" that worked this way. As the same system was on display again without mention of improvements it appears that the idea is yet to be perfected.

It uses a projection lamp rather than the normal car globe, with a controllable projection aperture that can be vignetted with a servo-driven slide to cut off one side of the beam.

A photo-cell senses the location of the oncoming car by the car's beam strength and causes the shutter to move across accordingly.

By far the most actively promoted scheme to reduce glare is the use of polarized lights and special polarized viewers fitted in front of the driver.

It is a relatively simple matter to polarize white light from lamps by using special optical elements. Treated this way the light can only pass a similar viewing window when the direction of polarization is the same as that of the window material.

Rotation of the polarization of the oncoming beams to be at a different angle to the viewer will give a very marked reduction in intensity. No electronics are needed and (in principle) it works.

A demonstration system was on display and one could easily look into a 100 W halogen lamp and see past it.

Unfortunately, it is not quite so easy to implement in everyday practice. Problems to be overcome include getting everyone to co-operate with the fitting of polarizers to both lights and windscreens, finding a way of maintaining correct polarization even though the vehicle is still tilted; producing polarized viewers that do not attenuate ordinary light substantially more than for polarized light and able to withstand heat generated in headlamps. Finally producing cheap polarizing elements.

A Bosch proposal is shown in Fig. 7 together with a picture of an installation in a recent model car.

The subject has been in vogue since the late 40's and could continue for some time before we see it in widespread use.

Rear lights are also receiving attention. In the ESV shown by Nissan, the tail lamps have changeable brightness to suit day or night conditions.

On the 'heavier' side are the now standard high-intensity rear warning fog lamps fitted to the Crane-Fruehauf 'doubles' haulage units.

It has long since been recognised that lighting columns should break away under impact thus reducing vehicle damage substantially.

To further reduce the hazard, and to reduce re-erection cost of the columns, TRRL have designed a special breakaway joint which also disconnects the electricity (see Fig.8) on impact.

INSTRUMENTATION

There was a period in automobile design when the instrument panel was reduced to a bare minimum.

That time seems to be passing as more alarms and indicators are introduced to keep the driver informed.

Several vehicle accessory manufacturers were displaying lamp failure indicators. Smiths method, for which a schematic circuit is given in Fig. 9, uses two reed-relay switches to monitor the two rear stop lamps. If either fails to operate, a transistor driver is operated by one of the relays, lighting a warning lamp.

Side and rear lamp indicators use a series connected bimetal switch contact that closes if no through

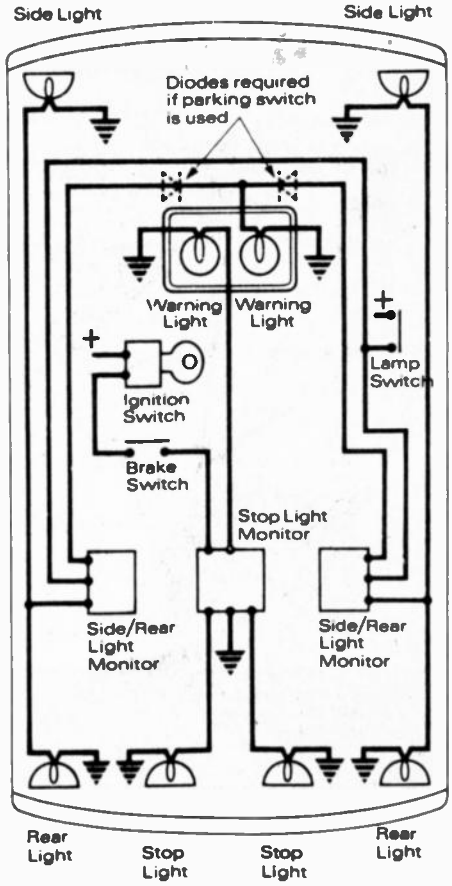


Fig.9. Lamp failure indicators are now available from original equipment suppliers.

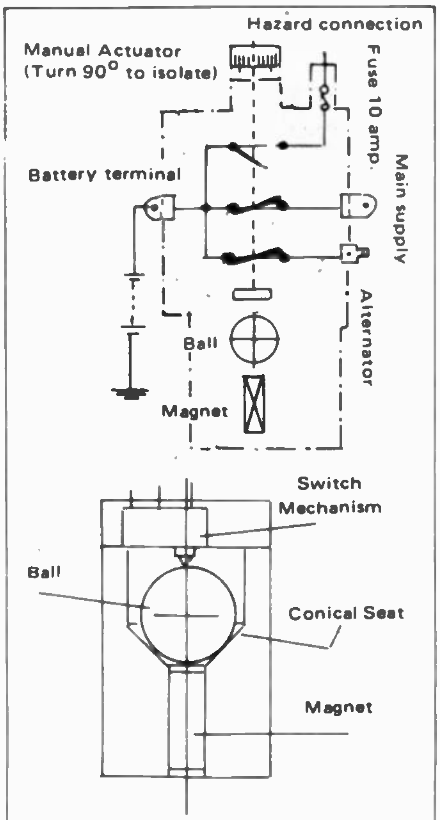


Fig.10. Schematic arrangement of inertia switch.

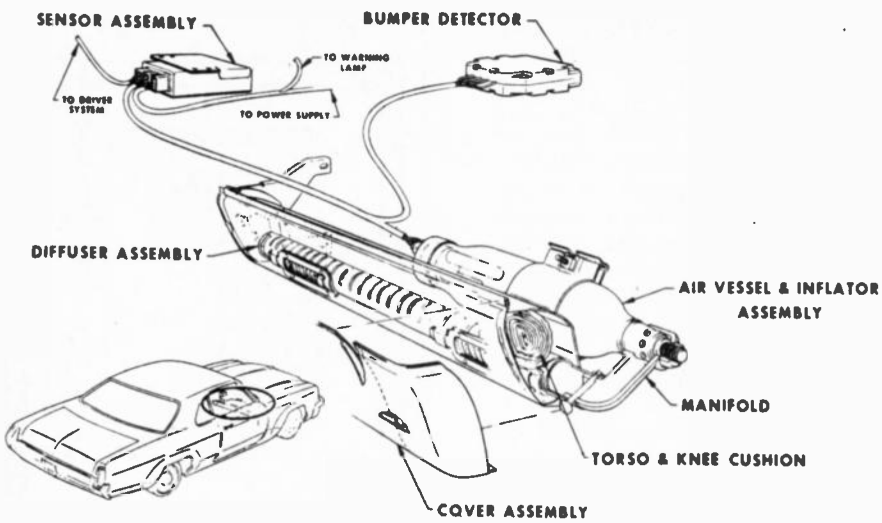


Fig.11. Accelerometers mounted in the bumper and on the fire wall are used to trigger the developmental air bag of GM.

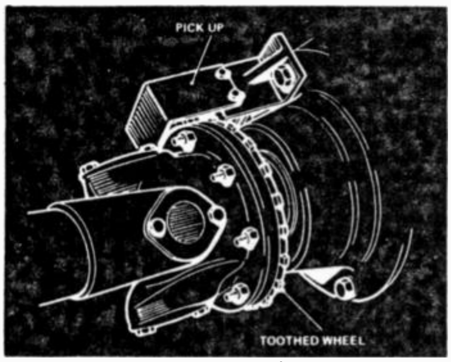
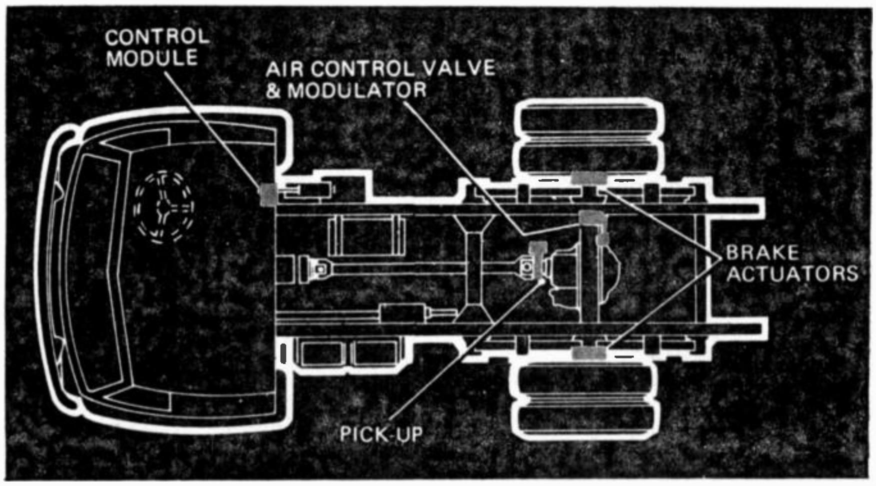


Fig.12. Position and appearance of velocity sensor used in Lockheed anti-lock braking system.



current exists to heat and bend the bimetal.

Tyre pressure sensors are also incorporated in some of the ESV units. Checks that doors are locked and even a built-in device indicating excessive breath alcohol content (Honda) were also outlined along with indication of vital component failure.

Another unit, available for original equipment only at this stage, is the Smiths dual level sensor for indicating low coolant and brake fluid levels.

The sensors make use of the change in electrical conductivity between probes mounted high in the fluid chamber. The two sensors use one integrated circuit mounted on a printed circuit board.

Several manufacturers have included audible as well as visual alarms, into their instrumentation array.

The Crane-Fruehauf double outfit (engine unit with its semi-trailer and a second coupled trailer) goes as far as incorporating closed-circuit television to aid the operator in backing.

The camera is contained in a safety enclosure under the rear of the tray.

Also on show were several forms of headup display of vital panel meter readings. These use a simple projector to place an image of the dial on the windscreen, the speedometer for instance is in the direct view of the driver as he looks ahead.

Digital and analogue forms are being tried out in tests in which the West Yorkshire Metropolitan Police are co-operating.

COLLISION AND ANTI-COLLISION MEASURES

When collision occurs, some mechanisms need to be terminated, others initiated.

Various safety standards now call for devices that cut the petrol supply and the ignition via the battery circuit, thereby reducing fire risk.

Switches that open or close have been devised to act when the acceleration (or deceleration) exceeds certain values, typically in excess of 5g.

Inertia seat belts also require acceleration sensing — in the range exceeding 0.4g; electrical sensing has been proposed for this as an alternative to mechanical methods.

A whole range of sensors covers electric supply isolation, fuel pump cut-off, fuel line cut-off, passive restraint crash sensors; severe braking indication to operate high intensity ·ear warning lights and inertia switches :o operate seat belt locks.

The method used by Inertia Switches s simple, as Fig. 10 shows. Magnetic ›ull on a steel ball provides the etardation force to hold the ball until ıe g forces exceed the limit, releasing ıe ball and toggling the contacts.

The ball seats in a cone holder, thus roviding a directional force haracteristic that can be tailored to ɹit side accelerations as well as those roduced dead ahead.

A typical 48 km/h impact produces eceleration of over 20 g with the ehicle coming to rest in only one ɜnth of a second!

The Honda and Nissan ESV's include ccelerometer sensing to disconnect ɩne fuel and electrical systems.

The General Motors development air-bag restraint system uses two accelerometers; one is placed in the bumper bar and operates the safety device at around 25 km/h impacts; a back-up unit is placed in the fire wall (see Fig.11) acting at 35 km/h impact in case the bumpers override.

It was also clear that more advanced sensors are in the research stages. Nissan described a radar sensor that was now operational (in prototype form). No doubt theirs is but one of a number being developed.

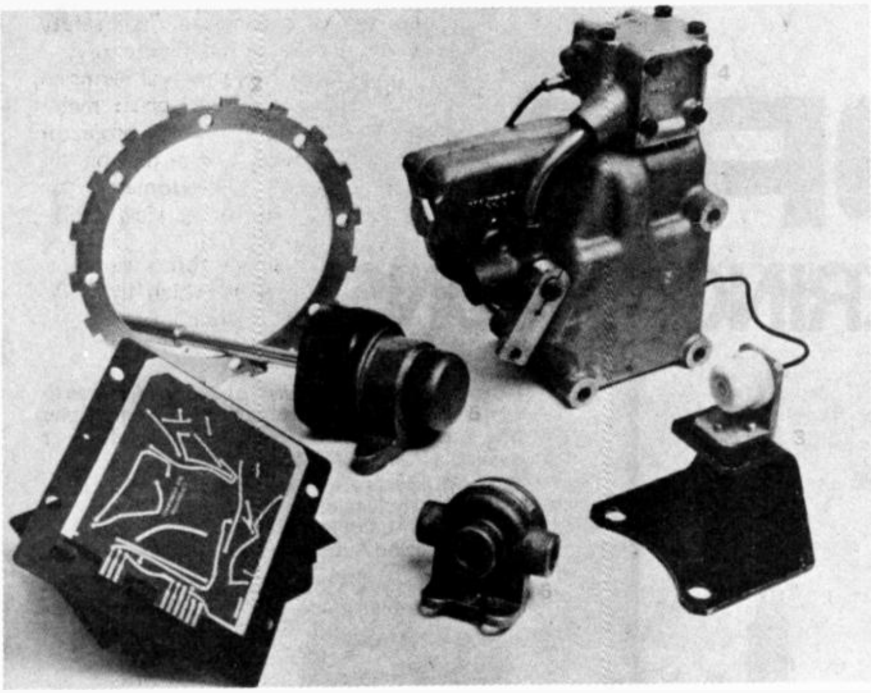


Fig.13. Actual components of anti-lock/system. The toothed wheel produces pulses in the pick-up coil shown on the lower right. After signal processing with the circuit (lower left) the brakes are applied and released as needed.

The Harrison-Fraba general-purpose infra-red sensing system makes use of a modulated IR beam to flood the path ahead. Any obstacle in the path sends a return signal to the photo detector which operates an alarm.

It can be adjusted to provide surveillance over a range set from 2-30m. A similar system can detect fog and monitor traffic flow.

VEHICLE CONTROL

It is some years now since anti-lock braking was launched as the answer to braking on slippery surfaces, but displaying a prototype is one thing, producing units is another.

Lockheed gave impressive demonstrations of their system as applied to semi-trailers. Although the system uses mainly hydraulic and pneumatic control its basis is an electrical sensor that measures the velocity of the propeller shaft.

Figure 12 shows the location of the pick-up sensor and the sensor itself. The principle of operation is that velocity change of the propeller shaft is processed to indicate the degree of deceleration.

If it exceeds the value known to be close to wheel lock (1.5 g), the brakes are released and reapplied when speed is regained.

The result, on wet roads, is pulsed brake operation with greatly reduced braking distances.

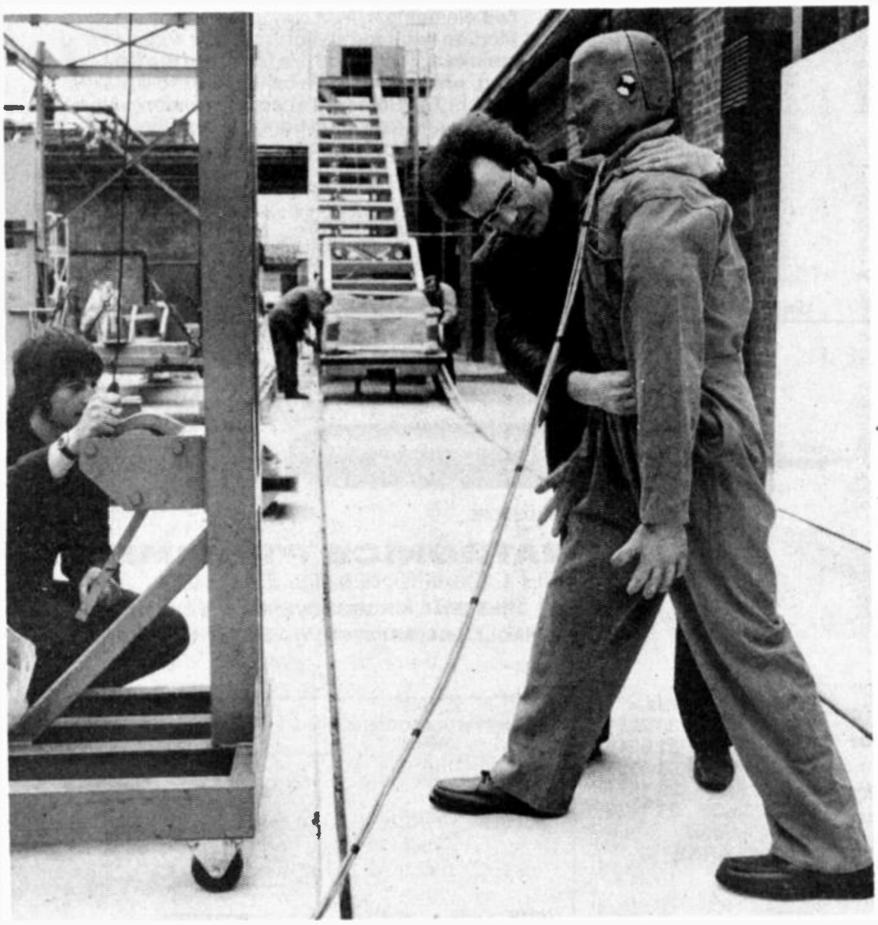


Fig.14. Engineers set up a pedestrian dummy at the Rolls Royce test centre.

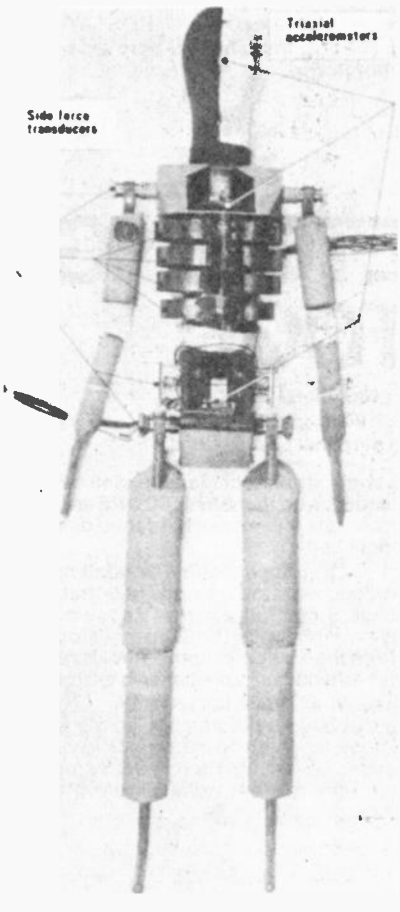


Fig.15. In his "birthday" suit an anthropometric dummy might look like this.

ROAD SAFETY

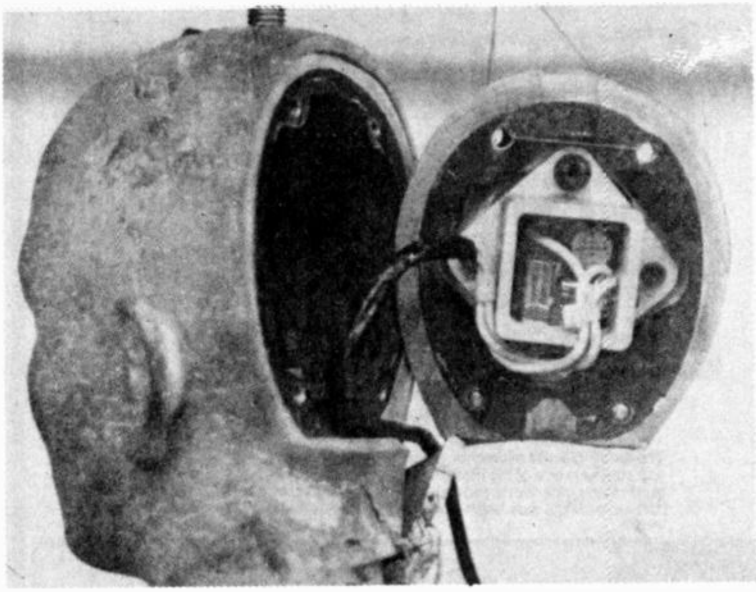


Fig.16. The main sensor unit used in dummies is the three-axis accelerometer.

On perfect road surface conditions braking is slightly inferior to ordinary (non-controlled) methods. Figure 13 shows the extra components that are added to provide anti-lock braking for the rear wheels of a semi-trailer prime mover.

A demonstration clearly showed that trucks without anti-lock are extreme hazards on wet surfaces and lack all control once skids start. With this device the unit could brake and steer around sharp bends under normal control.

Semi-trailers can now have a 'swing' sensor fitted to indicate when the rear has reached the *jack-knife* limit.

It will not be long, with so many warning devices to monitor, before the transport driver needs to be as highly trained as an air pilot.

RESEARCH

Considerable effort still goes into the use of actual crash testing using anthropometric dummies simulating occupants and now, with increasing interest, pedestrians.

The manufacture and sale of dummies is a commercial enterprise with a growing turnover. Designs are becoming very sophisticated. Triaxial accelerometers measure g forces. Side force transducers measure side impact loads at the main upper skeletal joints and bones. Compressional load cells determine the loads in the thigh bone.

Figure 14 shows a male dummy used in research at Rolls Royce Motors' pedestrian-to-car collision rig at Crewe in Cheshire.

The test trolley in the rear gains energy, falling down the ramp, rolling on to collide with the propped up dummy.

With clothes removed a well instrumented dummy appears as in Fig.15; this 'man' is used primarily for side-impact tests in cars.

Close-up, the triaxial accelerometer unit would look like the Endevico unit shown in Fig. 16. Dummies can be most complex with as many as 50 odd signal channels being needed.

Nevertheless, no manufacturer suggests that the anthropometric dummy is still any more than a crude experimental tool.

Another interesting phase of research is that of vehicle automation. Several exhibits, again mainly from TRRL sources, displayed how automation might come to road vehicles.

Estimates suggest it is worth $100 per vehicle and $5000 per kilometre of lane and that mass production costs would be less than these figures.

Given automated control, the gains expected would be less accidents, more accurate steering allowing more lanes in a road, safer headway as reaction time is reduced thus enabling vehicles to travel closer together, stress-free travelling for occupants and a cheaper mode of transport.

One pamplet suggested it could be in full scale use by 2000 AD.

Control systems envisaged are fairly obvious in principle; control of lateral steering and vehicle spacing. This creates the need for steer, braking and speed servomechanisms.

Numerous devices are envisaged as alternatives for each, but basically the block diagram of eg. steering appears as in Fig.17. Sensors A, B decide the lateral clearances giving an error signal that actuates the power-steering mechanism. (The steering wheel, you will be pleased to know, will remain for override purposes).

The throttle controls of the TRRL design use electro-vacuum sensors in which the error signal acutates an electric-magnetic pull-motor that in turn controls a vacuum assisted control of the throttle butterfly.

If you see a radar set pointing at you on the highway it may not be a cause for alarm for they are now being used as much to investigate driver behaviour as to control speed.

One unit, lawful in the States but not in all countries, takes a photo as you approach, recording speed and time at the same time. These units can operate in fog as well as in the dark. As they use infra-red photography the driver is totally unaware of their existence.

Another means of observing drivers is to follow the unsuspecting with a television camera. A video tape unit mounted out of sight records the scene. The aim of these research workers is not to catch a driver out or invade his privacy but to establish how drivers react in real situations.

It is clear that electronics plays a major role in road safety. The motor vehicle is rapidly becoming a piece of elaborate equipment that needs sophisticated servicing and care. The days of do-it-yourself repairs will soon be over.

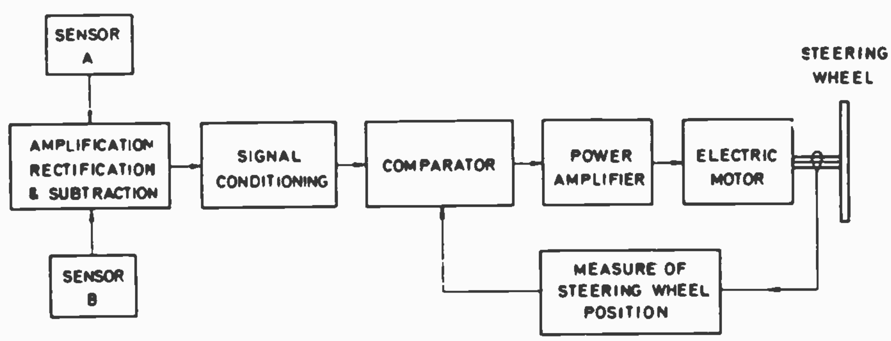


Fig.17. Block diagrams of lateral control system of probable automatically controlled car.

ELECTRONIC SPEED CONTROL FOR MOTORS

How various types of motor can be controlled in speed using semiconductor devices, Applications Department, Motorola, Phoenix.

SPEED CONTROL of motors in domestic appliances has been technically possible for a long time, but only recently has it become a good proposition economically.

Such diverse items as blenders, furnace blowers, clothes dryers, and food mixers can now use electronic controls. In this article, we review some of the common circuits being used today, and also describe some of the new circuits.

By far the easiest to control electronically are universal (or series-wound ac-dc) motors. Their characteristics and construction allow the use of a simple circuit to provide an electrical feedback so that speed is held relatively constant under varying load conditions.

Permanent-magnet motors are also easy to control. Perhaps surprisingly, the speed of several forms of induction motors may also be successfully controlled by electronic means — if these motors have a suitable load.

How AC power control

The most common method of electronic ac power control is called phase control.

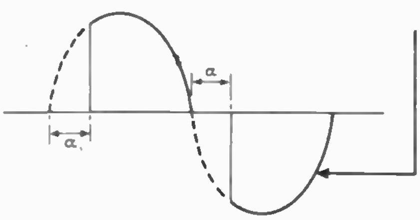


Fig.1. Illustrating the basic principles of phase control. The portion of the waveform applied to the load is shown shaded.

Figure 1 illustrates this concept. During the first portion of each half-cycle of the ac sine wave, an electronic switch is opened to block current flow. At some specific phase angle, *a*, this switch is closed to allow the full line voltage to be applied to the load for the remainder of that half-cycle. Varying *a* will control the portion of the total sine wave that is applied to the load (shaded area), and thereby regulate the power flow to the load.

The simplest circuit for accomplishing phase control is shown in Fig. 2. The electronic switch in this case is a triac *(Q)* which can be turned ON by a small current pulse to its gate. The triac turns OFF automatically when the current through it passes through zero.

In the circuit shown capacitor C_T is charged during each half-cycle by the current flowing through resistor R_T and the load. The fact that the load is in series with R_T during this portion of the cycle is of little consequence since the resistance of R_T is many times greater than that of the load. When the voltage across C_T reaches the breakdown voltage of the trigger diode (D), the energy stored in capacitor C_T is released. This energy produces a current pulse in the trigger diode, which flows through the gate of the triac and turns it ON. Since both the trigger diode and the triac are bidirectional devices, the values of R_T and C_T will determine the phase angle at which the triac will be triggered in both the positive and negative half-cycles of the ac sine wave.

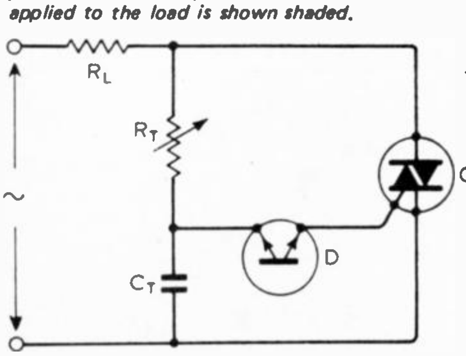


Fig.2. The simplest possible circuit for phase control. The load is represented by resistor R_L.

The wave form of the voltage across the capacitor for two typical control conditions (a = 90° and 150°) is shown in Fig. 3. If a silicon controlled rectifier is used in this circuit in place of the triac, only one half-cycle of the wave form will be controlled. The other half-cycle will be blocked, resulting in a pulsing dc output whose average value can be varied by adjusting R_T.

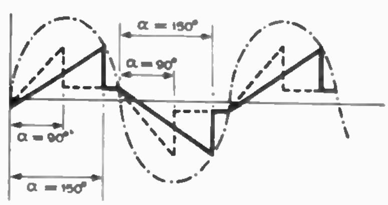
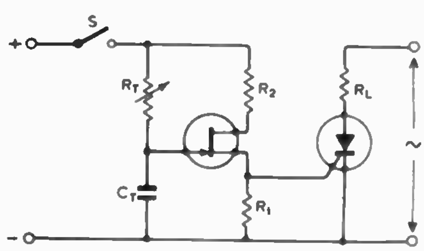


Fig.3. Waveforms across the capacitor at two different phase angles. The applied sine wave is shown dotted.

Characteristics of semiconductor switches

The silicon controlled rectifier (SCR) was the first of several thyristors developed for controlling electric power efficiently. It blocks current flow in both directions as long as no gate signal is applied and the applied voltage is below the rated breakover voltage. Exceeding the breakover voltage in the forward direction (with anode more positive than cathode) will cause the SCR to switch to its ON condition, in which the voltage from anode to cathode is approximately 1 V (and the current is limited only by the external circuitry). When the forward current is interrupted, the SCR recovers its blocking character.

Fig.4. A typical phase control circuit using a unijunction transistor firing circuit.



Exceeding the reverse breakdown voltage of an SCR will destroy the device, most often causing a permanent short circuit.

Current flowing into the gate of an SCR will also cause it to turn ON when forward voltage is applied. Since the SCR is a regenerative device (that is, it remains in the ON condition as long as anode current is flowing), only a current pulse at the gate is necessary to effect switching. Thus, in the previously described circuits, a properly timed current pulse into the gate of an SCR can control average power flow to a load.

The triac is a bidirectional SCR. It is designed for use with alternating current, and functions the same way in both directions of applied voltage (as an SCR does in the forward direction). Its gate characteristics are different from that of an SCR in that gate current of either polarity will cause the triac to turn ON, with either polarity of applied anode voltage.

The trigger diode is a device designed specifically to provide current pulses to trigger SCR or triacs. In use, it acts much like a triac without a gate. That is, it will block current flow in either direction as long as the applied voltage is below the breakover voltage, which is generally between 16 and 36 V, depending on the device type. When the breakover voltage is exceeded, the device turns ON. In this state, the current is limited by the external circuitry, and the voltage drop across the diode is about 10 to 15 V. The trigger diode is most commonly used in circuits similar to the one shown in Fig. 2.

The unijunction transistor (UJT) is a three-terminal trigger device in which the characteristics of the emitter and base 1 are very much like those of the trigger diode. However, its breakover voltage can be controlled by the power supply voltage applied between base 1 and base 2. Since the UJT is a unidirectional device, unlike the bidirectional trigger diode, it requires a source of direct current for the interbase voltage as well as for the timing-circuit components, R_T and C_T. Figure 4 shows a UJT in a typical control circuit.

Because the breakover voltage of the UJT emitter is controlled by the interbase voltage, the unijunction transistor can be used for the timing circuit with a much lower source voltage than can be trigger diode, whose breakover voltage is controlled by the parameters of its structural materials. As a result, the UJT is quite popular for use with electronic control systems utilizing feedback.

In many applications it is desirable to vary motor speed in proportion to the magnitude of a change in a physical condition, such as a change in temperature. A furnace blower responding to the air temperature of a house is one example. Similarly, a control device can light a lamp in response to the fading twilight. Control of these circuits can be effected by resistors that change in value in response to a change in temperature or light intensity. A typical circuit using such a variable resistor is shown in Fig. 5. If motor speed is the quantity to be controlled, R_S may be a fixed resistor, and a direct-current tachometer generator may be inserted as shown. Only a few additional components are necessary to turn these elementary circuits into working modules.

Fig. 5 Motor speed control with a unijunction transistor using feedback.

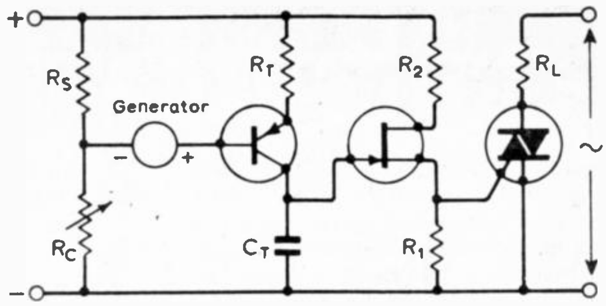


Fig. 6 Simple full-wave trigger circuit for a 900 W resistive load.

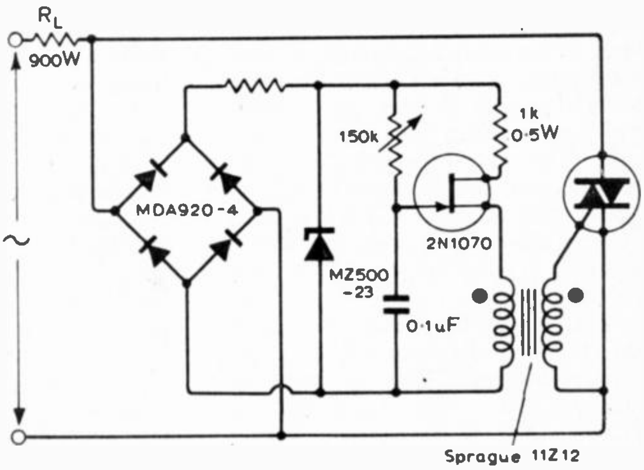


Figure 6 shows a simple full-wave trigger circuit for controlling a 900 W load. The additional components required are a full-wave bridge, a resistor, and a Zener diode, which make up the dc power supply, and a pulse transformer which provides the isolation between the UJT circuit and the power line, necessitated by the bridge rectifier. The feedback circuitry shown in Fig. 5 could also be added to this circuit.

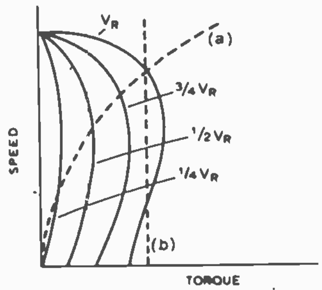


Fig. 7 Characteristics of a shaded pole motor at several voltages. V_R is the full rated voltage, (a) indicates a typical fan load and (b) shows a constant torque load.

Control of induction motors

Shaded-pole motors driving low-starting-torque loads such as fans and blowers may readily be controlled using any of the previously described full-wave circuits. One needs only to substitute the winding of the shaded-pole motor for the load resistor shown in the circuit diagrams.

Constant-torque loads or high-starting-torque loads are difficult, if not impossible, to control using the voltage controls described here. Figure 7 shows the effect of varying voltage on the speed-torque curve of a typical shaded-pole motor. A typical fan-load curve and a constant-torque-load curve have been superimposed upon this graph. It is not difficult to see that the torque developed by the motor is

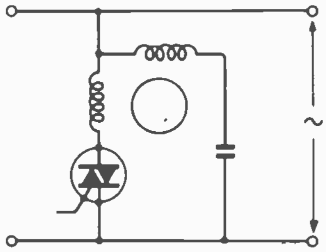


Fig. 8 Connection diagram for permanent split capacitor motors.

ELECTRONIC SPEED CONTROL FOR MOTORS

equal to the load torque at two different points on the constant-torque-load curve, giving two points of equilibrium and thus an ambiguity to the speed control. The equilibrium point at the lower speed is a condition of high motor current because of low counter emf and would result in burnout of the motor winding if the motor were left in this condition for any length of time. By contrast, the fan speed-torque curve crosses each of the motor speed-torque curves at only one point, therefore causing no ambiguities. In addition, the low-speed point is one of low voltage well within the motor winding's current-carrying capabilities.

Permanent-split-capacitor motors can also be controlled by any of these circuits, but more effective control is achieved if the motor is connected as shown in Fig. 8. Here only the main winding is controlled and the capacitor winding is continuously connected to the entire ac line voltage. This connection maintains the phase shift between the windings, which is lost if the capacitor phase is also controlled. Figure 9(a) shows the effect of voltage on the speed-torque characteristics of this motor and a superimposed fan-load curve.

Not all induction motors of either the shaded-pole or the permanent-split-capacitor types can be controlled effectively using these techniques, even with the proper loads.

Motors designed for the highest efficiences and, therefore, low slip also have a very low starting torque and may, under certain conditions, have a speed-torque characteristic that could be crossed twice by a specific fan-load speed-torque characteristic.

Figure 9(b) shows motor torque-speed characteristic curves upon which has been superimposed the curve of a fan with high starting torque. It is therefore desirable to use a motor whose squirrel-cage rotor is designed for medium-to-high impedance levels and, therefore, has a high starting torque. The slight loss in efficiency of such a motor at full rated speed and load is a small price to pay for the advantage of speed control.

A unique circuit for use with capacitor-start motors in explosive or highly corrosive atmospheres, in which the arcing or the corrosion of switch contacts is severe and undesirable, is shown in Fig. 10. Resistor R_1 is connected in series with the main running winding and is of such a resistance that the voltage drop under normal full-load conditions is approximately 0.2 V peak. Since starting currents on these motors are quite high, this peak voltage drop will exceed 1 V during starting conditions, triggering the triac, which will cause current to flow in the capacitor winding. When full speed is reached, the voltage across the main winding will decrease to about 0.2 V, which is insufficient to trigger the triac – thus the capacitor winding will no longer be energized. Resistor $R2$ and capacitor C_2 form a dv/dt suppression network; this prevents the triac from turning on due to line transients and inductive switching transients.

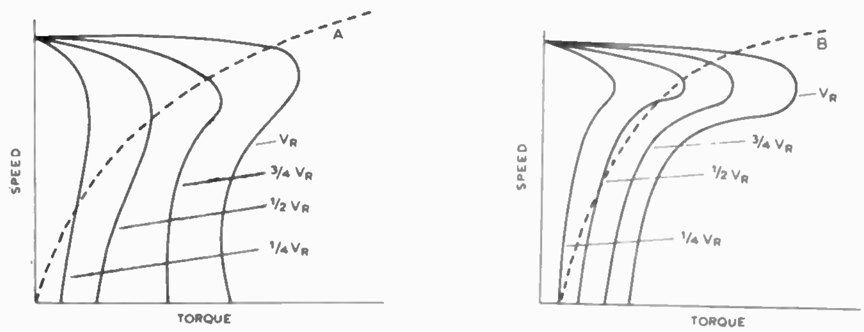


Fig. 9 Speed-torque curves for (A) high starting torque and (B) high efficiency permanent split capacitor motors at several voltages. The dotted line indicates a typical fan load and V_R is the full rated voltage.

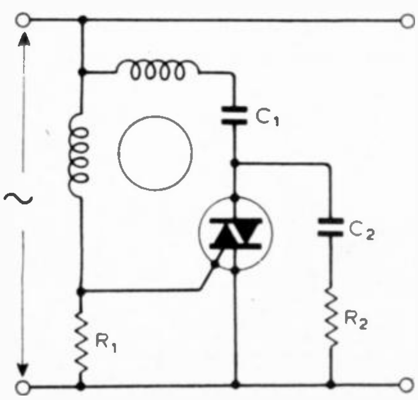


Fig. 10 Circuit diagram for a capacitor start motor.

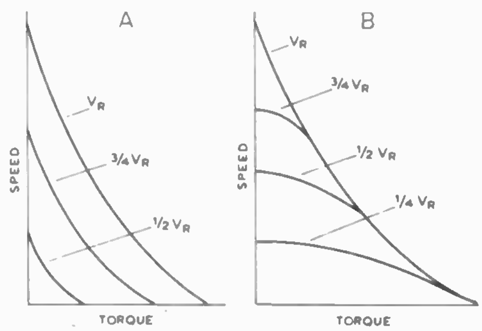


Fig. 11 Speed control, with (A), and without (B), feedback, compared.

Control of universal motors

Any of the half-wave or full-wave controls described previously can be used to control universal motors. Non feed-back, manual controls, such as those shown in Fig. 2, are simple and inexpensive, but they provide very little torque at low speeds. A comparison of typical speed torque curves using a control of this type with those of feedback control is shown in Fig. 11.

These motors have some unique characteristics which allow their speed to be controlled very easily and efficiently with a feedback circuit such as that shown in Fig.12. This circuit provides phase-controlled half-wave power to the motor: that is, on the negative half-cycle, the SCR blocks current flow in the negative direction causing the motor to be driven by a pulsating direct current whose amplitude is dependent on the phase control of the SCR.

The theory of operation of this control circuit is not at all difficult to understand. Assuming that the motor has been running, the voltage at point A in the circuit diagram (Fig.12) must be larger than the forward drop of diode D_1, the gate-to-cathode drop of the SCR,and the emf generated by the residual (magneto-motive force) in the motor, to get sufficient current flow to trigger the SCR.

The waveform at point A(V_A,) for one positive half-cycle is shown in Fig.13, along with the voltage levels of the SCR gate (V_{scr}), the diode drop (V_D), and the motor-generated emf (V_M). The phase angle (a) at which the SCR would trigger is shown by the vertical dotted line. Should the motor for any reason speed up so that the generated motor voltage would increase, the trigger point would move upward and to the right along the curve so that the SCR would trigger later in the half-cycle and thus provide less power to the motor, causing it to slow down again.

Similarly, if the motor speed decreased, the trigger point would move to the left and down the curve, causing the triac to trigger earlier in the half-cycle providing more power to the motor, thereby speeding it up.

Resistors R_1, R_2 and R_3, along with diode D_2 and capacitor C_1 form the ramp-generator section of the circuit, as shown in the diagram in Fig.12. Capacitor C_1 is charged by the voltage divider R_1, $R2$ and R_3 during the positive half-cycle. Diode D_2 prevents negative current flow during the negative half-cycle, therefore C_1 discharges through only R_2 and R_3 during that half-cycle. Adjustment of R_3 controls the amount by which C_1 discharges during the negative half-cycle. Because the resistance of R_1 is very much larger than the ac impedance of capacitor C_1, the voltage waveform on C_1 approaches that of a perfect cosine wave with a dc component. As potentiometer R_2 is varied, both the dc and the ac voltages are divided, giving a family of curves as shown in Fig.14.

The gain of the system, that is, the ratio of the change of effective SCR output voltage to the change in generator emf is considerably greater at low speed settings than it is at high speed settings. This high gain coupled with a motor with a very low residual emf will cause a condition sometimes known as cycle skipping. In this mode of operation, the motor speed is controlled by skipping entire cycles or groups of cycles, then triggering one or two cycles early in the period to compensate for the loss in speed. Loading the motor would eliminate this condition; however, the undesirable sound and vibration of the motor necessitate that this condition be eliminated. This can be done in two ways.

The first method is used if the motor design is fixed and cannot be changed. In this case, the impedance level of the voltage divider R_1, R_2 and R_3 can be lowered so that C_1 will charge more rapidly, thus increasing the slope of the ramp and lowering the system gain. The second method, which will provide an overall benefit in improved circuit performance, involves a redesign of the motor so that the residual emf becomes greater. In general, this means using a lower grade of magnetic steel for the laminations. As a matter of fact, some people have found that ordinary cold-rolled steel used as rotor laminations makes a motor ideally suited for this type of electronic control.

Another common problem encountered with this circuit is that of

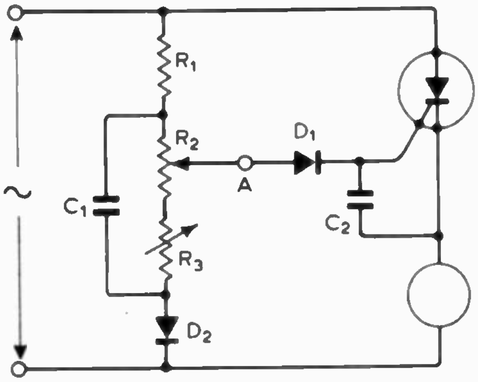


Fig. 12 Speed control scheme for universal motors.

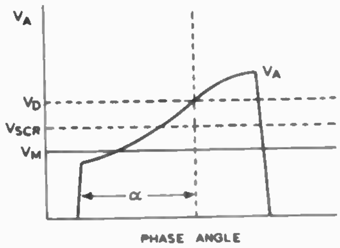


Fig. 13. Waveform for one positive half cycle in the circuit shown in Fig. 12.

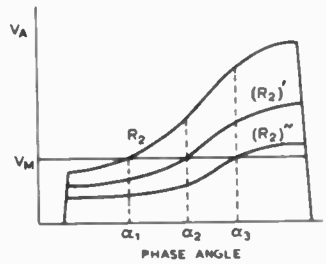


Fig. 14. Voltage waveform at point A (Fig. 12) for three different settings of R_2.

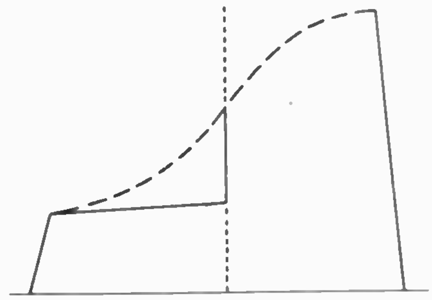


Fig. 15 When resistor $R1$ (Fig. 12) is too large, this voltage waveform appears at point. A. The dotted line is the unloaded waveform and the unbroken line is the actual waveform.

thermal runaway. With the speed control set at low or medium speed, at high ambient temperatures the speed may increase uncontrollably to its maximum value. This phenomenon is caused by an excessive impedance in the voltage divider chain for the SCR being triggered. If the voltage-divider current is too low, current will flow into the gate of the SCR without turning it on, causing the waveform at point A to be as shown in Fig.15. The flat portion of the waveform in the early part of the half-cycle is caused by the SCR gate current loading the voltage divider before the SCR is triggered. After the SCR is triggered, diode D_1 is back-biased and a load is no longer on the voltage divider so that it jumps up to its unloaded voltage. As the ambient temperature increases, the SCR becomes more sensitive, thereby requiring less gate current to trigger, and is triggered earlier in the half-cycles. This early triggering causes increased current in the SCR thereby heating the junction still further and increasing the sensitivity of the SCR until maximum speed has been reached.

The solutions to this problem are the use of the most sensitive SCR practical and a voltage divider network of sufficiently low impedance. As a rough rule of thumb, the average current through the voltage divider during the positive half-cycle should be approximately three times the current necessary to trigger the lowest sensitivity (highest gate current) SCR being used.

In addition to the type of steel used in the motor laminations, consideration should also be given to the design of motors used in this half-wave speed control. Since the

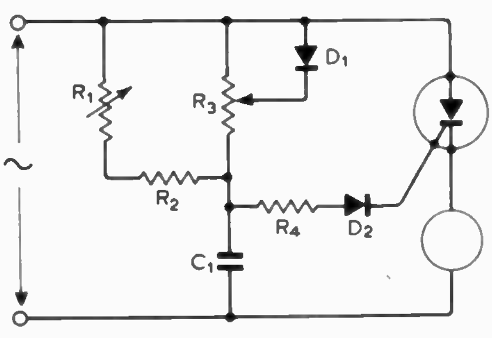


Fig. 16 Speed control of permanent magnat d.c. motors.

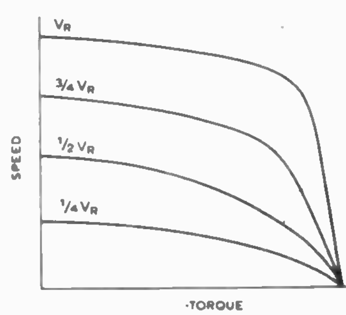


Fig. 17 Speed-torque characteristic of permanent magnet motors at various applied voltages.

ELECTRONIC SPEED CONTROL FOR MOTORS

maximum rms voltage available to the motor under half-wave conditions is less than for full-wave, the motor should be designed for use under these conditions to obtain maximum speed.

CONTROL OF PERMANENT MAGNET MOTORS

As a result of recent developments in ceramic permanent-magnet materials that can be easily moulded into complex shapes at low cost, the permanent-magnet motor has become increasingly attractive as an appliance component. Electronic control of this type of motor can be easily achieved using techniques similar to those just described for the universal motor. Figure 16 is a circuit diagram of a control system to control permanent-magnet motors presently being used in blenders. Potentiometer R_3 and diode D_1 form a dc charging path for capacitor C_1; variable resistor R_1 and resistor R_2 form an ac charging path which creates the ramp voltage on the capacitor. Resistor R_4 and diode D_2 serve to isolate the motor control circuit from the ramp generator during the positive and negative half-cycles, respectively.

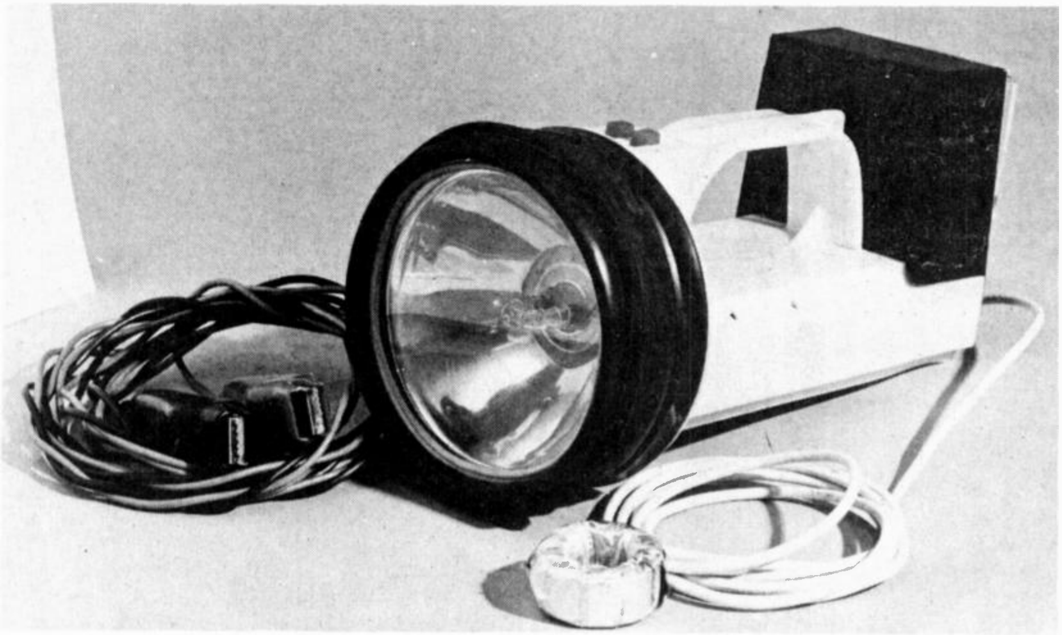
A small amount of cycle skipping can be experienced at low speeds using this control, but not enough to necessitate further development work. Since the voltage generated during off time is very high, the thermal runaway problem does not appear at all.

HEATER CONTROL AND TIMERS

The circuit shown in Fig.2 or 3 could well be made to control heaters in domestic appliances without any modifications.

If the capacitor C_T in Fig.3 is made very large a timer results. The time delay is set by the value of C_T and the variable resistor R_T. ●

TACHO-TIMING LIGHT



eti PROJECT 311

Extended circuitry allows timing check over full speed range.

IN our June 1974 issue we described a simple timing light using a Zenon flash lamp. The unit described in this issue is a more complex version of the same instrument. It has a built in tachometer and is capable of checking timing over the full range of engine RPM.

The use of such an instrument will allow checks on the correct operation of the distributor particularly with respect to mechanical and vacuum advance with increasing RPM.

CONSTRUCTION

The layout and construction of the timing light will vary depending on the housing.

We purchased a cheap torch (readily available from chain stores) which takes four size 'D' batteries.

Our layout and method of construction can be seen from the illustration but this can readily be varied to suit the housing used.

Most of the electronic components are mounted on a printed circuit board which can be assembled with the aid of the circuit diagram and the component overlay, Fig. 2. Check the polarity of diodes, capacitors and transistors etc before soldering. All external wiring to the PC board is numbered and interconnections from the PC board to external components should be made with the aid of the circuit diagram, note that C4 is mounted on the back of the meter and C12 on the rear of the reflector.

The inverter power transistors should be mounted on, but insulated from, a heatsink made from aluminium sheet of at least 40 square centimetres area.

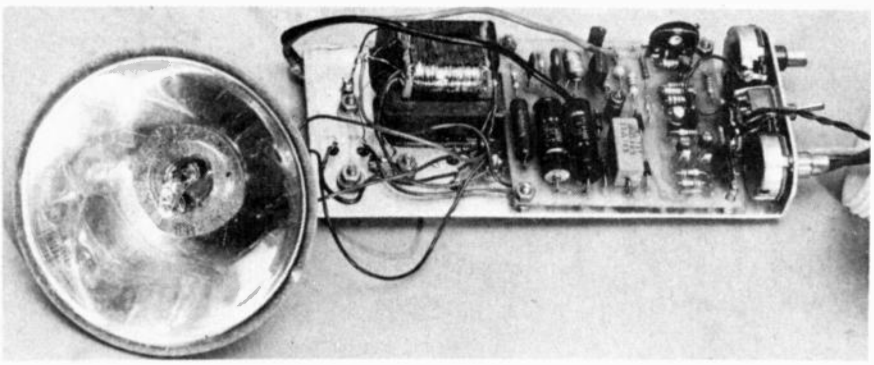
Details of the transformer are given in Table 1. As there are relatively few turns, this transformer may quite readily be wound by the home constructor. Ensure that the polarities of the primary (25T + 25T) and feedback (18T) windings are as shown in the circuit diagram — this is important!

If the unit will not oscillate, (you will hear a 2 kHz whistle when it is oscillating) try reversing the feedback winding.

The secondary voltage is around 350 volts and care should therefore be taken to insert insulation as specified in Table 1, between the primary and secondary windings in the transformer, and to keep the windings separate on the matrix board.

The reflector of the torch may be modified to house the flash lamp in the following manner.

Remove the existing socket, using a pair of pliers or cutters, and file the



Assembly of the unit may be seen from this photograph.

WARNING

On some cars the fan blades rotate close to or at a multiple of the crankshaft speed. When strobed by the timing light, the fan may appear to be stationary or rotating slowly.

This is common to all strobe light timers and failure to remember this can result in serious personal injury, or a wrecked timing light.

ALWAYS — keep well clear of the fan, or remove the fan belt whilst timing the engine.

opening until it is large enough to accept the flash lamp with about one millimetre clearance all round. Wind some tinned copper wire around the flash lamp, as shown in the photograph, to act as a trigger electrode, and bring the wire out between the two main electrodes. Insert the lamp from the front and use modelling clay at the rear of the reflector to hold the lamp and seal the opening. Then pour quick-dry epoxy cement into the reflector until there is sufficient around the base of the tube to secure it in place. Be careful not to get epoxy elsewhere on the reflector. When dry, remove the clay and use more epoxy to fill any recesses in the rear.

If and when the tube is to be replaced a hot soldering iron may be used to destroy the epoxy thus permitting removal.

The discharge, C12 should be mounted on the rear of the flash-tube/reflector assembly as shown in the photograph.

The transducer is wound on a toroidal ferrite core, as shown in the photograph, using shielded audio cable as follows. Remove about 0.8 metres of the inner cable from its shield and wind 20 turns of this around the ferrite core. Then solder the end of the inner conductor to the shield thus creating a complete loop.

The coil should also be shielded to prevent the magnetic field around nearby spark-plugs (other than number one plug) from triggering the timing light. To do this we cut strips of aluminium foil about 10mm wide and sandwiched them between two layers of 12mm wide cellulose-tape to produce a continuous strip of insulated foil 1 metre long. A length of wire should be connected to one end so that the strip may be connected to the shield of the coaxial cable. The foil is wrapped around the coil, in a similar manner to the coax, except that the ends of the foil must not touch. Should the ends touch, a shorted turn would be created which would prevent the transducer from operating at all. The coil should be completely covered and will appear as shown in the photograph.

CALIBRATION

Two different methods may be used to calibrate the timing light. In method A, the preferred method, you will need an oscilloscope with a triggered and calibrated time base, and an accurate tacho. In method B you will have to prevail on the local garage to allow you to calibrate your unit against their accurate (?) unit.

Method A.

1. Connect the unit to the motor with the transducer over number 1 spark lead.
2. Switch the timing light to "tacho" mode.
3. Start the engine and adjust the sensitivity control to the minimum setting that allows the meter to move smoothly as engine revs are increased.
4. With the CRO monitor between the common line and the collector of Q4, the voltage should swing from zero to +9 volts and back to zero each time the number one plug fires.
5. Adjust RV2 such that the pulse width at Q4 collector is 1.67 milliseconds.
6. Remove the CRO leads and set the engine revs to 3000 with the aid of the accurate tachometer.
7. Adjust RV4 such that the meter reads 3000 RPM. This completes the calibration.

Method B.

1. Connect both your timing unit and the garage unit to the car.
2. Switch the unit to "timing" mode.
3. Start the engine and set the RPM to 3000.
5. Now using your own unit adjust the sensitivity control as in step 3 method A.
6. Adjust RV1 until the timing marks coincide.
7. Adjust RV4 such that the same reading is obtained on meter M1 as on the garage unit.
8. Switch to tacho and adjust RV2 to read 3000 RPM.

Note that the motor must be held at constant speed throughout this process.

USING THE UNIT

The workshop manual for most cars contains details of the timing changes with respect to engine RPM and vacuum. If an engine is to perform at maximum efficiency these characteristics need to be checked and corrective measures taken if out of tolerance.

To check mechanical advance:

1. Remove vacuum line to distributor.
2. Fit transducer over number 1 spark-plug lead.
3. Switch timing light to "TACHO"
4. Start engine and switch on timing light.
5. Adjust sensitivity such that meter indicates correct RPM over full range without undue jitter.
6. Set the idle speed as specified in manual.
7. Switch to TIMING and set "timing adjust" potentiometer until the flywheel mark corresponds with TDC mark on the crankcase. (If some other mark than TDC is used, simply add the number of degrees the mark is BTDC (before top dead centre) onto the meter reading). If this is less than 2° advance (minimum obtainable with delay) switch SW3 may be used to remove all delay.
8. Switch back to tacho and increase speed to next calibration point as detailed in the manual.
9. Whilst holding engine revs steady at this setting, switch back to "TIMING" and set "TIMING ADJUST" until the marks again coincide. The meter now indicates the number of degrees of advance. Note that engine revs must not change otherwise the reading will be in error.
10. Repeat 8 and 9 for all other specified calibration points.

To check vacuum advance:

The only points on vacuum advance that need checking are the maximum advance with vacuum and that a vacuum is held, ie no leaks in the distributor.

1. With the motor idling check the timing with the vacuum line disconnected.

2. Draw a vacuum in excess of the normal vacuum (sucking the line by mouth will be sufficiently effective) and check the timing advance against that specified in the manual.

3. Hold the vacuum in the line and check that the timing does not shift (due to leak in distributor vacuum mechanism).

If a more accurate check is required the above checks can be done in conjunction with a vacuum gauge.

(Note — refer to June 1974 issue re capacitor life)

SPECIFICATION

Energy per flash	0.2 joule
Maximum flash rate	>50/sec (6000 rpm)
Trigger method	current transformer on No 1 spark lead.
Input voltage	10-14 volts dc
Timing meter range	0-50°
Minimum delay 0° is switchable	<4°/1000 rpm
Maximum delay 50° maximum	>40°/1000 rpm
Tacho meter range	0-5000 rpm

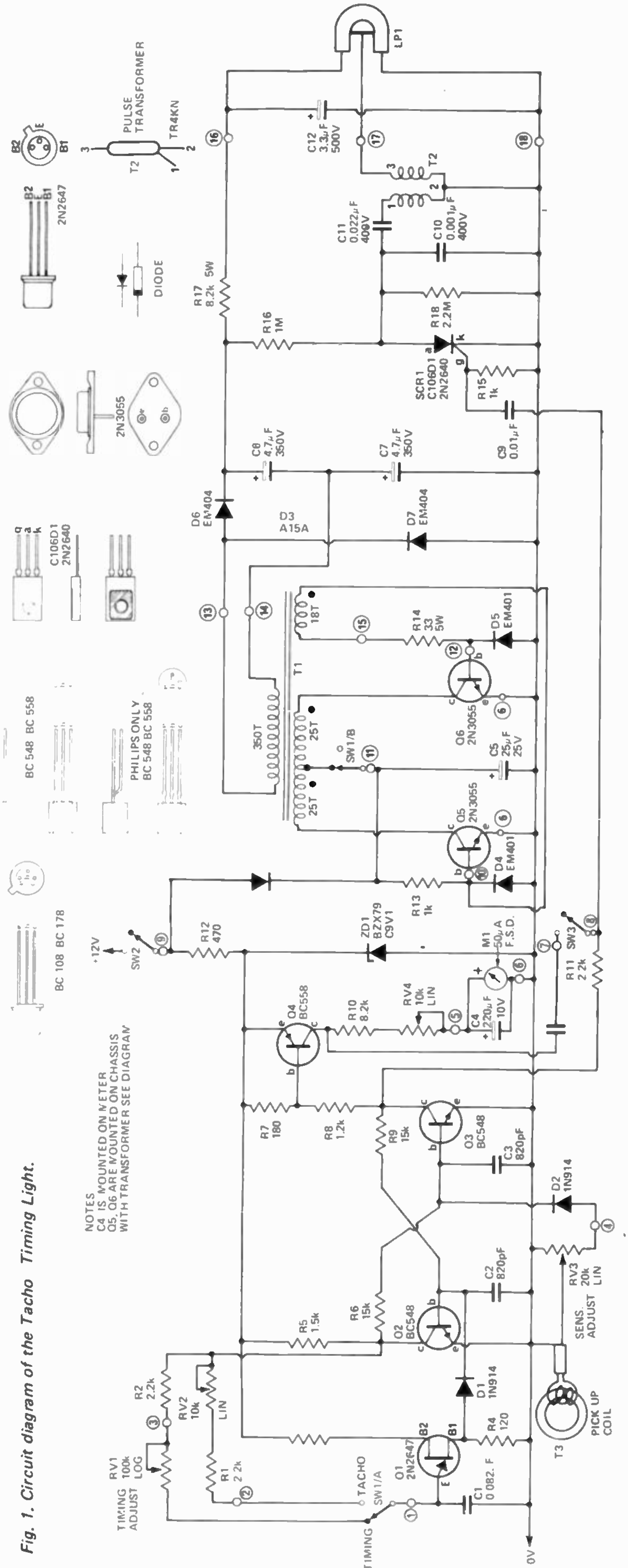
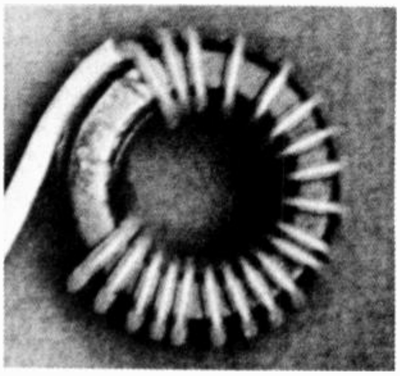


Fig. 1. Circuit diagram of the Tacho Timing Light.



This picture shows how the transducer is wound with the inner core of shielded cable. Aluminium foil shielding is wound over the completed coil as detailed in the text.

PARTS LIST
TIMING LIGHT
ETI 311

R14	Resistor	33 5W	5%
R4	"	120 ¼W	"
R7	"	180 ¼W	"
R3	"	470 ¼W	"
R12	"	470 ½W	"
R13,15	"	1k ¼W	"
R8	"	1.2k ¼W	"
R5	"	1.5k ¼W	"
R1,2,11	"	2.2k ¼W	"
R10	"	8.2k ¼W	"
R17	"	8.2k 5W	"
R6,9	"	15k ¼W	"
R16	"	1M ¼W	"
R18	"	2.2M ¼W	"
RV1	Potentiometer	100k log rotary	
RV2,4	"	10k trim type VTU or similar	
RV3	"	20k lin rotary	
C2,3	Capacitor	820pF ceramic	
C10	"	0.001µF 400V polyester	
C11	"	0.022µF 400V polyester	
C8,9	"	0.01µF polyester	
C1	"	0.082µF polyester	
C12	"	3.3µF 500V electrolytic	
C6,7	"	4.7µF 350V electrolytic	
C5	"	25µF 25V electrolytic	
C4	"	220µF 10V electrolytic	
Q1	Transistor	2N2647	
Q2,3	"	BC548, BC108	
Q4	"	BC558, BC178	
Q5,6	"	2N3055	
SCR1	SCR	2N2640, C106D	
D1,2	Diode	IN914 or equivalent	
D3	"	A15A or equivalent	
D4,5	"	EM401 or equivalent	
D6, 7	"	EM404 or equivalent	
ZD1	Zener diode	BZX79C9V1 (9.1V 400mW)	
T1	Transformer	(see table 1)	
T2	Pulse Transformer TR4 kN		
T3	Pickup coil	(see table 2)	
LP1	Flash tube	MFT-1000, MFT-1200, or similar	

PC board ETI-311
M1 meter 0.50µA FSD
SW1 Switch 2 pole 2 position, position
SW2,3 switch single pole on-off. (There were already incorporated in the torch housing used in our prototype)
reflector, heatsink, housing for electronics.

HOW IT WORKS ETI 311

The flash tube used requires a supply of 300 to 400 volts. This is obtained by stepping up the vehicle 12 volts supply by means of an inverter.

Transformer T1, together with transistors Q5 and Q6 form a self oscillatory inverter. The frequency of operation, about 2 kHz on a 12 volt supply, is primarily determined by the core materials, the number of primary turns and the supply voltage. Protection against reversed-polarity supply leads is provided by diode D3.

The output from the secondary of transformer T1 is voltage doubled by D6, D7, C6 and C7 to provide about 400 volts dc which is fed to the flash tube via R17. Capacitor C12, in parallel with the flash tube, charges to this voltage and thus stores the energy needed for the flash.

Capacitor C11 is also charged up via R16 and the energy stored in this capacitor is used to trigger the flash as follows. When the SCR is triggered by a pulse on its gate it conducts and rapidly discharges C11 through the primary of pulse transformer T2. The pulse of current through the primary of T2 induces a 4000 volt pulse in the secondary winding which fires the flash tube.

When C11 is fully discharged the current through R16 is not sufficient to hold the SCR on and it turns off. Thus the flash is fired at a time determined by timing of the trigger pulse to the SCR.

The pulse from number one spark-plug lead is picked up by transducer T3 and used to trigger a monostable consisting of Q1, 2 and 3. Each time a spark-plug pulse occurs Q3 turns on and Q2 turns off, and remains off for a predetermined time before resetting. Whilst Q2 is off C1 charges via RV1/R2 (or RV2/R1) and when the voltage across it reaches about 6 volts the unijunction transistor Q1 fires, discharging C1, producing a pulse which resets the monostable. By varying the setting of RV1 the time duration of the monostable pulse can be altered.

Transistor Q4 simply inverts the output pulse train from Q3 and drives the meter M1. When Q3 is on Q4 is on and its collector is at +9 volts, and when Q3 is off Q4 is off and its collector at zero volts. Thus capacitor C4 will charge to a voltage which is proportional to the average of the on/off ratio, and this voltage is read by the meter. Zener diode ZD1 stabilizes the supply to Q4 at 9.1 volts.

The output of Q3 (Q4 in the no delay mode) is used to trigger the SCR. Since the SCR requires a positive pulse to trigger it, it will fire when Q3 turns off, that is, at the end of the delay period produced by the monostable. Since the output of Q4 is "inverted", when this output is selected the SCR fires the instant Q3 turns on, that is without any delay.

In the timing mode the delay period is adjustable by means of RV1 so that the timing mark on the flywheel is aligned with that on the block. The meter M1 will then read the number of degrees of spark advance. In the tacho mode the inverter is disconnected to disable the strobe and a preset delay of 1.66 msec is selected. The meter now reads RPM with full scale of 5000 RPM.

The picture shows how the transducer is wound with the inner core of shielded cable. Aluminium foil shielding is wound over the completed coil as detailed in the text.

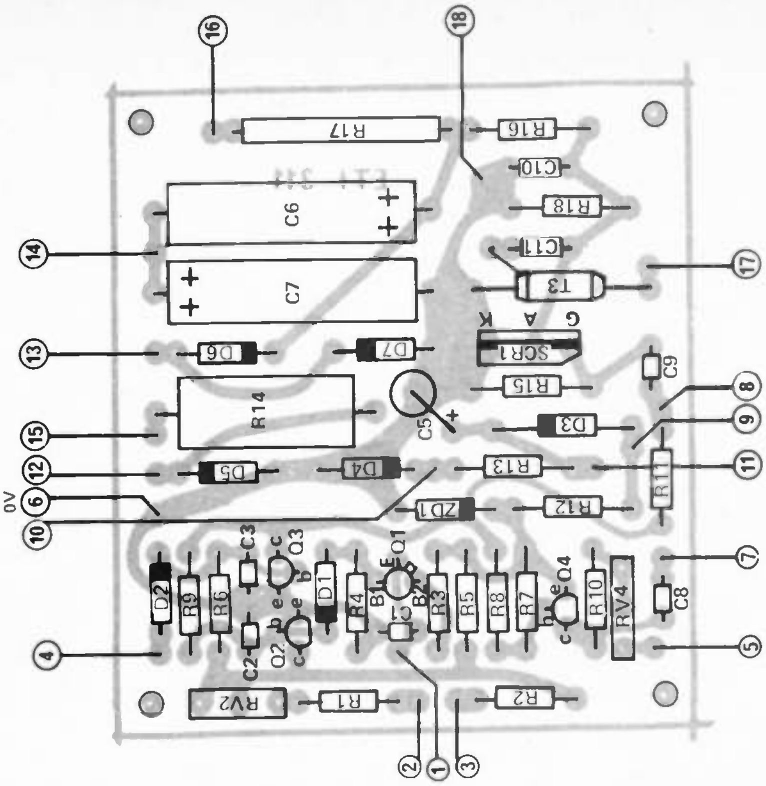


Fig. 2. Compont overlay for the Tacho Timing Light (this drawing has been placed sideways on the page to simplify checking against main circuit drawing).

TABLE 1. Transformer Winding Details

WINDING	TURNS	GAUGE	NOTES
Primary 1	25	20 B&S	Bifilar wound
Primary 2	25	20 B&S	
Feedback	18	26 B&S	
	0.01 inches insulation between primary and secondary windings		
Secondary	350	26 B&S	

Core 2 x "E" core Philips type 4322 020 34720
Coil Former Philips type 4312 021 28622
or Philips type 4322 021 31830
(the latter type has solder pins on former)

TABLE 2. Transducer Winding Details
Core Philips type 4322 020 36570
20 turns of audio coax inner, wound and shielded as detailed in text and illustration.

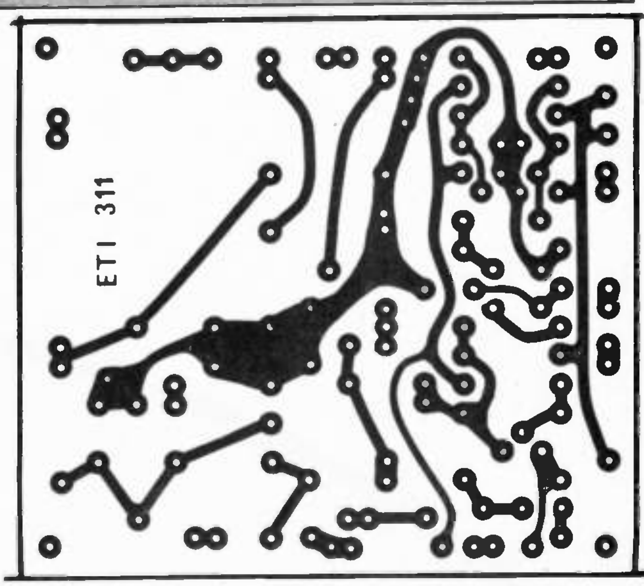
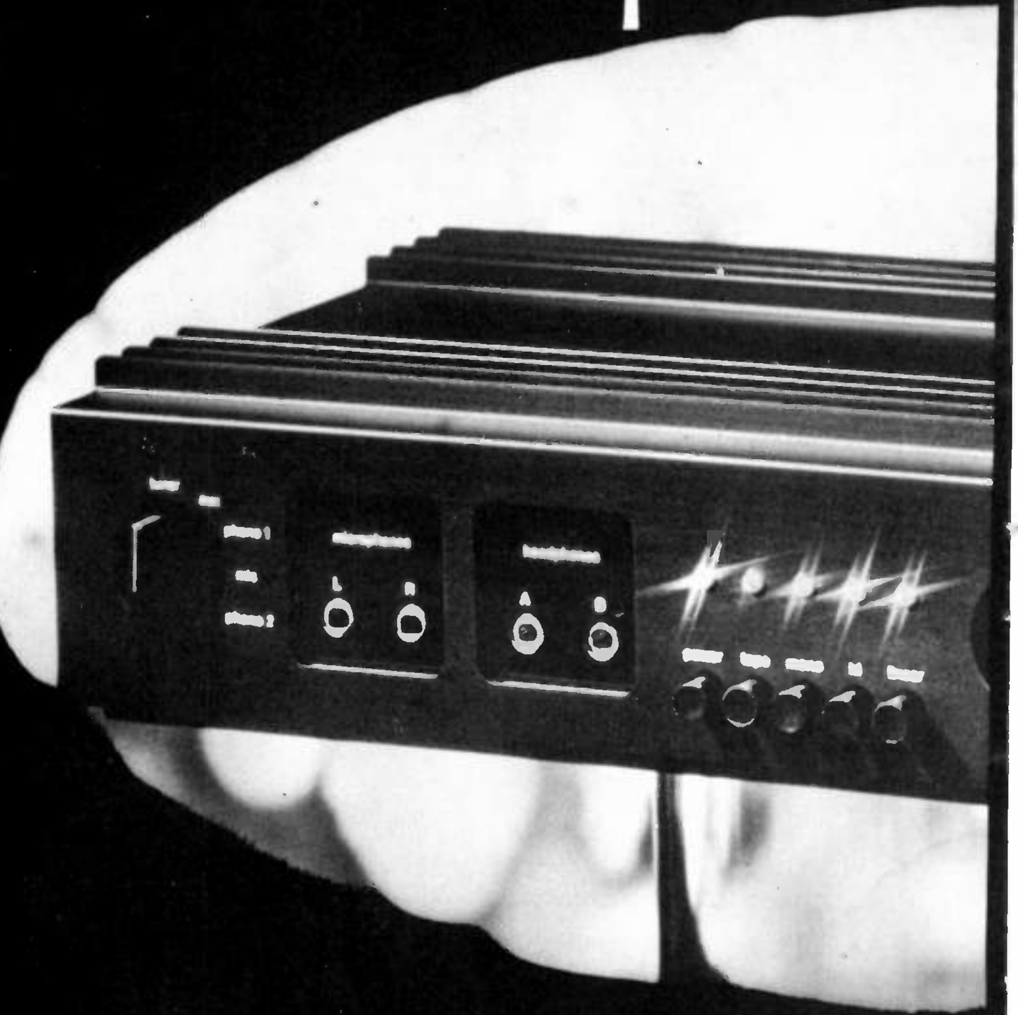


Fig. 3. Printed circuit board dimensions 74mm x 82mm (full size).

Modesty almost for
just how good the r
amplifier



The Swedes are a modest race.

They prefer to play things down. Exaggeration doesn't go down well in their cold climate. So the world has come to realise that when a Swede says something is passable it's good. And when a Swede says something is good — it's great.

In Sweden the new Sonab P4000 amplifier is considered good. Which is hardly surprising since it took thousands of design man-hours to develop.

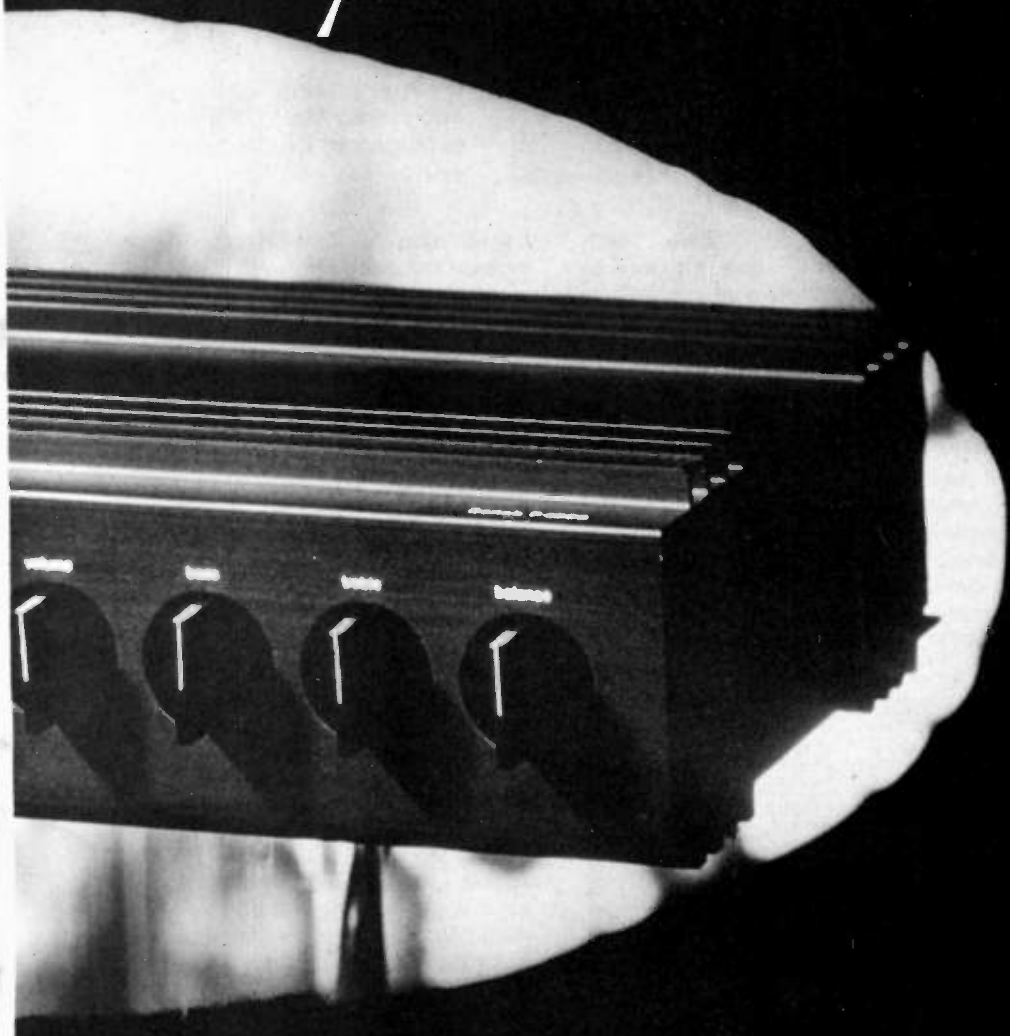
The man responsible was Clas Wanning — Stig Carlsson's greatest disciple. Clas Wanning is an honours graduate in Audio Electronics from the Institute of Technology of the University of Stockholm.

The P4000 is his brainchild.

So what makes it so good?

It has 50 watts per channel output, and an almost flat frequency response curve. So you never miss a note.

rbids us from saying ew Sonab P.4000 really is.



It's good looking too. The chassis is made from extruded aluminium almost ¼" thick. With all the inputs, outputs and knobs you need. And it's so strong not even a ton of bricks could harm it. In fact it's as durable inside as out.

The electronics are so good they're guaranteed. Not just for 12 months like ordinary amplifiers are. But for a whole 5 years, with no holds barred. So modesty certainly doesn't prevent Sonab from putting their money where their mouth is. And it doesn't cost you a fortune either. Just $399.00.

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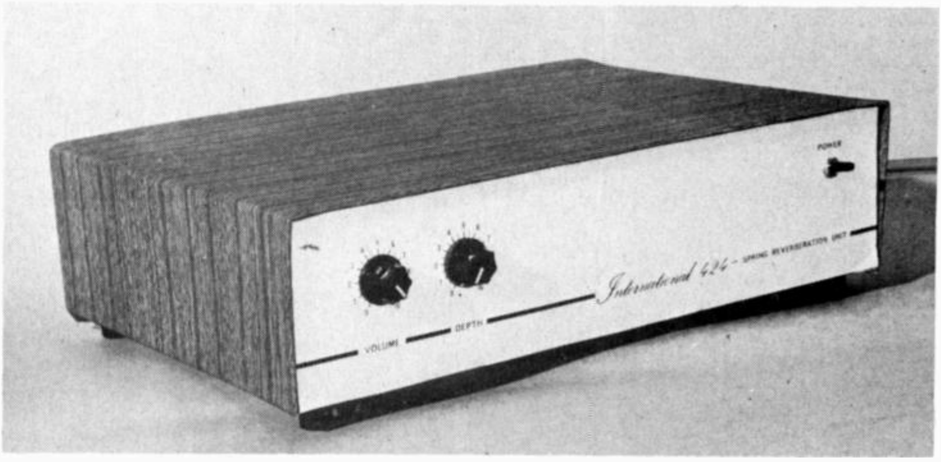
SPRING REVERBERATION UNIT



Built-in mixing facilities and stereo operation are provided in this versatile unit.

THE SOUND of many musical instruments may be "enhanced" by the addition of reverberation. Particular examples of instruments, to which reverberation is commonly applied, are the electronic organ and the guitar.

Reverberation is defined as the persistance of sound within an enclosure after the original sound has ceased. It may also be defined as a series of multiple echoes, decreasing in intensity, so closely spaced in time as to merge into a single continuous sound eventually dying away to nothing.

Reverberation, added with discretion, gives life and brilliance to the music from individual instruments which otherwise appear dull and flat. It is less commonly known that, when reproducing recorded material, the addition of reverberation can considerably enhance the liveliness of the material and its apparent spatial depth.

Artificial reverberation can be achieved in several ways. One system employs echo chambers to achieve the delay. A second system employs magnetic tape-loop techniques, whilst a third, the one used in this project, uses an amplifier that drives springs to provide the delay. It is also possible to achieve delay by fully electronic means but, for normal instrumental or home use, the circuitry is prohibitively complex and expensive.

The unit described is based on a readily available reverberation spring assembly and is suitable for incorporation into existing amplifier instrumental setups, or for adding reverberation to the reproduction from stereo Hi-Fi systems.

In March of 1972 a simpler unit was described in Electronics Today. This was very popular but, required a separate mixer in order that the generated echo and original signal could be combined in controllable proportions.

This unit has the required mixing facilities built-in, the proportion of echo to original signal being adjustable by a control called DEPTH. In addition, we decided to make the unit capable of adding reverberation to stereo systems. This involves very few extra components since both channels are mixed into the reverb spring and the combined echo then separately mixed with the original left and right channels. This extra expense is only that of an extra transistor stage and is well justified, even if the unit is mainly intended for monophonic work.

As the unit is completely functional within itself, and fitted into a strong but attractive metal cabinet it will be equally suitable for use by professionals or high-fidelity audio enthusiasts.

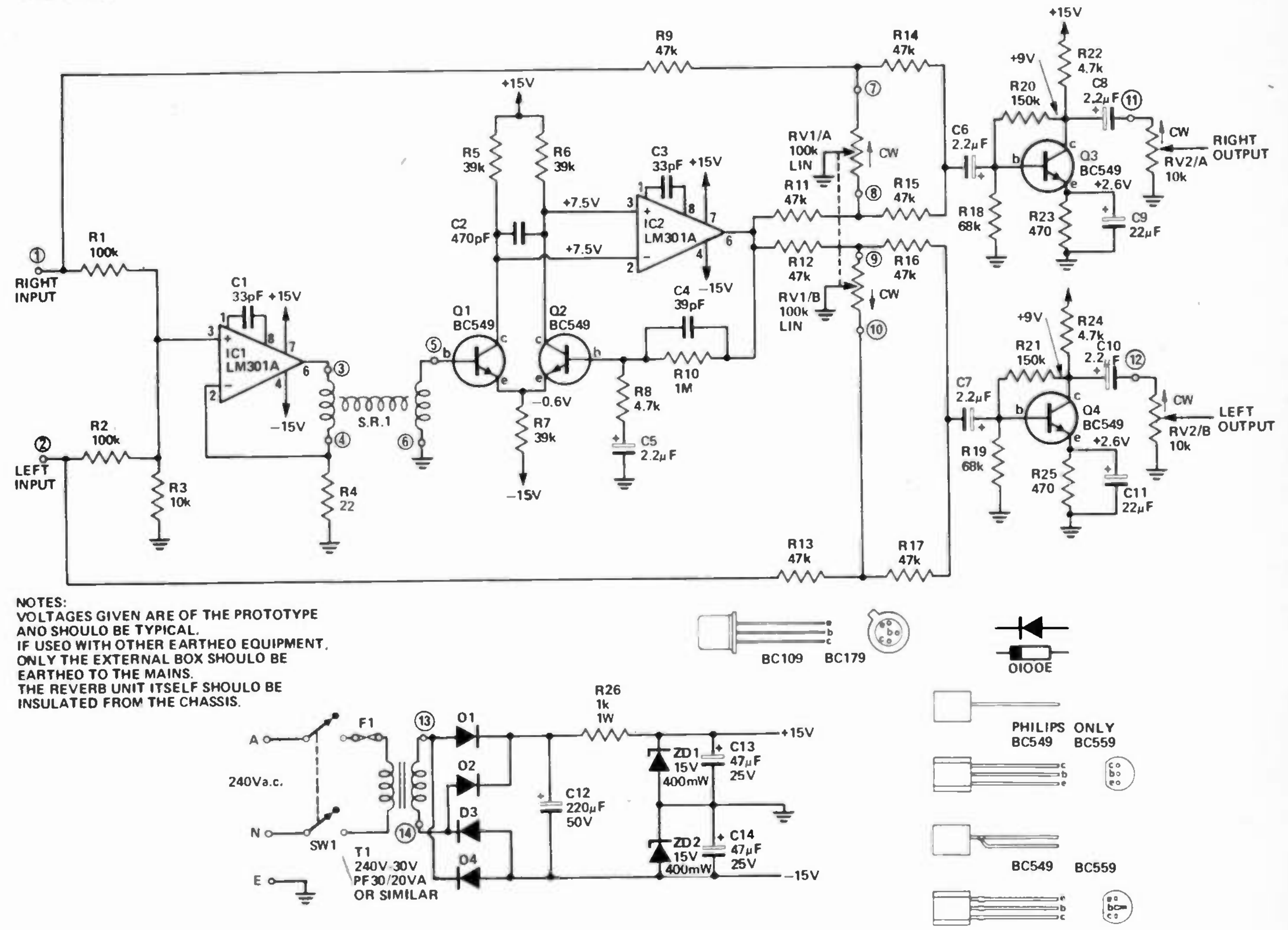
SPECIFICATION

INPUT VOLTAGE	
Maximum	1 volt
Range	100 mV – 1 volt
FREQUENCY RESPONSE	
Direct	–3 dB at 20 Hz, 50 kHz
Delayed	50 Hz – 4 kHz
IMPEDANCE	
Input	approx. 47 k
Output	< 5 k
CROSS TALK	
With 10 k source impedance	– 40 dB
GAIN	
Maximum	unity
SIGNAL TO NOISE RATIO	
Direct	> –60 dB ref IV
Reverberation	> –50 dB ref IV

CONSTRUCTION

We housed our unit in a simple pan-shaped chassis with metal cover,

PROJECT 424



NOTES:
VOLTAGES GIVEN ARE OF THE PROTOTYPE AND SHOULD BE TYPICAL.
IF USED WITH OTHER EARTHED EQUIPMENT, ONLY THE EXTERNAL BOX SHOULD BE EARTHED TO THE MAINS.
THE REVERB UNIT ITSELF SHOULD BE INSULATED FROM THE CHASSIS.

Fig. 1. Circuit diagram of the spring reverberation un

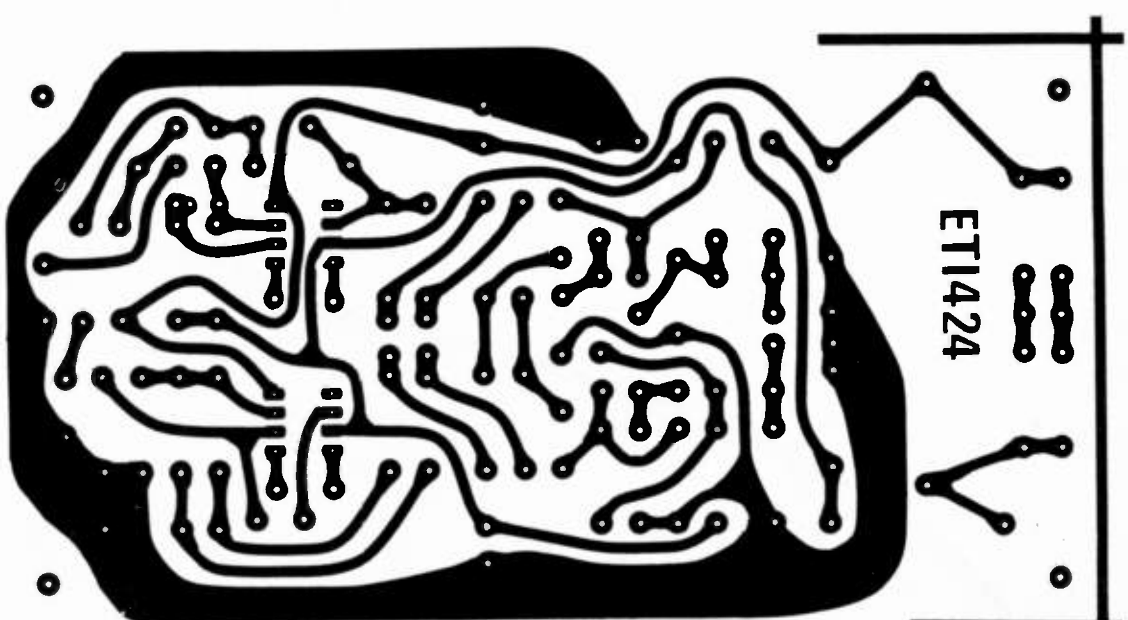


Fig. 2. Full size printed circuit bo layout.

SPRING REVERBERATION UNIT

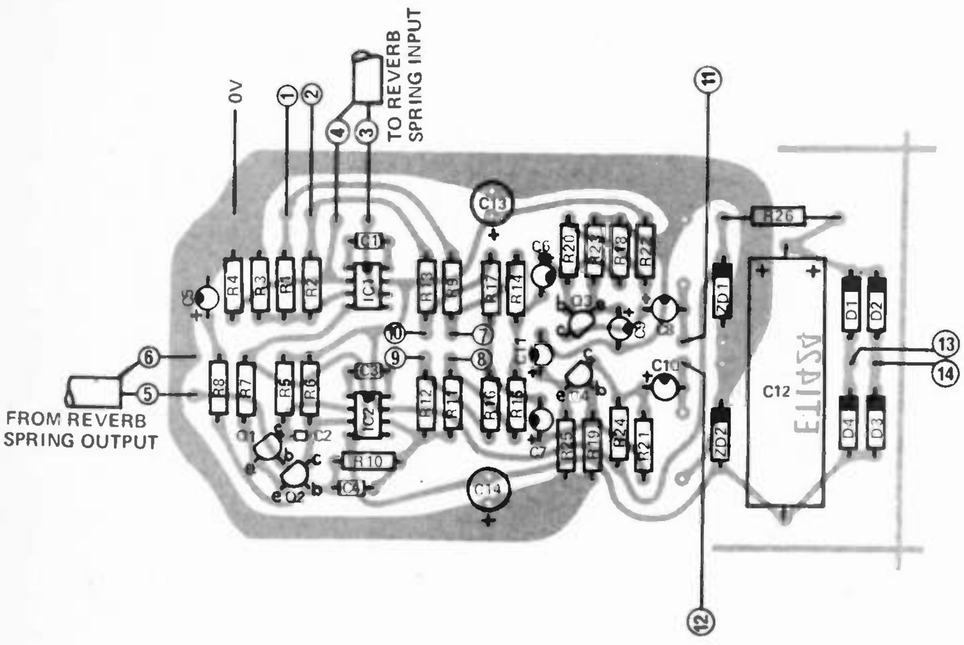


Fig. 3. Component overlay.

This enables the unit to be used as a flexible system component, but, if desired, the electronics may easily be incorporated within an existing system-box if room permits.

The majority of the components are mounted upon one single printed-circuit board, although matrix or veroboard can quite easily be used if preferred.

Whichever constructional method is used, it is essential to check polarized components, for correct orientation, before soldering. Note especially that two different pin configurations for the BC549 are available and that it is the Philips type which is shown on the overlay.

The input socket of the reverberation spring must be removed and replaced with an insulated type. To do this it is

HOW IT WORKS

The reverberation spring is an electro-mechanical device for delaying and producing echo on audio signals – it operates in the following manner. A relay-like transducer vibrates one end of a spring in response to an input audio signal. The spring continues to vibrate after the excitation has been removed and thereby produces a decaying 'echo' as well as delaying the propagation of the signal to the transducer at the other end.

The mechanical system naturally has many resonances and the frequency response therefore cannot be flat over a small frequency range, but is substantially flat over the broad frequency range of 50 Hz to 4 kHz.

Integrated circuit IC1 is connected so as to provide current drive to the input transducer of the spring. The transducer is inductive and hence, the voltage across it will increase with frequency. However, since the current remains constant, the power in the transducer also remains constant. The stereo input is summed into R3 by resistors R1 and R2 (with a loss of 20 dB) to provide a composite signal at pin 3 of IC1. As the amplifier always tries to keep pin 2 at the same potential as pin 3, the voltage across R4, and the current through it, is therefore proportional to the input voltage. As very little current flows into pin 2 of the IC, all this current flows through the transducer.

The output signal from the transducer at the other end of the spring is very small (about –50dB referred to the input and is therefore amplified back to a reasonable level by Q1, Q2 and IC2. Transistors Q1 and Q2 are low noise types and are arranged as a differential pair to add gain before the inherently noisy IC. The gain is set by (R10+R8)/R8 to about 46 dB. The low frequency cutoff is set by C5 and R8, and the high frequency cutoff by R10 and C4. Note that these last figures refer only to the receiving transducer amplifier and not to the whole system.

The direct inputs, left and right, are now both mixed with the common reverberation signal in mixers Q3 (right) and Q4 (left). The proportion of direct and reverberation signals is adjustable by means of depth control RV1. The gain of the output stage is set by R20, R21 and the bias by R18, 19, the overall gain of the complete system being approximately unity.

If single channel operation only is required, simply delete the second mixer transistor and its associated components. If reverberation only, without the mixing facility, is required the output may be taken direct from pin 6 of IC2.

In the event that a volume control is not required resistors may be fitted to the board (holes provided on board) to set the volume to any desired level. These resistors may have any value between 10 k and 1M.

ETI 424 PARTS LIST

R4	Resistor	22	½W	5%
R23,25	"	470	"	"
R26	"	1 k	1W	"
R8,22,24	"	4.7 k	½W	"
R3,	"	10 k	"	"
R5,6,7	"	39 k	"	"
R9,11,12,13	"	47 k	"	"
R14,15,16,17	"	47 k	"	"
R18,19	"	68 k	"	"
R1,2,	"	100 k	"	"
R20,21	"	150 k	"	"
R10	"	1 M	"	"

RV1	Potentiometer	100k dual lin rotary
RV2	"	10 k dual log rotary
C1,3	capacitor	33pF ceramic
C4	"	39pF ceramic
C2	"	470pF ceramic
C5,6,7,8,10	"	2.2µF 10V electrolytic
C9,11	"	22µF 10V electrolytic
C12	"	220µF 50V electrolytic
C13,14	"	47µF 25V electrolytic

Note: all electolytics except C12 are pc mounting.

D1-D4	diodes	EM401 or equivalent
ZD1-ZD202	Zener diodes	BZX 79 C15 or equivalent
Q1-Q4	transistor	BC549, BC109 or equivalent
IC1,2	operational amplifier	LM301A

PC board ETI 424
SW1 switch 2 pole on-off 240V rated
F1 fuse and fuse holder 500 ma chassis mounting
Spring reverb unit Plessey type 51 or equivalent
T1 transformer PF30/20VA, PF 3600 or equivalent
3 core flex and plug
2-way RCA sockets — 2 off
12mm long spacers 4 off
chassis to Fig. 7
metal cover to Fig. 8
front panel to Fig. 6
rubber grommet for power cord and insulating reverb unit.
Insulated RCA socket for reverb.

necessary to enlarge the mounting hole to provide adequate clearance. Take care not to damage the spring mechanism whilst doing this.

The reverberation spring must also be insulated from the chassis by means of rubber grommets or similar. This is necessary to prevent earth loops, when used in conjunction with other equipment, which would cause high hum levels.

The unit should be wired, as shown in Fig. 1, taking care to keep all 240 volt ac wiring well clear of the electronics and especially clear of the receive end of the reverberation spring. The metal case itself should be earthed even though the electronics itself is not earthed.

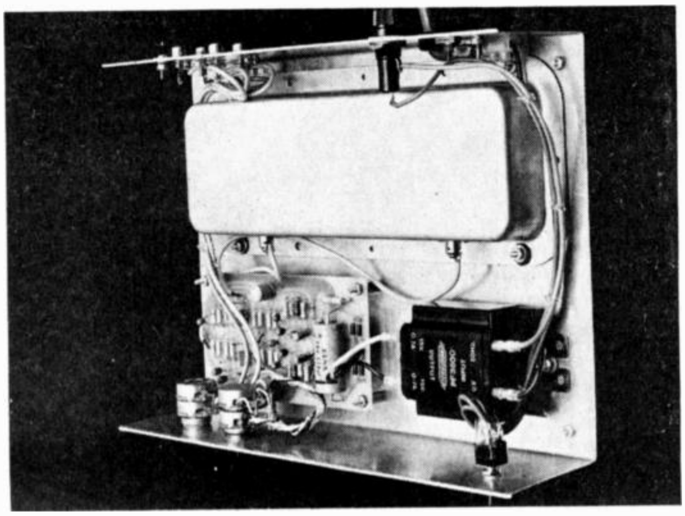


Fig. 4. Method of mounting the hardware and printed circuit board into the chassis is illustrated in this internal view.

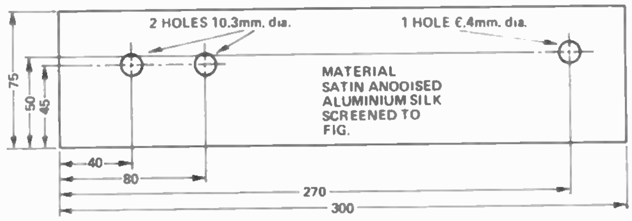


Fig. 5 Front panel drilling details.

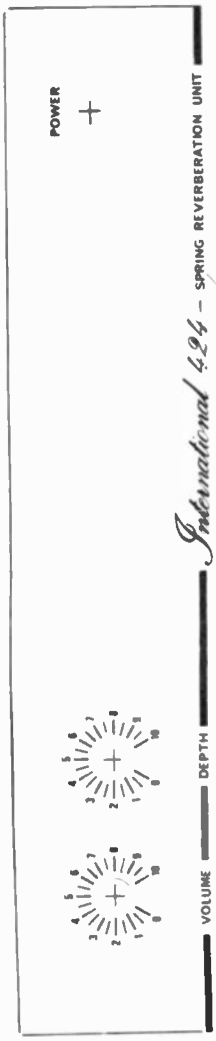


Fig. 6. Front panel artwork for the spring reverberation unit (half size)

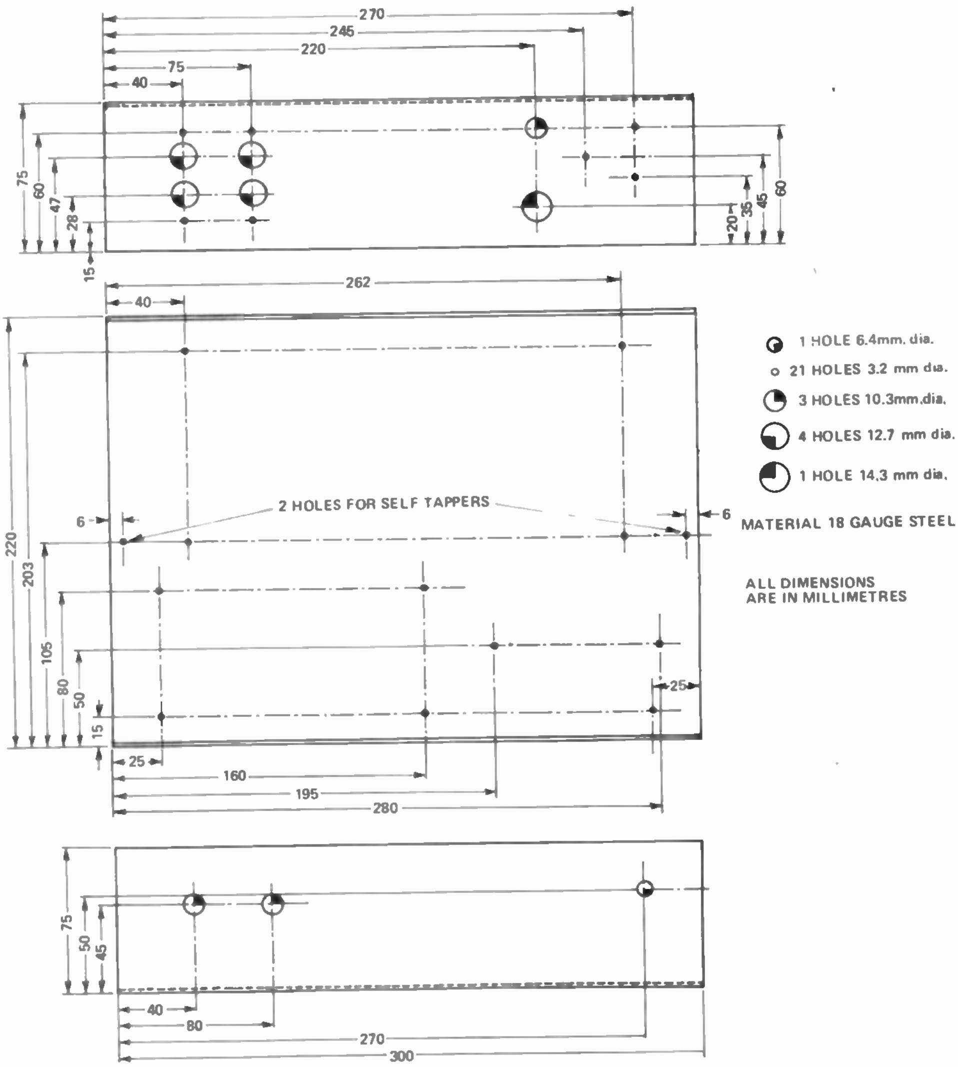


Fig. 7. Dimensions and drilling details of the chassis.

SPRING REVERBERATION UNIT

SETTING UP

As the reverberation spring is a mechanical device, vibration will produce unwanted outputs. Hence it is an inherently noisy device and should be used at a point in the system where the signal level is high.

Two typical points at which the unit may be inserted in the system are:—

1. Between the preamplifier and the main amplifier.
2. After the disc preamplifier, or high level input and the preamplifier.

If inserted between pre and main-amplifiers, i.e. after the volume control, turn the reverb volume control to maximum and adjust the preamplifier volume control such that the main amplifier is just below clipping level. The reverb volume control can then be used to set the level required.

If the reverberation unit is inserted before the system volume control, the volume control on the reverberation unit should be set to maximum (or deleted altogether if desired) and the preamplifier volume control used to set the required level. ●

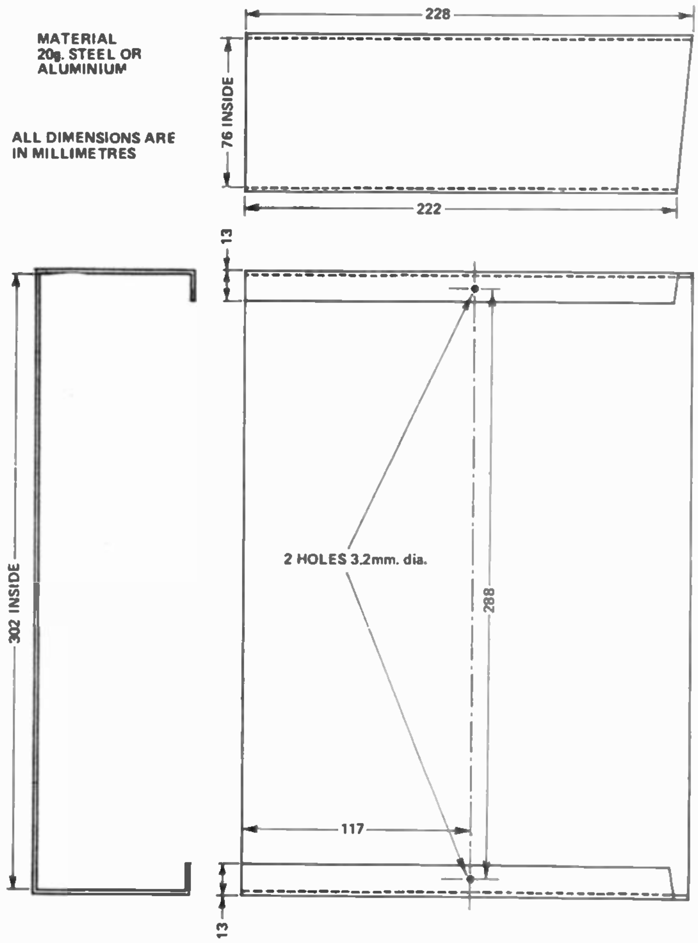


Fig. 8. Detail of the cover.

RTR Industries of California, to promote its products, use a phrase that has more meaning with each passing year . . . "total capability". If "High Fidelity" in reproduction is to be an end, "total capability" must be the means. In loudspeaker design, that demands a fundamental understanding of each speaker component. What better way is there to understand than to build. And this is exactly what RTR does, from the smallest tweeter and electrostatic panels, right up to the massive Magnum 25.

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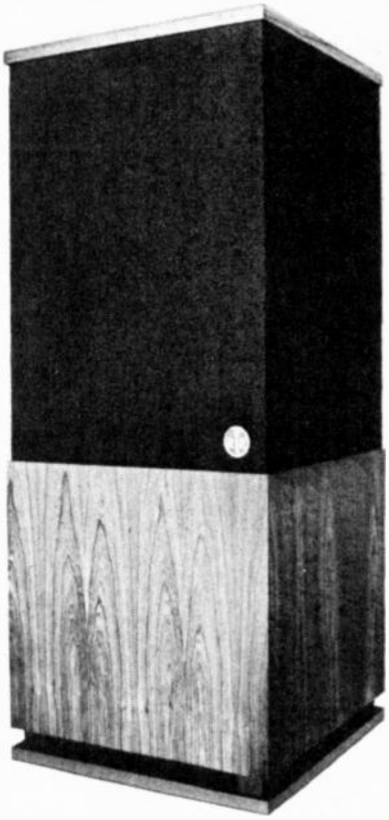


A NEW CONCEPT

The RTR columns are a new concept in transducer application. Each elegant walnut enclosure houses multiple ultralinear butyl edge suspension woofers, one of which is planar resistive loaded. This technique yields maximum acoustic low frequency coupling, increased damping and a very smooth response curve. This powerful low frequency concept is the cornerstone of the RTR column speaker systems. The ideal speaker system should radiate uniformly hemispherically, and a RTR column achieves this ideal at the low frequency end of the spectrum. To achieve "total dispersion" at the high end of the spectrum, high frequency drivers are employed on three faces of the columns to produce an incredibly uniform polar energy response plot.

RTR column speakers, a "concert hall experience".

MODEL 88/D

Freq. Resp:– 40-18500 Hz. Size:– 11" x 26¼" x 11" Deep. Rec. Amp. Power:– 20-60 WRMS

MODEL 180/D

Freq. Resp:– 28-18500 Hz. Size:– 14" x 33¼" x 14" Deep. Rec. Amp. Power:– 25-60 WRMS

MODEL 280/DR

Freq. Resp:– 22-25000 Hz. Size:– 16½" x 39" x 16½" Deep. Rec. Amp. Power:– 25-100 WRMS

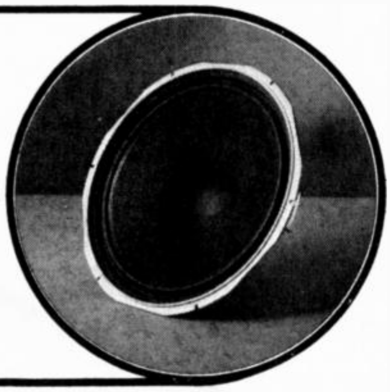
Go to your nearest RTR dealer, and have a "musical experience".

THE MAGNUM 25

The Magnum 25 is the largest transducer RTR builds . . . a 25" woofer with a 6" voice coil. It is the world's finest woofer and has no parallel.

SPECIFICATIONS

Power Handling:–	150 watts RMS
Free Air Resonance:–	12 Hz
Impedance:–	8 ohms
Freq. Response:–	15-800 Hz, properly loaded
B/L Product:–	7.5 pounds/amp.



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LD **Linear Design** BRINGS ON THE NEW

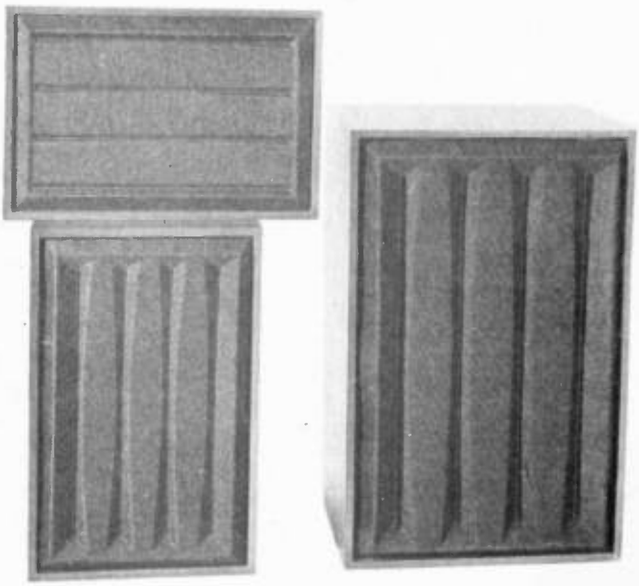
For your listening pleasure –
THE EXCITING RANGE OF 'PARAMOUNTS'

The hi-fi market has long needed a range of high-performance aesthetically pleasing speaker systems, for the hi-fi enthusiast who wants the best but can't afford overpriced imported systems.

The individual drivers in each of these systems are imported from one of America's largest speaker manufacturers, who have designed and engineered the "Paramount" range for Linear Design. The bass drivers are skilfully engineered bump-down chassis, to produce maximum cone excursions. This long-throw travel will allow for the reproduction of rich, deep bass notes without cone distortion. All the bass drivers also have the patented AlumineTM voice coil for maximum heat dissipation. All in all, a woofer that insures unparalleled power handling capabilities and low distortion.

For high frequency reproduction, the "tweeters" are engineered with a moulded high density curvilinear cone for wide angle dispersion, and are acoustically dampened within sealed back housings. Large ferrite magnets insure superb transient response and definition. Of special design is the "phenolic ring" tweeter, as used in the models P 100 and P 300, that is a unique feature and further improves dispersion. The "phenolic ring" tweeter is used in many well-known U.S. speaker systems.

All the components are carefully selected and tested. This procedure gives you the ultimate in a speaker system, based upon your particular needs, power ratings and price range.



PARAMOUNT 100:

An 8" woofer, with a 4 layer voice coil and butyl rubber edge suspension, insure the flattest low frequency response in the budget price bracket. This woofer, when coupled with the revolutionary "phenolic ring" tweeter, creates a system that is truly an advance of the statement-of-the-art.

Power handling:– 25 WRMS – Frequency response: 45-20,000 Hz.

Price:– $129 per pair

PARAMOUNT 200:

Elegant sound reproduction provides exciting listening with this "Paramount" three-way system. Powerful bass from a 10" polyurethane edged woofer, pure midrange clarity from a 4½" sealed back driver, and add a 3" curvilinear tweeter for reproduction well beyond the audible range, and you have a luxuriousness of sound that is difficult to imagine.

Power handling:– 50 WRMS – Frequency response:- 41-20,000 Hz.

Price: $199 per pair

PARAMOUNT 300

The maximum in sound, the ultimate in quality, that's Linear Design's Paramount 300. Engineered to be the best 3-way speaker system on the market at a medium price, the 12" polyurethane woofer, 4½" midrange and the best of the "phenolic ring" tweeters, all superbly matched, span the frequency spectrum in a way that adds "culture" to your sound. The Paramount 300 will reproduce the gargantuan roar of the fourteen foot organ pipe, and the freshest tinkle of the glockenspiel with absolute clarity.

Power handing: 50 WRMS –

Frequency Response: 35-22,000 Hz.

Price: $249 per pair

When you're shopping for fabulous sounds, Listen to Linear Design's "Paramounts".

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PART 3

ELECTRONICS IN CRIME

In the battle against crime — *both* sides are using increasingly sophisticated techniques, Electronics Today reports.

MOST people have an 'it couldn't happen to me' attitude toward crime. This results in what the police call 'patchwork' security — the householder waits until a crime has been committed before installing an alarm system — which is then more than not only partially effective.

Nevertheless there are many domestic alarm systems, commercially available, that can provide very effective anti-intrusion security — especially if tailored to suit individual applications.

PERSONNEL SECURITY SYSTEMS

On a larger scale the security of widely dispersed installations presents a more complex problem.

Airports, factories, warehouses and other public buildings must be protected not only against the clandestine intruder, but, also against the activities of extremists carrying firearms or explosives as well.

Arson is particularly difficult to prevent. If the potential arsonist can penetrate an intrusion security screen, then there is very little that can be done to prevent him planting devices and successfully starting a fire. Such devices are quite ingenious and can be made to look like everyday objects.

One example is a device used by saboteurs during the Second World War. It looked just like a pencil — hence its name 'fire-pencil'. Inside were two compartments, separated by a thin wall of copper. One compartment contained picric acid (a highly sensitive explosive compound). The other contained a concentrated mineral acid inside a membrane.

When the membrane was perforated the acid would come in contact with the copper dividing wall and after a desired time, (determined by the thickness of copper), would eat through the wall and attack the picric acid.

The result was a violent reaction producing a sheet of flame of high temperature that ignited any surrounding flammable material. The time delay gave the saboteur ample time to leave the scene.

More effective intrusion security and patrolling of areas seems to be the only effective measure against the potential arsonist.

Where an "insurance" job takes place, about all that can be done is to determine the cause of a fire and investigate suspected persons.

It is estimated that about a third of reported fires are deliberately lighted.

AREA SECURITY

Alarm systems play a key role in the reduction of burglary, robbery and other crimes. The mere presence of an audible alarm system may act as a deterrent. Its primary mission is to

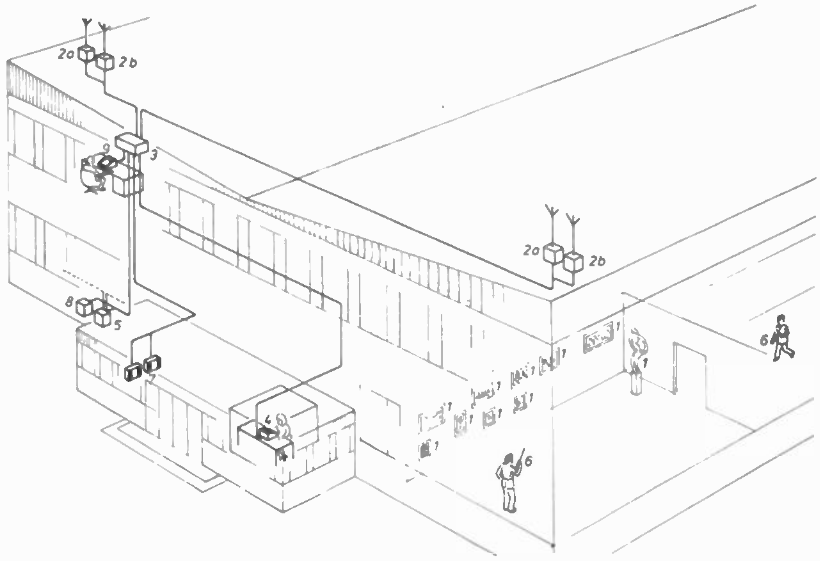


Fig. 1a. Perimeter Security Area and guard communications.

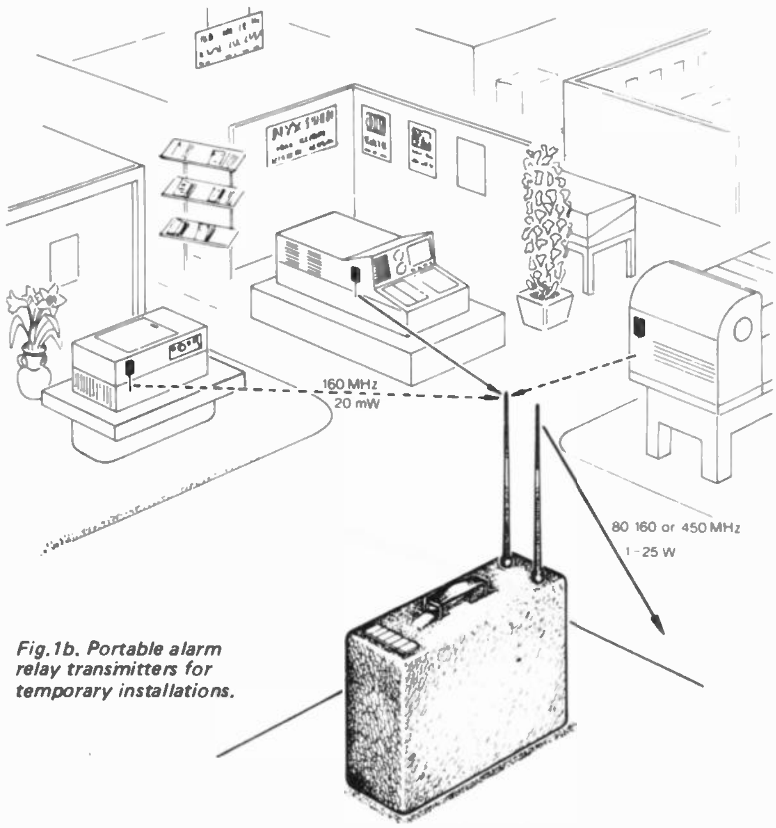


Fig. 1b. Portable alarm relay transmitters for temporary installations.

ELECTRONICS IN CRIME

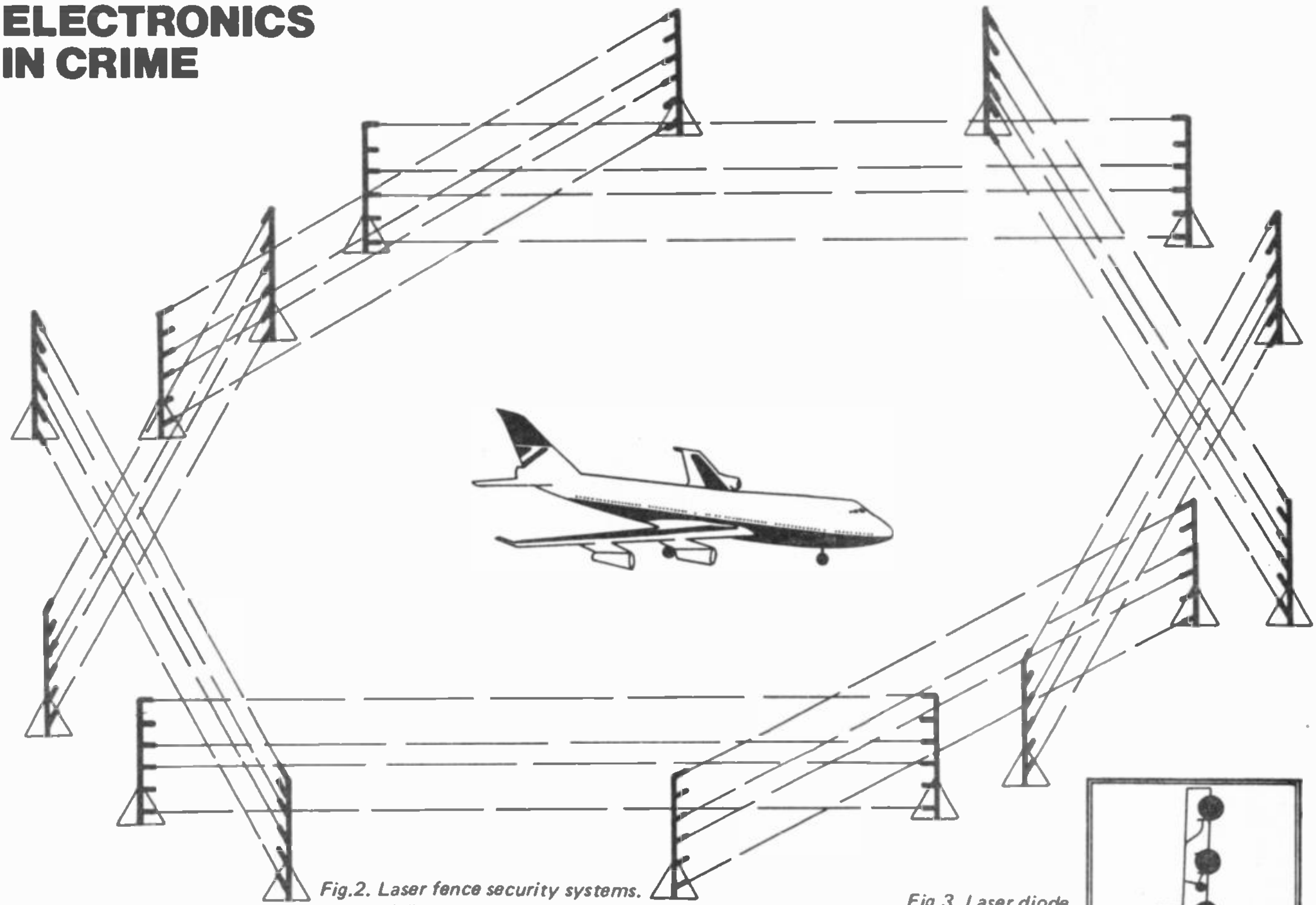


Fig.2. Laser fence security systems. Airliner is not drawn to scale.

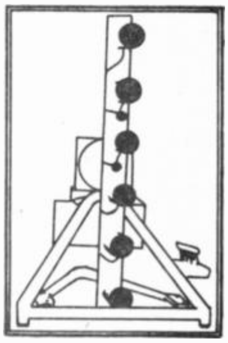


Fig.3. Laser diode array for security fence.

prevent a crime from occurring and thereby prevent loss.

In contrast a "silent" alarm with remote "alert" facility has no deterrent value, but provides a better opportunity to capture the intruder.

The widespread introduction of electronic alarm systems is forcing many criminals to rethink their methods of working. Successful disabling of alarm systems demands an increased level of skill — and more specialised tools.

Various types of alarm systems are used:

The hard-wired alarm system

In this a series of switches and trips are wired into strategic locations such as windows, door catches etc. The alarm is triggered if any of these switches is activated.

Whilst fairly effective against the casual thief, the more determined intruder can overcome such alarms by studying the system and placing "jumpers" across switch terminals or trip wires. Furthermore if the system is mains powered the simple expedient of disconnecting the power at the main will immobilise the system unless automatic changeover to standby batteries is included.

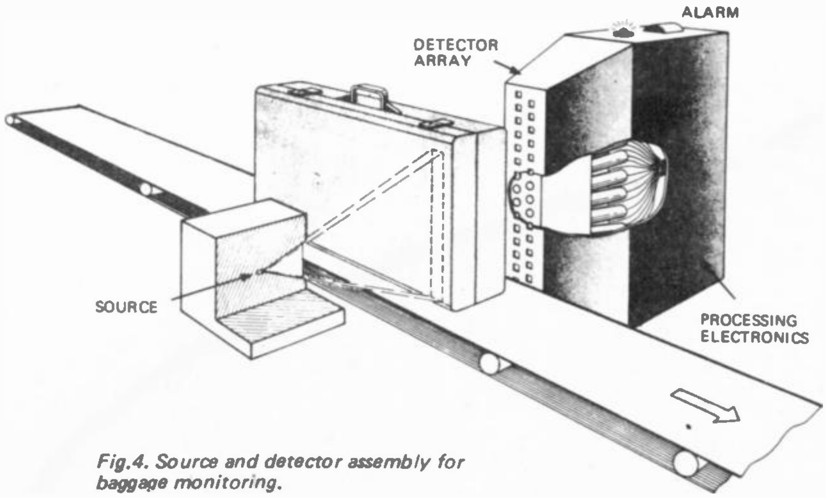


Fig.4. Source and detector assembly for baggage monitoring.

"Volumetric sensor" alarm systems

Volumetric sensors provide a three-dimensional detection zone. A variety of these devices are available; ultrasonic, passive acoustic, microwave, radar, optical and passive infra-red are the most widely used.

They offer a formidable obstacle to the intruder, but are prone to a high percentage of false alarms.

They operate by detecting noise or heat produced by the intruder, or by detecting movement in the protected area (by reflected energy or by Doppler effects introduced into a sonic or RF field saturating the area).

"Perimeter security" systems

In larger industrial applications where security is required beyond the buildings themselves, more elaborate methods are necessary. Here, alarm systems may be used in conjunction with guards patrolling the area.

Where variable factors come into play as at exhibitions, museums, trade fairs etc. a flexible system has been developed that can be quickly set up and linked to a central control unit, as well as providing communications with guards. (see Fig. 1a and 1b)

This system consists of miniature alarm transmitters that are portable and can be quickly placed at strategic locations. Portable alarm relay stations link one or more of these transmitters with a central processing unit, (which is part of the fixed equipment) together with diversity receivers and control units.

The alarms are sensitive to acceleration, temperature and position and when triggered send a signal identifying that transmitter. The alarm signal is picked up by a receiver and transmitted to a central processing unit.

Immediately a signal is received, the guard nearest the alarm point is alerted by UHF radio or an inductive loop. If the guard fails to acknowledge the call a nearby group of guards is alerted. At pre-set time intervals other actions may be initiated, eg. automatic closure of doors, telephone alarms to the police etc.

All alerts are registered on a printer which registers date, time and location as well as the name of the guard.

This integrated system has been developed by Sweden's Sonab AB and is representative of a modern highly effective security system.

The laser "fence"

Because installations such as airports and military bases are vulnerable to intrusion, the US Air Force has developed a laser system for perimeter security.

Solid-state injection lasers (giving off radiation in the near infra-red) generate narrow beams of energy which are monitored by remote receivers.

Any intruder crossing the optical path will trigger an alarm. Fig. 2 shows how an overlapping array of laser fences can provide total security around a given area. The units shown in Fig. 3 are portable and can withstand the high winds experienced around airfields.

They are operable even when visibility is poor. The low power laser sources are safe to personnel.

Weapon detection

With the current wave of terrorist attacks and hijackings the need for security at airports, post offices, and other public places has resulted in a large range of devices coming into use.

Baggage, for instance, is checked prior to loading into a plane's cargo-hold. Security guards usually search each piece by hand but this is both time consuming and costly.

Devices are now available for automatically checking luggage for weapons and other hidden items.

Westinghouse, have developed a gamma-ray detection system for continous luggage monitoring.

The luggage is scanned as it is carried along a horizontal conveyor, between the gamma source and the detector array. (see Fig.4).

A fan beam of gamma rays passes through the luggage and is monitored by an array of scintillation detectors. By adjusting the detection level appropriately the system detects the presence of a weapon by looking for radiation falling below a preset threshold level.

The high degree of absorbtion by weapons, especially lead bullets, makes them stand out compared to most metal objects carried by travellers. The incidence of false alarms is sufficiently low to make this an effective and fast security monitor.

Since the radiation source consists of a radioisotope inside a shielded container, the unit is compact and easily transportable.

Another type of system that can be used on conveyor belts is the magnetic metal detector similar to that used to detect tramp metal in quarries and mines.

Goods moving along the conveyor pass through a detector loop which is adjusted to detect metal objects above a certain size. When a metal object enters the activated loop, it distorts the magnetic field and triggers the alarm. Units such as this have been tested in postal sorting offices with good results.

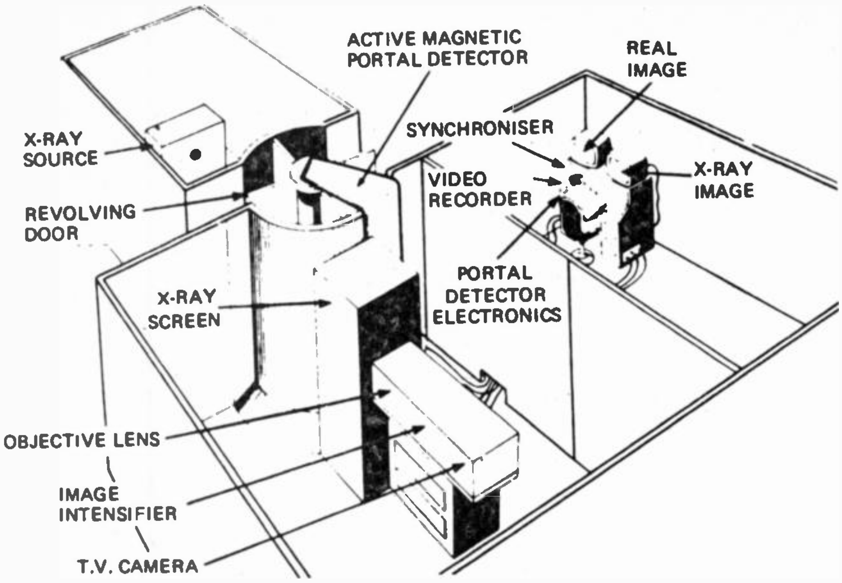


Fig.5. Personnel X-Ray screening portal and alarm system.

Detecting explosive and non-metallic objects

Firearms are relatively easy to detect, their concentrated mass of metal can be spotted by conventional metal detectors.

But explosives and non-metallic objects pose a more difficult problem

Fig.6. X-Ray of dummy carrying concealed weapons.

ELECTRONICS IN CRIME

— in fact many of the recent 'letter bombs' were impossible to detect without the use of very sophisticated equipment.

At present the only effective way to detect explosives and non-metallic objects is to sense their characteristic odours.

Explosives are naturally unstable compounds. They emit vapours that can be detected by gas chromatographs, and other forms of chemical analysers.

These 'electronic sniffers' sample the air (often routinely), in places where explosives are likely to be concealed: luggage lockers at airports and railway stations are common examples. These units can also detect fire-arms by sensing the oil vapours with which they are usually lubricated.

Specially-trained dogs are also used to detect the odour of explosives, firearms and other contraband material. At present, trained dogs are the most sensitive of our sensors, in fact their sensitivity to very small concentrations of vapour far exceeds that of even the most sensitive gas chromatograph. (Both dogs and chromatographs are much more sensitive than an unaided human.)

Protecting key public figures

Assassination and terrorism is a growing menace.

Four American Presidents have been assassinated in the past one hundred years — and there have been unsuccessful attempts on two more. Innumerable public figures have been killed in the same way.

The assassination of Archduke Ferdinand at Sarajevo triggered the First World War. In more recent times Robert Kennedy, Martin Luther King, Malcolm X . . . . . . the list goes on and on.

Clearly it is becoming increasingly necessary to protect key public figures and bystanders as well, in 'crisis centrepoints'.

A great deal of research into personal protection has been carried out by the

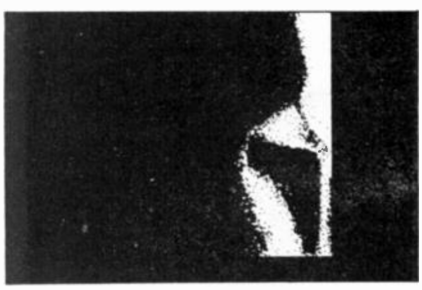


Fig.8. Thermal image of concealed weapon.

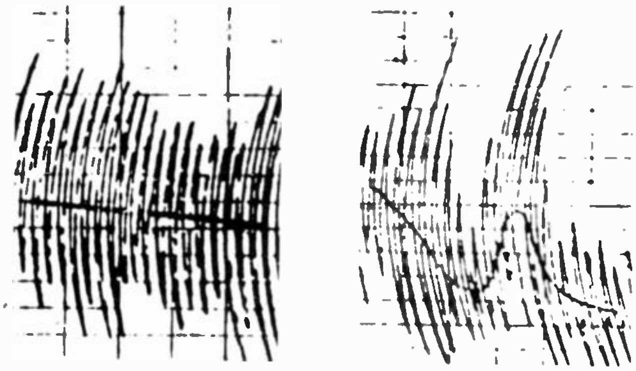


Fig.7. Voiceprints of stressed and unstressed subjects (well defined) modulation of the unstressed (right) voice all but dissappears "under stress" (left).

US Army's Mobility Equipment Research and Development Centre (MERDC).

MERDC's recent efforts have been concentrated on three main research projects. These are, controlled access to crisis areas, crowd surveillance, and sniper fire detection.

Controlled access checkpoints have existed since hostile actions started between groups of human beings. Until recently these consisted of visual and physical checks, and evaluation of behaviour patterns. But now, these checks are aided by various electronic devices.

The principle hazard is concealed weapons. These are usually detectable by channelling people through a limited number of entrances housing various types of magnetic and X-ray equipment coupled to alarm systems. (Fig.5). Figure 6 shows an X-ray of a simulated 80 kg human. The dummy is a walking arsenal. Observable on the X-ray are several otherwise-concealed weapons distributed about the body. This X-ray photo was taken using an image intensifier. TV screen displays are also used. These are less clear but improved systems are being developed.

Whilst this technique provides a quick generalised 'scan' of the population, more sophisticated methods are used to investigate individual suspects.

One device that shows great promise is the psychological stress analyser. This device analyses changes in involuntarily modulated components of the human voice (Fig. 7). In use, the suspect is asked a series of questions and his answers recorded. The subsequent tape is run through the analyser which produces a chart which must then be interpreted by a trained operator.

MERDC's goal is to produce a unit which can analyse suspects' speech directly, indicating the presence and degree of stress without operator interpretation.

Basic voice analysis units are currently being used by several police forces and army units worldwide. Regrettably, these devices are also being used by employers to vet their prospective employees — with or without their permission. However legislation may well soon be passed in the USA to outlaw their use — except, presumably, by security organisations.

Another device used for crowd surveillance is the infra-red imager. Figure 8 shows how a weapon will reveal its presence thermally at a distance of about four metres. This technique works well but has not yet been evaluated practically.

Magnetic weapons can also be detected by active hand-held devices. These units are based on army mine detectors and are effective only over very short distances, about a third of a metre at best. These detectors are not very effective, as operators must 'frisk' their suspects at close range — without detection.

Another device developed by MERDC detects and locates the source of sniper fire. Naturally this is only effective *after* the act, but some measure of protection is provided if the origin of a shot is known.

The device uses multiple radiometers in a 360 degree array to detect and locate the infra-red component of a gun-flash. Maximum range is about 300 metres. The unit covers twelve 30 degree segments in azimuth and four 20 degree layers in elevation. Thus

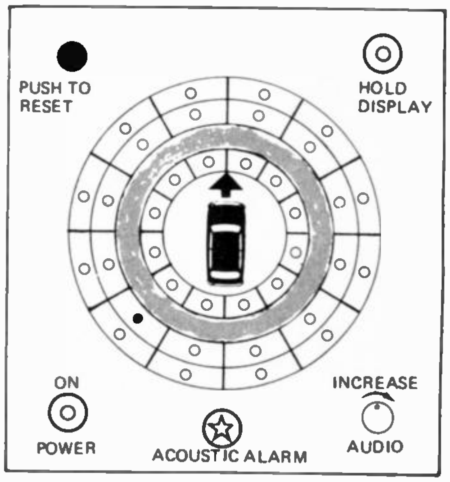


Fig.9. IR gunflash detector display console.

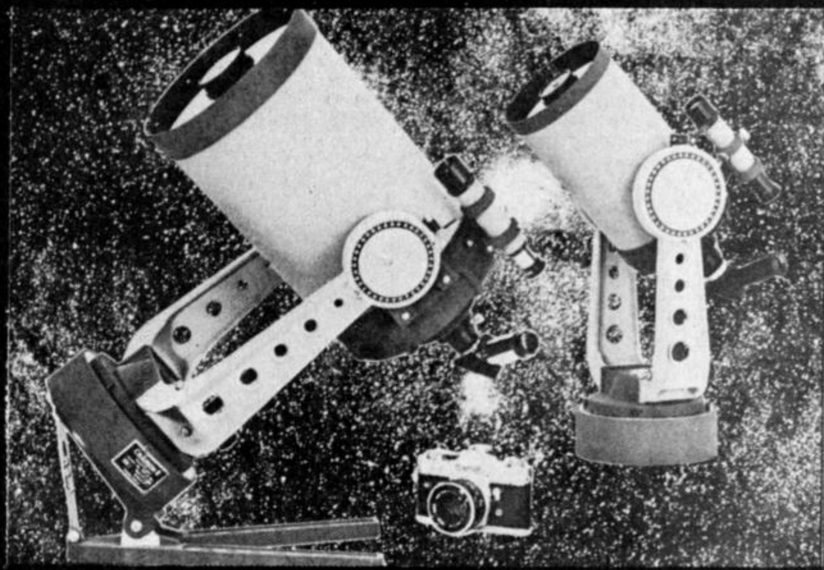
there are 48 fields of view (Fig. 9). The unit incorporates an acoustic alarm actuated when ancillary sensors detect gunshots close by.

The various and diverse technologies being researched by MERDC have many civilian applications and their efforts have been closely coordinated with the US Dept. of Transportation, Federal Aviation Agency, Customs, Secret Service etc.

At the beginning of this century there were only three crimes a year per thousand people. By 1971, this figure had increased to three per one hundred people — ten times as many. (Source — Prof. Sir Leon Radzinowicz, Wolfson Professor of Criminology, University of Cambridge).

It had been hoped that, with relative peace and prosperity, crime would decrease. But it hasn't worked out that way.

American gangster Al Capone once said 'There is in this country a gangrene . . . it is called the almighty buck. As long as people are prepared to do anything to get it, I can control them'. ●



YAMAHA NS690/670

SOFT DOME 3-WAY
BOOKSHELF SPEAKER SYSTEMS

FEATURES

- Die-cast transducer frames to prevent undesirable resonance
- Powerful magnet structures for superior transient response
- High space-factor voice coil windings for increased power handling
- Soft-dome transducers for smooth midranges and trebles
- High temperature voice coil bobbins for superior overload capacity
- Low resistance crossover networks for minimum power loss and better speaker damping
- Extra-thick cabinet laminates for maximum structural stability.

SPECIFICATIONS

	NS-690	NS-670
Frequency response	35–20,000Hz	40–20,000Hz
Power handling capacity	60 watts	50 watts
Nominal Impedance	8Ω	8Ω
Type	3-way	3-way
Woofer	300mmφ cone (JA-3056)	250mmφ cone (JA-2501A)
Midrange	75mmφ soft dome (JA-0701)	60mmφ soft dome (JA-0601)
Tweeter	30mmφ soft dome (JA-0509)	30mmφ soft dome (JA-0509)
Crossover frequencies	800Hz, 6,000Hz	800Hz, 6,000Hz
Fundamental resonance frequency (f_0)	40Hz	45Hz
Operating power*	4 watts	6.3 watts
Dimensions	630mm H×350mm W×291mm D (24¾"H×13¾"W×11½"D)	577mm H×320mm W×269mm D (22¾"H×12⅝"W×10⅝"D)
Weight	22kg (48 lbs.)	19kg (42 lbs.)

**Input electrical power required to obtain 96dB sound pressure level at 1 meter according to DIN 45500.* *Specifications subject to change without notice*

CROSSOVER NETWORK

Yamaha have developed a totally new crossover network for the NS-600 series systems. It features special coils having extra thick 1mm diameter copper wire wound around ferrite cores. The copper wire minimizes power loss, and improves speaker damping because of its low electrical resistance. The use of ferrite cores offers similar advantages since it reduces the number of coil windings. Also utilized are metallized paper capacitors which, because of their low power loss factor, help to improve tonal quality. The NS-690/670 series crossover frequencies are 800Hz between woofer and midrange, 6,000Hz between mid-range and tweeter, and have a cut-off characteristic of 12dB/oct.

For further information, send coupon to:
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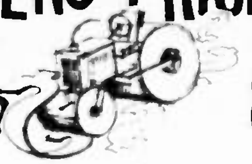

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AC126	45c	BD140	80c		
AC127	55c	BF115	65c		
AC128	55c	BFY50 (2N3053)	80c	2N3638	45c
AC187	65c	BFY51	80c	2N3638A	55c
AD149	2.35	BFY52	80c	2N3640	60c
AD161	1.30	2N6027 (D13T1)	1.25	2N3641	45c
AD162	1.30	MJE2955	2.90	2N3642	45c
AF116N	85c	MJE3055	2.00	PN3643	50c
ASZ15	3.55	2N5459 (MPF105)	95c	2N3644	45c
ASZ16	3.60	2N5485 (MPF106)	95c	2N4249	50c
ASZ17	3.55	OC44N	40c	2N4250	50c
AY9149	1.35	TT801	1.00	2N5294	1.10
BC107	25c	2N706	80c	AY8140	$1.20
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BC177	28c	2N3054	1.55	2N1554	$1.50
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MANSANTO type MAN7 7 segment solid state LED display, red 1.6V $4.25 p & p 30c

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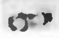
combined RED and GREEN LED'S, housed in handsome metallic case. $2.75 ea. 12c p & p



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PB40 400v 25amp	6.70
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Type GR-211. Electronic gas-filled Cold Cathode display device. In-line 9-0 Side viewing. Anode supply voltage 200v Diameter of Glass Tube 30mm. Height of digits 35mm. Colour of display digits Neon Red. $2.50 each to clear Data sheet supplied.

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Philips 1" dome tweeters. 20W RMS 8 ohms. The best there is. All new and individually packed . . . only limited quantities available so don't miss out. Only $7.85 each + 65c p & p.

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50 Assorted tag strips from 2 to 9 tags with and without mounting feet. Normal value $7.50 our anti-inflation price $1.50 + 35c p & p.

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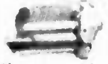

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Beautifully packed easy to build kit. Complete with Volume, bass and treble controls, power supply and components (Transformer not included) and Plessey I.C.'s. Complete with comprehensive instructions. Price $28.50 plus 75c post. Transformer to suit A & R 5508 $7.50 plus 50c P&P.

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All new and unused . . . fully imported. Complete with Time-setting control, denoting HOURS, MINUTES & SECONDS. Clearly visible figures of 5/16" Ht. Also incorporated is a remote micro-switch for setting Alarms, Radio's or Television etc. With 240V 50Hz Motor. AMAZING VALUE AT $8.95, each P & P $1.00.

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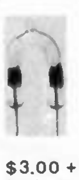

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A & R TRANSFORMERS
Great savings for 'Hard to Get' Transformers. All Listed are 240V Primary.

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1993	225 0 225 & 6 3V	2A	$ 9.00
2150	6 3 or 12 6V	2.5 or 1 25A	$ 6.95
2155	15, 12 6, 9 5, 8 5 7 5 & 6 3V	1A	$ 6 25
5502	22 or 44V	2.5 or 1 25A	$ 9 00
5508	6 3 or 12 6V	4 or 2A	$ 7 50
5509	12 6 or 25 2V	5 or 2 5A	$11 00
5579	6 3V	1A	$ 5 50
6413	32V	2A OC FWO	$12 95
6672	30, 27 5, 24 20, 17 5 & 15V	1A	$ 9 50
6978	15, 12 6, 10 5, 9, 7 5, 6 3V	2A	$11 25
7243	50,40,33,25 & 19V	2A	$15.00
7309	12V	2.5A (30VA)	$ 6 50
PS82A	BATTERY SAVER – 4½, 6, 7½ & 9V (Nominal Voltage)	0 1A	$12 25
PS164	BATTERY SAVER – REGULATED 4 5, 6, 7.5 or 9V	0 3A	$15 50
FERGUSON Low Height Power Transformers			
PF3596	2 x 6V each at 10VA	Approx 1A	$ 6.00
PF3597	2 x 7.5V each at 10VA	ditto	$ 6.00
PF3598	2 x 9V each at 10VA	ditto	$ 6 00
PF3599	2 x 12V each at 10VA	ditto	$ 6 00
PF3600	2 x 15V each at 10VA	ditto	$ 6 00
PF3601	2 x 20V each at 10VA	ditto	$ 6 00
PF3602	2 x 25V each at 10VA	ditto	$ 6.00
PF2851	12 6V CT	150mA	$ 6.00
PF3577	56V CT	1.5A	$12 90
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All transformers listed above are subject to $1.00 P & P

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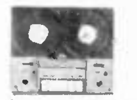

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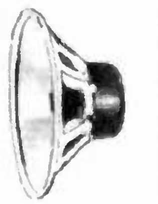
GUITAR/ORGAN/PA USE

Model 12C10L — 12", 25 watt (continuous) for lead guitar or organ. Ultra sensitive and efficient, gives "big power" sound to small amps. Heat-proofed coil, 70Hz — 75KHz resp. Imp — 8 ohms. **$24**

MODEL 18G54B $90

18" 100 watt (continous) for bass guitar. Huge "super-power" speaker that works down LOW — like from 20Hz to 3KHz. Epoxy aluminized voice coil withstands high temperatures, while the massive 54oz. ceramic magnet provides 100db sensitivity.



MODEL 12E18L for lead guitar/organ. **$43**

MODEL 12E18B for bass guitar.

12" 60 watt (continuous) heavy duty model. A rugged long life 8 ohm speaker with 1½" diam. heat-proofed voice, coil, 80Hz — 75KHz (lead), 50Hz — 4KHz (bass) freq. response.

MODEL 12G54B for bass guitar **MODEL 12G54L** for lead guitar/organ. **$67**

12", 100 watt (continuous) "super heavyweight". Extremely rigid construction with massive 54oz. ceramic magnet and 2" epoxy voice coil, 70Hz — 7KHZ (lead), 30Hz — 4KHz (bass) freq. response.

MODEL 15E28B for bass guitar. **MODEL 15E28L** for lead guitar/organ **$60**

15", 60 watt (continuous) "boomer" for high power installations in large halls etc. Heavy duty construction, epoxy voice coil, 70Hz — 8KHz (lead), 30Hz — 4KHz (bass) freq. response.

MODEL 15G54L for lead guitar/organ **$76**

MODEL 15G54B for bass guitar

15", 100 watt (continuous) "super-boomer", "big brother" to the 15E28, includes massive 54oz. magnet and reinforced cone assembly. Freq. response 80Hz — 8KHz (lead), 30Hz — 4KHz (bass). One of the most popular CTS speakers.

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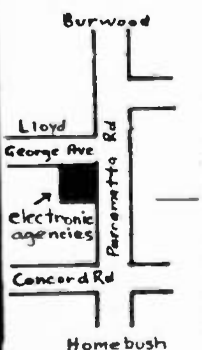

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Popular replacement speaker for local and imported transistor radios. Model 225A, 300 Hz to 5kHz.

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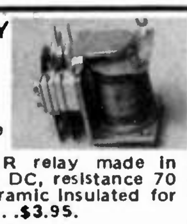

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- 5 amp contacts.
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- compact, reliable
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A quality B & R relay made in England. Coil 6V DC, resistance 70 ohms, contacts ceramic insulated for 250V switching . . . .$3.95.

NEW FANTASTIC ULTRASONIC TRANSDUCER

$5.95. ☐

Use as transmitter or receiver at 30-40 kHz for ultrasonic experiments. As featured in E.A. English P.W. and American magazines. Size 1" diameter x 1¼" long with lead and RCA type plug.

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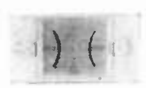
Send S.A.E. (size about 10" x 6") with 25c postage stamp for our fantastic Winter Catalogue of stock lines, specials and bargain-priced components. You won't be sorry!

VU STEREO METERS $6.95 Lge 1¾" x 1 3/8" Scales.



Dual Meters in one case — will "dress-up" any amplifier or tape recorder — for amateur or professional use.

5 inch T.V. TUBE

Brand new, sealed in manufacturer's carton

SPECIAL PRICE **$11.95.**

Ideal for servicemen, amateurs and experimenters. Specifications:— Electromagnetic deflection, 70 deg. angle, filament 12 Volt 70mA, Anode voltage 8KV at 50µA, 2nd grid voltage 300V, 1st grid cut-off voltage —25V, electrostatic focusing, size 5½" x 4" x 7" long.

Price $11.95. (plus $1.00 registered post)

A limited quantity of yokes is available to suit above T.V. tube.

Price $9.50 ☐

DE-LUXE TUNER MODULE 304

A high sensitivity 4 transistor AM tuner with tuned RF amplifier and two IF stages for extra selectivity and sensitivity. The Module is ready assembled and operates from 9V DC at approximately 3MA. A permeability type tuner and push-button On-Off switch are supplied together with circuit and application diagrams. As the module may be used with a ferrite road type aerial OR an external wire type antenna, it is ideally suited to car, portable or home use. Size 5¼" long x 1½" wide x 7/8" deep. Ferrite rod aerial $1.25ea. **$12.99** ☐

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- 20Hz — 25kHz o 2-5 gms tracking.
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- Connisseurs choice.

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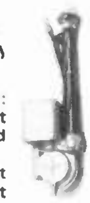

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FENDER MOUNT: Standard mounting on front or rear fender, gives good reception all areas. $2.50.

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- Latest taut-band suspension system.
- Sensitive 500µA movement, knife-edge pointer.
- Easily re-scaled (presently scaled —20 to 3dB).
- size 5¼" x 3¾" x 2½" deep (Master Insts. FB50).

DIGITAL CLOCK KIT 4 DIGIT "NIXIE" DISPLAY $45.00

Build your own case!

A complete, easy-to-assemble kit ready to install in your own cabinet. All top quality fully branded, full spec. parts incl. Printed Circuit Board, Mullard Display Tubes, transformer, I.C.'s, resistors, capacitors etc.

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7" x 3" 15 Ohm	$2.90	3TC 8, 15 Ohm	$3.75	
8" x 4" 4 Ohm	$4.50	3UC 8, 15 Ohm	$4.20	
5" x 3" 15 Ohm	$2.95	1" Philips Dome, 8 ohm	$9.00	

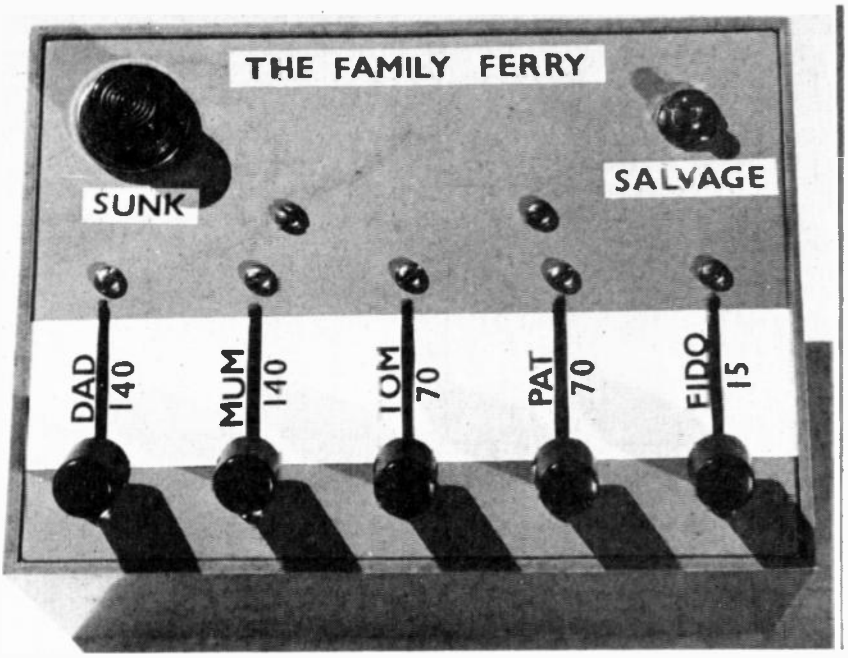


Fig. 1.

THE FAMILY FERRY

An old problem updated — electronically

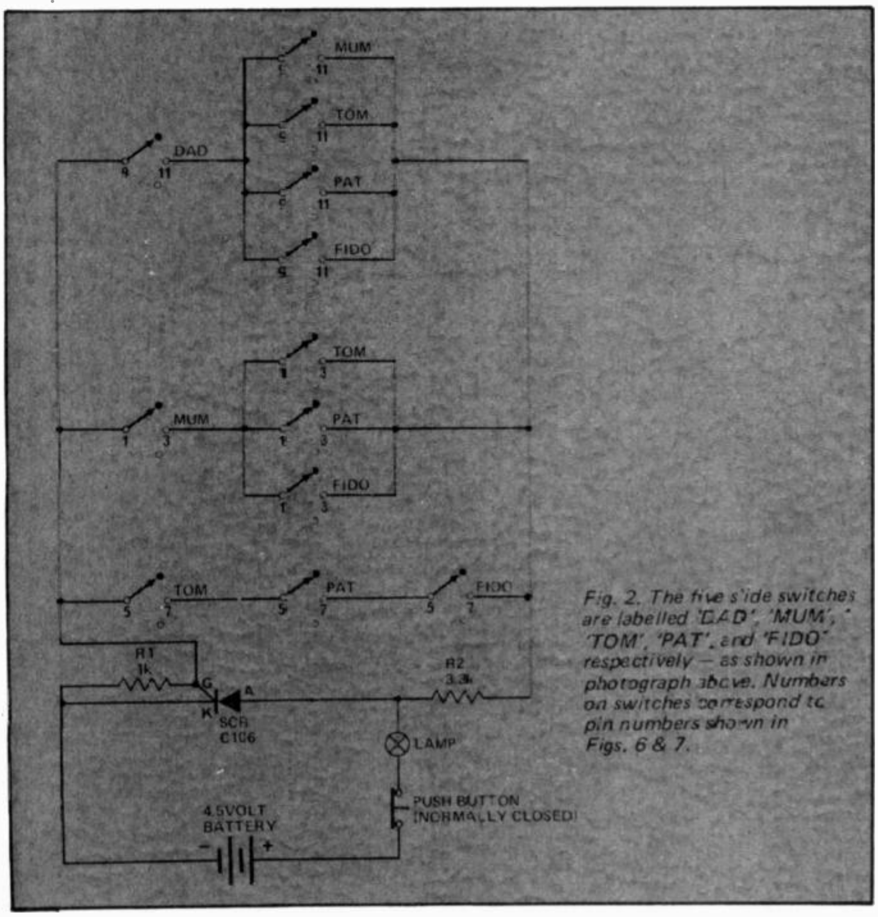


Fig. 2. The five side switches are labelled 'DAD', 'MUM', 'TOM', 'PAT', and 'FIDO' respectively — as shown in photograph above. Numbers on switches correspond to pin numbers shown in Figs. 6 & 7.

eti PROJECT 230

THE ORIGIN of this problem is not known. The writer heard it a while back, and thought it would be fun in electronic form. So here's the story:

> A family comprised Dad, who weighed in at 140 lbs, Mum, who also tipped the scales at 140 lbs; son Tom — 70 lbs, and daughter a nimble 70 lbs, plus Fido a well fed dog of 15 lbs. They all came to a river which they wanted to cross. In the boat which was tied up there, was a notice which read 'CAUTION! MAXIMUM LOAD 150 lb.' Now this river was infested with crocodiles, so no one was keen on swimming. Problem: how did all the family get across the river?

The circuit is arranged so that the alarm operates while switches are being moved from side to side — if the total load they represent exceeds 150 lbs.

Each member, including the dog, is represented by a three-position lever switch.

Only the contacts in the middle position are used, as they are closed while the levers are passing through the 'dangerous' position, i.e., while people are in the boat. Fig. 1 illustrates the arrangement. The alarm is a red pilot lamp marked SUNK.

The circuit is shown in Fig. 2. The lever switches used are 3-pole three position, although the links between poles are not shown in the circuit. All the levers are shown in one side position, and they close circuits only momentarily as they pass through their centre positions. This brief contact applies a voltage to the gate of the silicon controlled rectifier SCR, which turns it on and leaves it on, thus leaving the SUNK light turned on. The moving contacts on the switches are so wide that if the switches are moved reasonably together there is no chance of failing to make a circuit when one should be made.

To reset the game after the boat has been sunk, a SALVAGE push button is provided. This is a normally closed push button, which, on being pushed, simply opens the circuit momentarily

PARTS LIST — ETI 230

R1 Resistor 1k ½W 5%
R2 " 3.3k " "

Switches 5 by 3 pole 3 position rotary
1 by normally closed push button.
SCR1 Silicon controlled rectifier C106 or similar
4.5 volt battery, 4.5 volt pilot lamp.

and so turns off the SCR — unless the switches have been left in a 'sunk' arrangement.

A study of the circuit will show that the lamp is turned on if any circuit is made between the right and left hand side lines. The switches between these lines are such that, in all dangerous situations, a circuit IS made. No main switch is provided as the leakage through the SCR is negligible.

CONSTRUCTION

This project was assembled on an aluminium panel in a plastic box. The underside view of the panel is shown in Fig. 3. The SCR and two resistors involved are mounted on a tag strip, as shown in Fig. 4, 5 and the wiring diagram.

Switches should be assembled first, and wired one by one as they are mounted — there is too little space to get at all the terminals once they are all mounted.

(Continued on page 78)

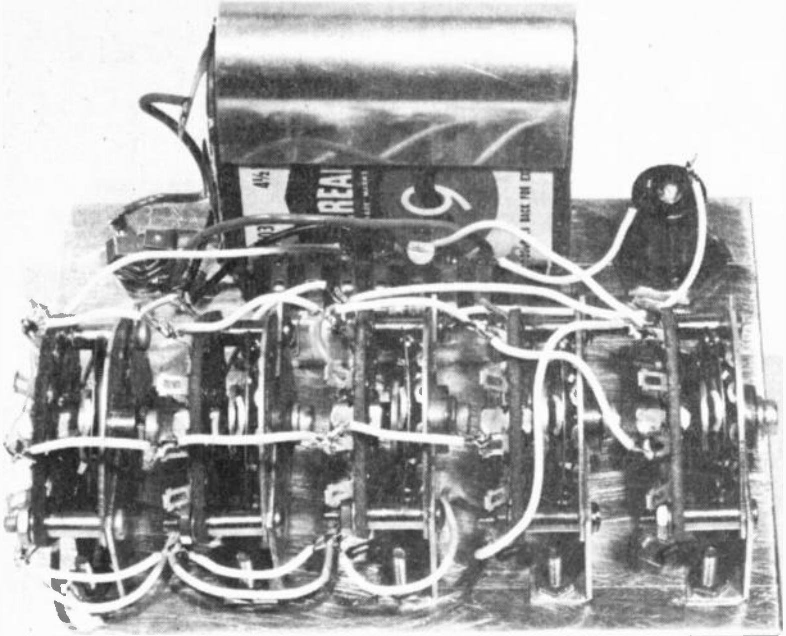
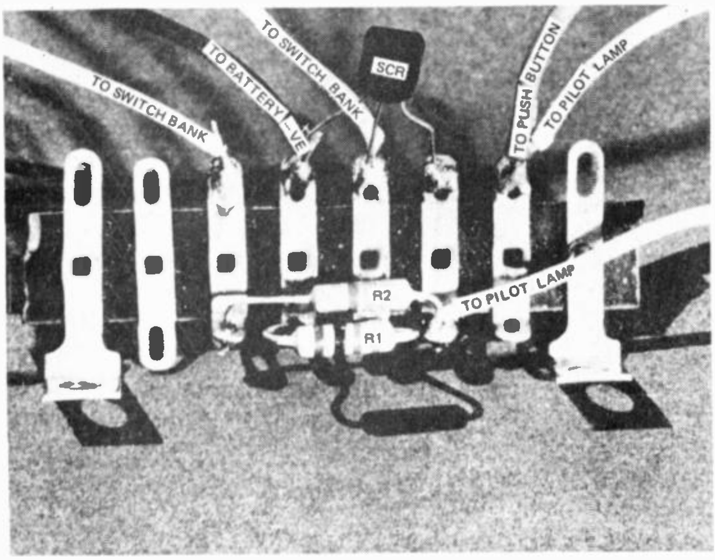


Fig. 3. Underside view of the front panel showing how switches are mounted.

Fig. 4. Method of assembling the components to the tag strip is shown here pictorially.

▼



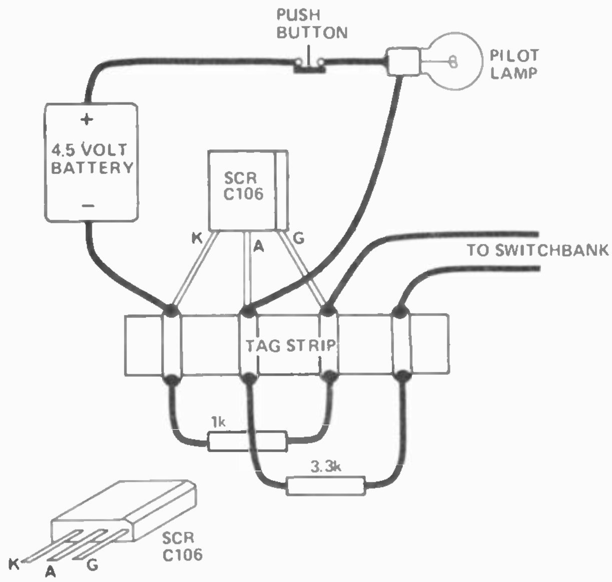


Fig. 5. Schematic of the connections to the tag strip.

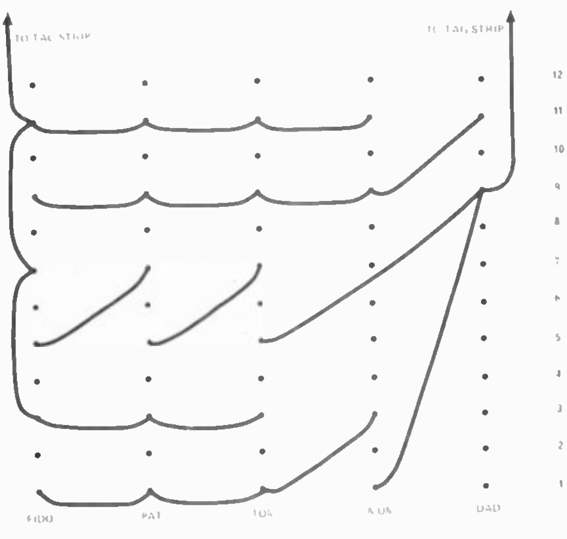


Fig. 6. Method of wiring the switches. Pin numbers at side are the same as those shown in Fig. 7.

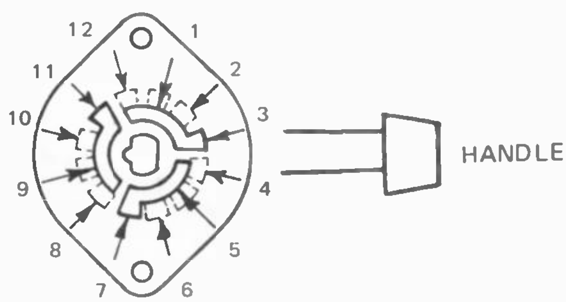


Fig. 7. Switch numbering convention used. Note that terminals 1, 5 and 9 are the wipers.

THE FAMILY FERRY

The switch wiring is shown in Fig. 6, where each dot represents one of the 12 terminals on each switch. The terminals on the switches are not actually numbered, but the numbers given to them in the right hand column of Fig. 6 relate to the positions indicated by numbers in the switch diagram in Fig. 7.

After mounting and wiring the switches the tag strip should be wired and mounted. An aluminium clip was made to hold the flat 4.5 volt battery, and this was anchored by the tag strip mounting screws. The pilot lamp and push button should be mounted and wired last.

CHECKING

Each of the 'dangerous' conditions should be set up to see that the SUNK lamp comes on as it should. If there is any difficulty with the SCR turning on, the value of R2 may be reduced. The value shown suits the SCR specified, but other SCRs with less sensitive gates may need more current to trigger them, and so the resistor may be reduced to suit.

Incidentally, if you can get this family across the river safely in less than eleven crossings, let's know how you do it! ●

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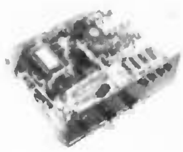

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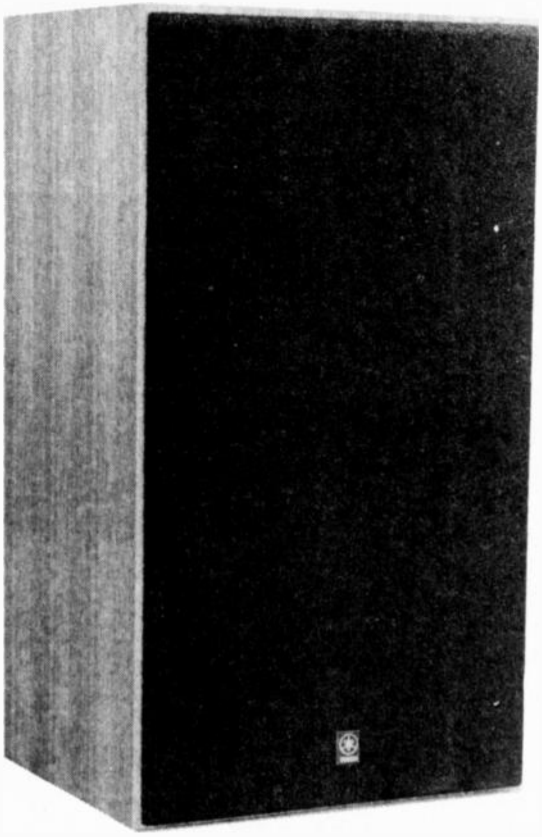


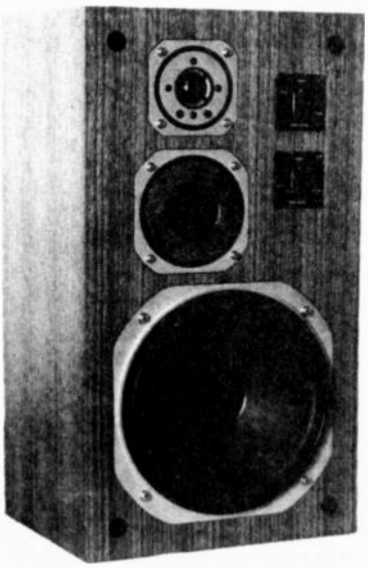
ETI PRODUCT TEST

YAMAHA NS-670 LOUDSPEAKER

"Built like a top-quality musical instrument"

NIPPON GAKKI CO. Limited (Yamaha, to us) have been producing musical instruments for over eighty years. Their pianos, organs, and guitars have a world reputation and it is not surprising to find that their speaker systems are apparently constructed with the same loving care and attention that they put into their musical instruments.

The Yamaha NS-670 speakers are probably the best finished speakers that we have ever seen, both in quality of detail, type of construction, and in the care and attention which has gone into the internal bracing, damping and finish. The design approach is fairly conventional – a three-way acoustic suspension system featuring a 250 mm diameter woofer with extended voice coil and a heavy duty cone



YAMAHA NS-670 SPEAKER – SERIAL NO. 13293		
Frequency Response	± 8dB ± 5dB	35 Hz – 20 kHz 50 Hz – 18 kHz
Total Harmonic Distortion (for 90 dB at 2 metres on axis)	100 Hz 1 kHz 6.3 kHz	0.9% 0.3% 0.3%
Electro-Acoustic Efficiency (for 90 dB at 2 metres on axis)	5 watts	
Measured Impedance:	100 Hz 1 kHz 6.3 kHz	6Ω 8Ω 9Ω
Cross-Over Frequency	800 Hz and 7 kHz	
Dimensions	577 x 320 x 269 mm	
Weight:	19 kg	

construction. This speaker (type JA2501A), looks for all the world like one of the better quality American woofers. It has an unusually shaped die-cast frame, flexible cloth surround, and with an edge-wound aluminium 70 mm diameter voice coil. The free air resonance of this driver is 25 Hz. This increases to 48 Hz when mounted in the enclosure.

The mid-range speaker (type JA0601), is constructed with a diaphragm formed from a hot-pressed fabric doubly coated with a thermo-setting resin and a viscous rubber resin. A tangential edge is formed at the same time to provide a flexible edge termination. Yamaha claim, and we confirmed, that this technique provides them with a speaker with excellent transient response, very high power handling capacity, and extremely low distortion.

This driver has a self-enclosed back and a (very necessary) formed mesh protection cover. The magnetic circuit uses a very large ferrite magnet with a flux density of 14 000 gauss.

The tweeter (type JA0509), is also a soft dome unit with a 30 mm diameter, and very unusual protective grid. As with the mid-range unit, the tweeter also has a large ferrite magnet.

All three speakers are recessed into the veneered face of the cabinet, which is itself then covered by a formed and moulded artificial fibre grill cloth fixed to a veneered plywood frame. The speaker grill cloth frame is retained on the face of the speaker by special plastic clips.

Two controls, for the tweeter and mid-range speakers, are also mounted on the front face and provide smooth control of approximately ±5 dB for the two soft dome speakers.

Our first series of tests was performed to determine the frequency linearity of the speaker in free field conditions, on axis. This showed conclusively that the NS-670 speaker has a very smooth response from 50 Hz right through to 18 kHz.

At 30° to the main axis there is less than 4 dB change in the region of the cross-over as a result of inter-action between the mid-range and tweeter speakers. Elsewhere in the spectrum the change is even less.

Yamaha claim that the tweeter offers extremely low directionality even up to 60° angle, and this we found to be substantiated by our measurements.

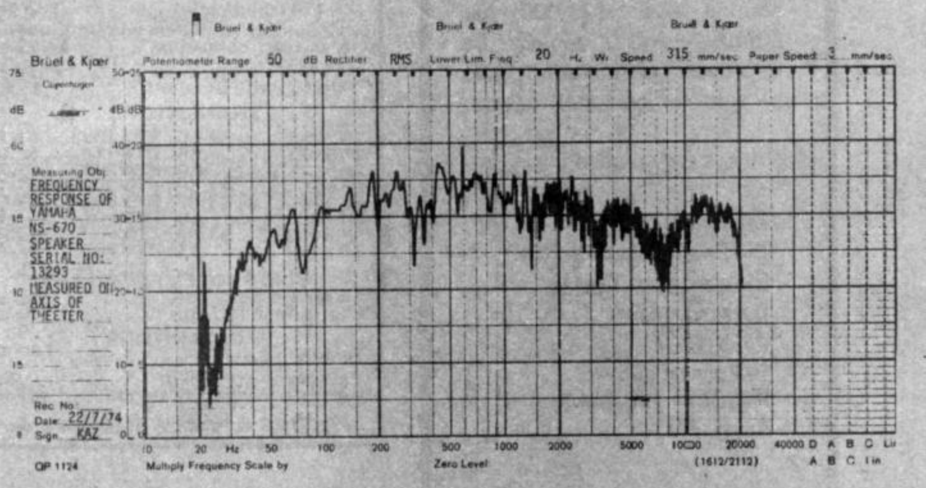
We then measured the tone burst response using our special ETI tone burst generator, and found the performance to be good right through to 20 kHz. The performance under tone burst conditions was one of the cleanest we had seen and almost as good as the best performance that we have yet measured.

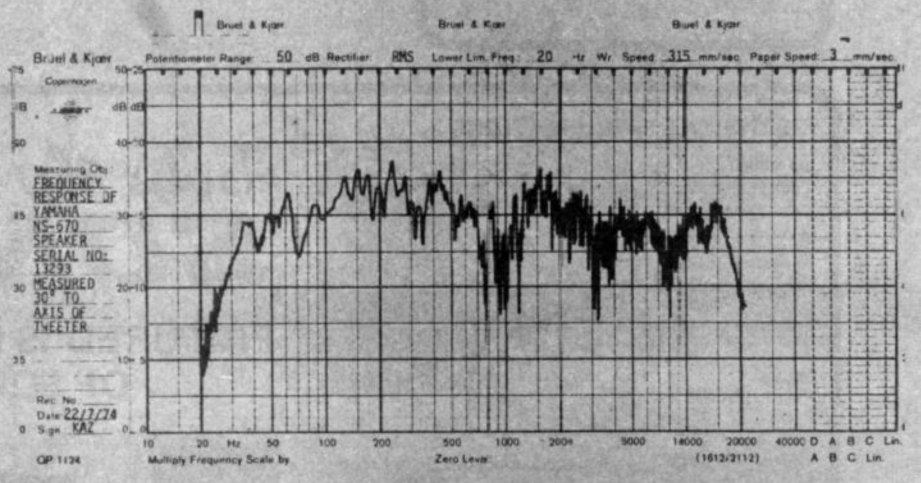
The impedance curve is not particularly smooth. The 32 Ω impedance at approximately 48 Hz is slightly higher than the norm for an acoustical suspension speaker system. The rest of the impedance characteristics are quite normal and more than acceptable.

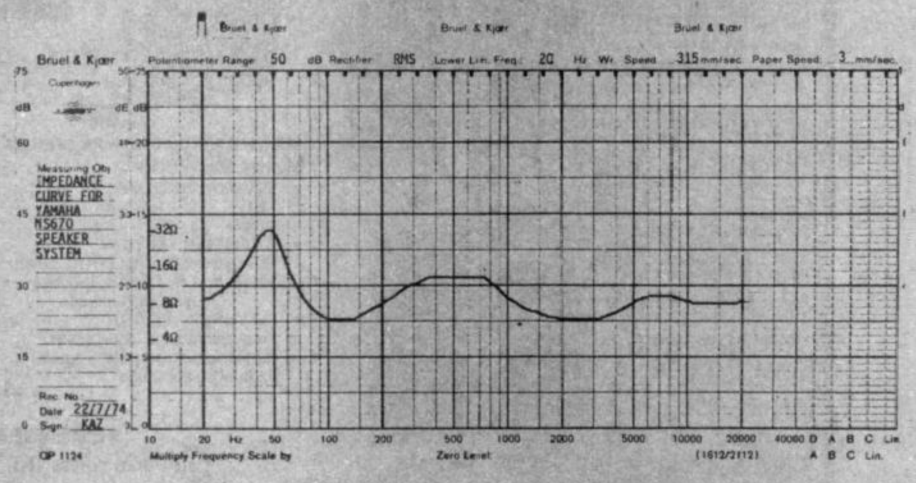
The distortior characteristics of the peaker are very good. With 90 dB at 2 metres on axis, the distortion at 100 Hz is only 0.9%, whilst at frequencies above 200 Hz distortion it is less than 0.4% right through to 15 kHz.

Listening tests were a revelation — this speaker sounds really good.

Its characteristics can only be likened to the best of American-designed acoustic suspension speakers, featuring as they do, low colouration, excellent transient response, and performance that is clear and sprightly.







YAMAHA NS-670 LOUDSPEAKER

Low frequency performance, i.e. below 60 Hz, is not outstanding and with power inputs in excess of 25 watts, it is possible to cause cone break-up on organ music and on heavy drum beats, but on voice, guitar, violin, and other programme content at quite high listening levels (100 dB at 1 metre on axis) the Yamaha's performance is particularly smooth and offers a very faithful rendition of the original sound.

Yamaha's NS-670 speakers are probably the best finished that we have ever seen – they are more akin, in this respect, to musical instruments of the finest quality.

Their colouration is negligible – they are therefore particularly suitable for classical music lovers. About the only criticism that we could make is that they cannot handle very high level signals below 60 Hz.

All in all they are a worthy contender in the high fidelity market for those who seek faithful reproduction and lack of colouration. ●

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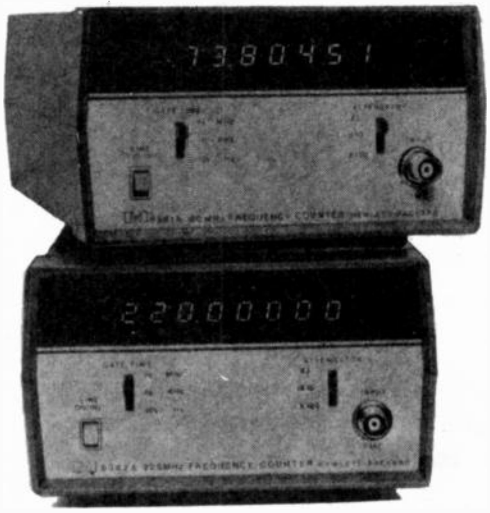

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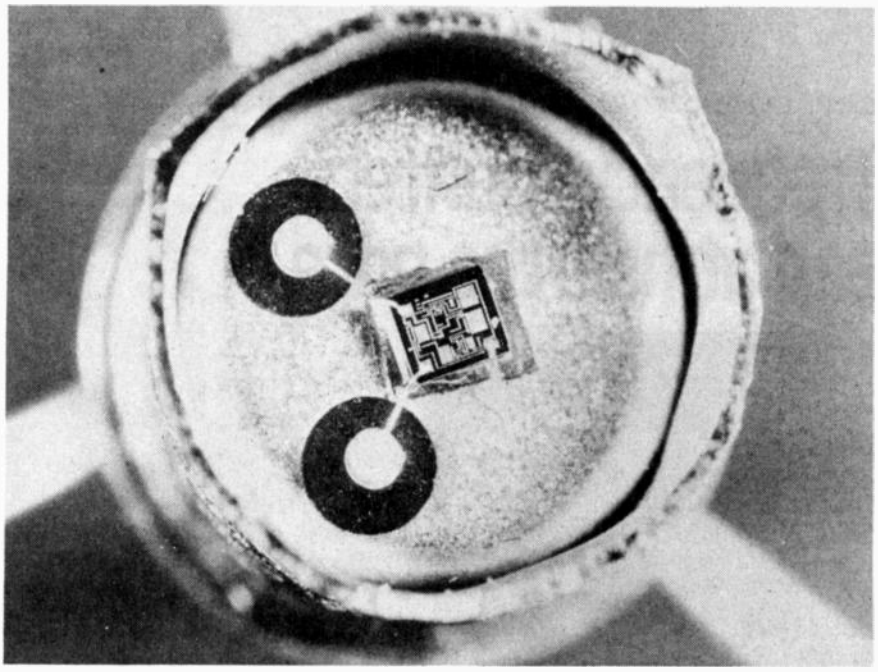


PART 10

Would you believe that there is a ten transistor radio on this tiny 1 mm square chip. The device is the Ferranti 2N414 radio IC.

ELECTRONICS -it's easy!

Introducing the elements of transistor amplifiers.

AN AMPLIFIER, whether electronic, mechanical, acoustic or optical, is a system building block. It allows the amplitude of an input signal to control a secondary source of power such that the amplifier output is of larger power (or voltage or current etc.) than the input signal. This concept is shown as a block diagram in Fig.1. In its simplest form, an electronic amplifier has one input, one output and source of power. The common line is usually not shown in block diagrams, being there by inference. Actual circuits always require a common line which is variously referred to as earth, ground or negative rail.

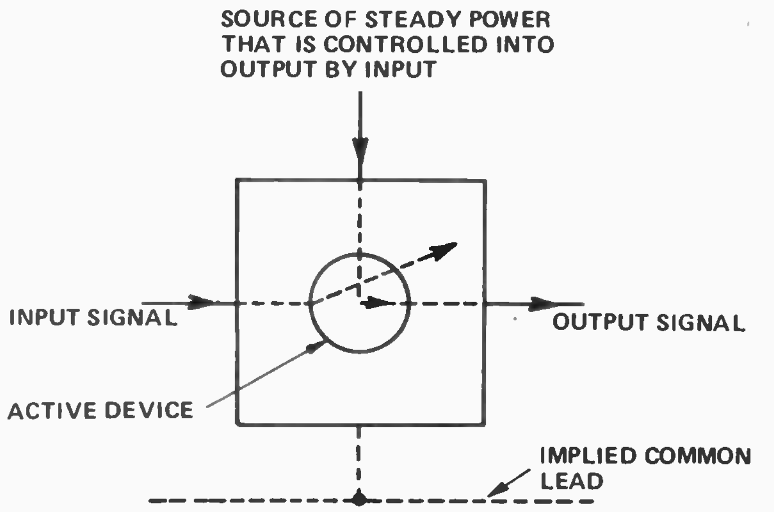


Fig.1. Schematic diagram illustrating the Amplifier function.

ALL SHAPES, SIZES AND PURPOSES

Although the basic electronic building blocks now available are extremely versatile, there is still no single magic box that can perform all amplifier tasks at the best price *and* performance. Consequently, we make do with many different forms of amplifier to suit an even greater number of applications.

Most amplifiers increase signal voltage amplitude; others, more unexpectedly may reduce it. In both cases we say the amplifier has a gain eg. a gain of 10 – or a gain of 0.1.

The most common need to amplify the *voltage* at the input, but often we may need to increase the current or power level. Yet another need might be to accept a current input and provide a voltage output. The purpose of the amplifier must be clearly understood, for the design and trouble-shooting procedures will differ for each case.

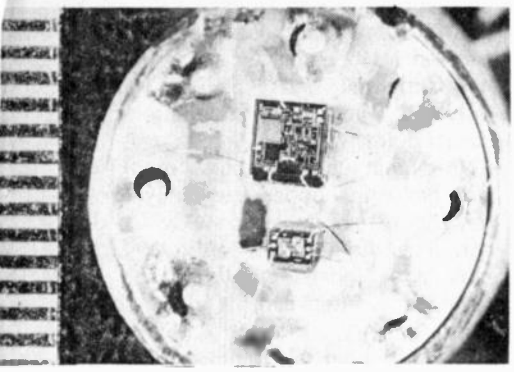
Newcomers to electronics may think that an amplifier must alter the signal/amplitude-level linearly without affecting its time or frequency characteristics, that is, it should amplify with fidelity. This is certainly so with hi-fi audio-frequency amplifiers and with very sensitive transducer amplifiers, but again some amplifiers are designed to distort the signal in some ways to suit a particular purpose. More about these later.

AMPLIFIER JARGON

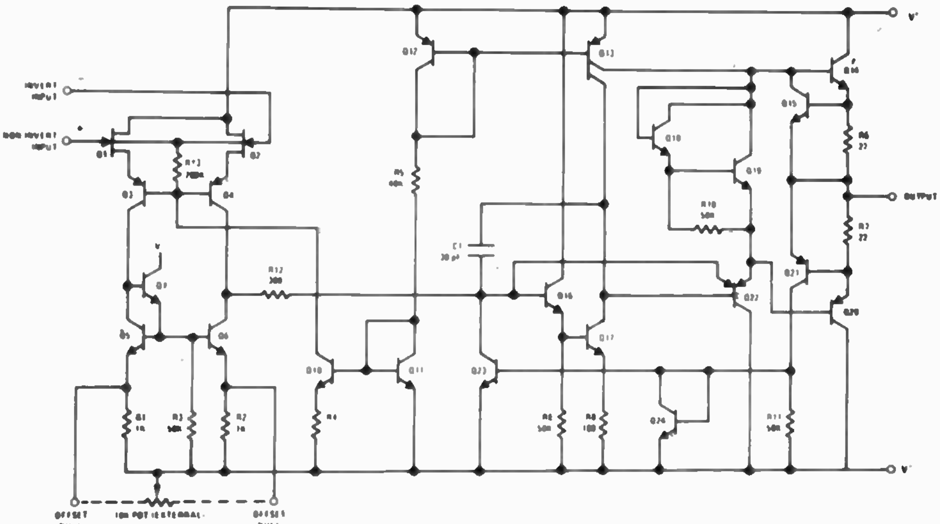
The role of an amplifier is denoted, to some extent, by a prefix. For example a *pre-amplifier* may precede a main amplifier. It amplifies low-level signals (micro-amperes, microvolts and microwatts). Figure 2 shows a string of amplifiers in a typical system.

A *power amplifier* increases the power level of signals in order to drive the output device of the electronic system e.g. the loudspeaker in a hi-fi system; the display tube in an electronic counter. What constitutes a power amplifier and what constitutes a small-signal amplifier is quite arbitrary in absolute terms – the power stage of a digital pocket calculator needs to drive devices rated in milliwatts, but a rolling-mill control may need tens-of-kilowatts capability.

Amplifiers have other applications apart from providing gain. You will



An example of a hybrid FET-input, operational amplifier IC. The small chip contains two FET transistors, the large chip the remaining bipolar transistors. The circuit contained in these two tiny chips is shown on the left. Each division of the scale on the left is ½ mm.



remember in an earlier section, we discussed how connecting a low impedance meter to a high impedance circuit could affect, or even damage, the circuit. This effect, the loading of one stage by another, may be overcome by using an amplifier as a "buffer" between the stages.

Buffer-amplifiers usually have a voltage gain of less than one. However, they do have a power gain and their usefullness is mainly in that their input resistance is considerably greater than their output resistance. Thus the output of a buffer stage can be loaded heavily with little effect on the input. They are, in effect, impedance converters.

Another amplifier characteristic of interest is whether it can handle direct-coupled signals or not. If the signal is coupled to the input via a capacitor, dc signals cannot pass, and such an amplifier is known as an *ac amplifier.* This is not necessarily a disadvantage for, in many systems, only ac signals are of interest.

Another type of amplifier that will often be encountered is the so-called *operational amplifier.* In the early days of electronics, dc amplifiers were difficult and expensive to build because any drift of component values or gain resulted in an unwanted output change. Thus special design procedures had to be used for dc amplifiers, making them very expensive. Nevertheless, they were used extensively in early analogue-computer systems to perform basic arithmetical operations — adding, subtracting, sign inversion and integration — hence their name. (This will be expanded later in the series). Today the operational amplifier can be manufactured inexpensively in integrated circuit form.

In fact, the tables are now turned; the modern operational amplifier is even challenging the single transistor in price, and has tremendous advantages in stability and flexibility, over discrete transistor stages. Indeed these new basic building blocks come close to providing an all-purpose basic amplifier unit.

FREQUENCY RESPONSE

A very small change in the dc level at the input of a dc amplifier will produce a corresponding dc output-level change. The ratio of output to input-level change is called *dc gain.* In an ac amplifier this change is virtually zero because dc signals are not recognised. This does not, however, mean that there is zero dc level at the output, merely that it is unchanged by very-low frequency signals.

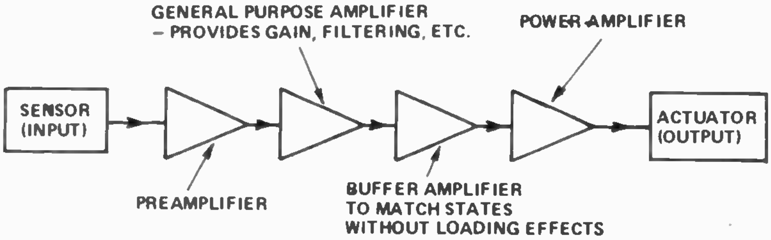


Fig.2. Amplifiers having different functions are often combined in a series chain to achieve an overall purpose.

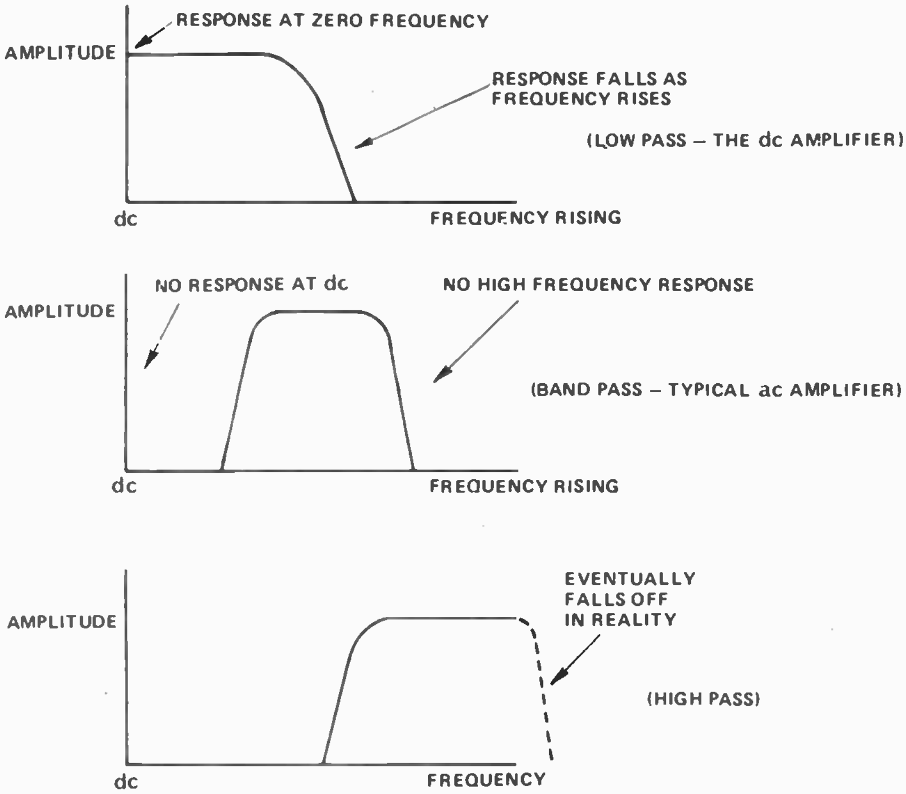


Fig.3. Response curves of amplifiers having three different amplitude/frequency characteristics.

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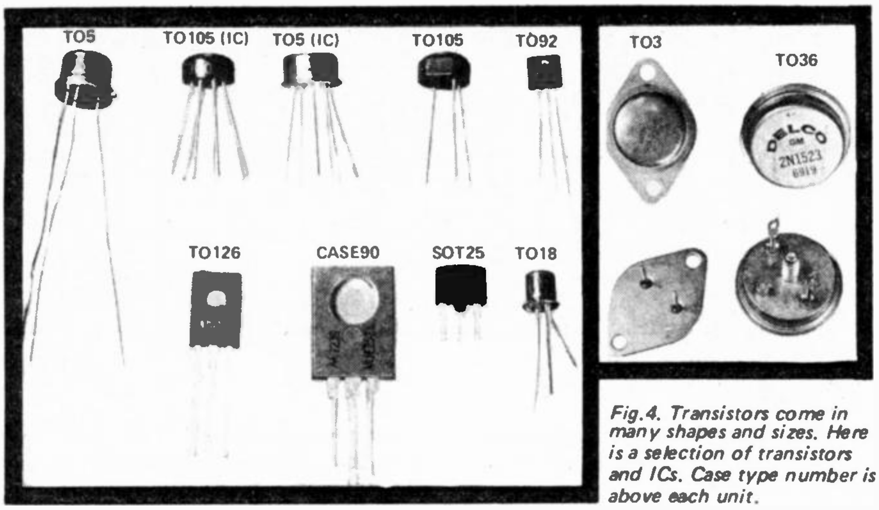


Fig.4. Transistors come in many shapes and sizes. Here is a selection of transistors and ICs. Case type number is above each unit.

The frequency performance of all amplifiers can be shown by two graphs – amplitude versus frequency and phase versus frequency. The first is more commonly encountered. There are other things a designer needs to know, such as time-response to a step-change input, but for the moment we will restrict ourselves to the amplitude versus frequency characteristics.

Physical factors make amplification very difficult at high frequencies. Thus all amplifiers cease to be effective at some upper frequency, but in practice, it is the attainable relative-frequency limit that matters. For example, if the signal to be amplified has no content beyond 20 kHz – as in hi-fi sound systems – there is little point in using a unit with 200 MHz capabilities. This would be more expensive to build and, therefore, a waste of effort.

We use several descriptive terms that denote an amplifier's type of frequency response. Figure 3 shows three main classes – Low Pass (passes only frequencies below a selected cutoff point) Band Pass (passes only frequencies between upper and lower cutoff points), and High Pass (passes only frequencies higher than a selected cutoff point).

Note that the high-pass amplifier still has some upper frequency limit beyond which its response will drop off. The same terms apply to filter circuits – indeed amplifiers can be regarded as filters capable of providing gain.

The frequency response of an amplifier is primarily limited by the active device itself (transistors etc) and secondly by the passive components around the active device which modify its performance. Some amplifying elements will work at megahertz frequencies, some only at kilohertz frequencies. Each have their uses.

PRACTICAL LIMITATIONS

The first active electronic-amplifier element was the triode thermionic valve (briefly described in the last section). This has now been replaced in most applications by the transistor. The transistor does the same job but with less power loss, smaller space requirements and much reduced cost. Several packaged forms of transistor are shown in Fig.4.

The system designer would ideally like amplifiers that accept any polarity of input signal (be it negative or positive with respect to the common lines) and amplifiy it without changing the polarity, or distorting the wave shape in time or amplitude.

Unfortunately neither the thermionic valve, or the transistor, can provide these facilities unless they are used in special ways along with passive elements. Both devices individually will only operate with one polarity of input signal – see Fig.5. If the signal swings to the other polarity, the output disappears: they become rectifiers. Transistors may be constructed to operate with either polarity dc signal, but not both polarities with the same device. That is, they may be constructed as *complementary* units, valves cannot.

Another practical limitation is that these basic devices can only tolerate certain maximum-magnitude signals; as the input signal is increased, a point is reached at which the output signal ceases to increase in amplitude (it gets clipped). If exceeded still further the device may fail altogether. These two effects are the main shortcomings of both valve and transistor, and are illustrated diagramatically in Fig.6.

Eventually an active element may be discovered that does not suffer from these shortcomings; until then we must modify the characteristics of existing active elements in order to obtain the characteristics we need.

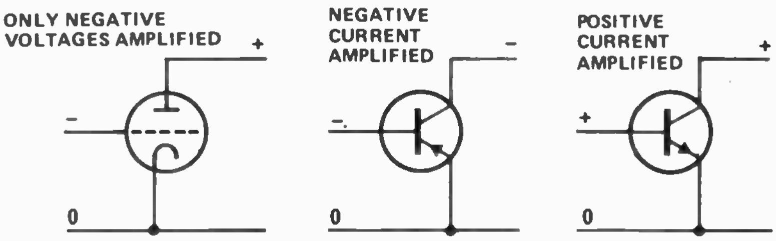


Fig.5. Valves and transistors, when used above, can only handle one polarity of signal. Any other polarity signal is clipped as in a rectifier.

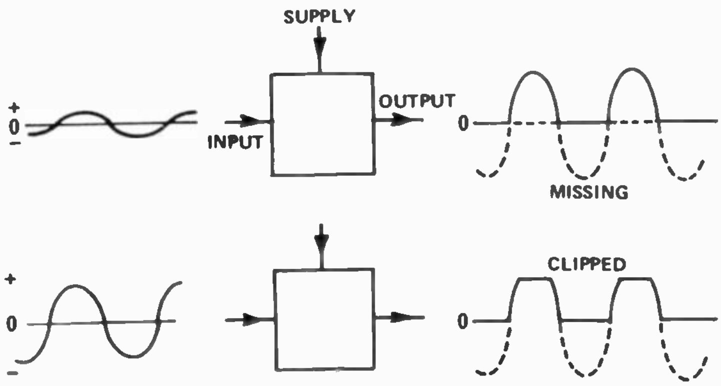
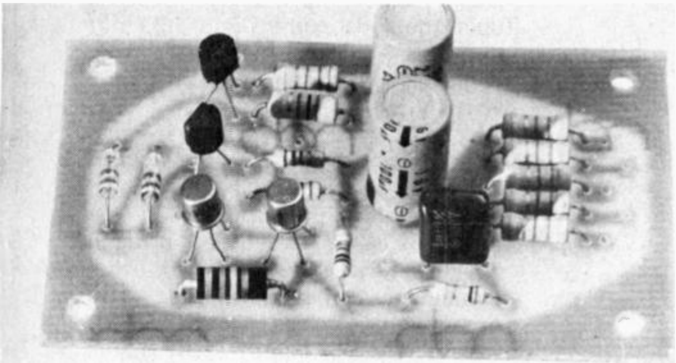
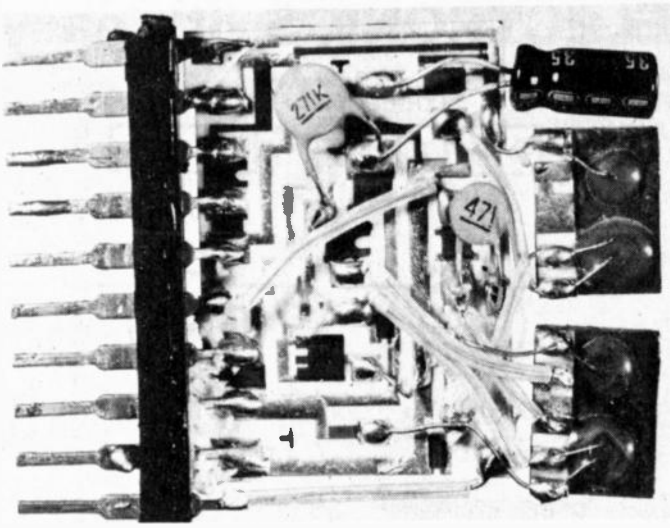


Fig.6a. Effect of feeding a smaller bipolar signal into a transistor. One polarity of half cycle is clipped. (6b). If the input signal is increased sufficiently the tops of the waveform will also be clipped.

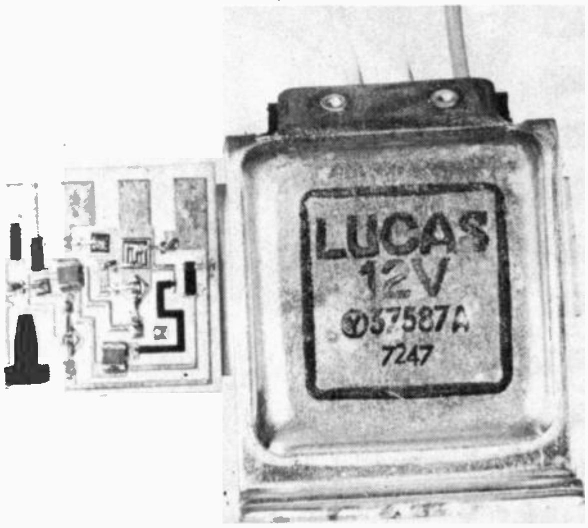


7(a)

7(b)



7(c)



7(d)

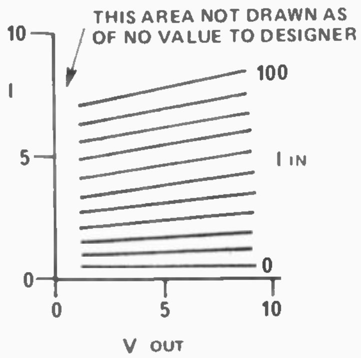
Fig.7. Typical amplifiers using devices having differing levels of integration. (a) Typical discreet transistor stage. (b) 25 watt amplifier using hybrid IC module. (c) Internal view of Sanken 10 watt power amplifier of hybrid design. Note power transistors at top of module. (d) Voltage regulator for cars (from Lucas). It contains the thick-film hybrid IC on left which has three transistors, two diodes, two capacitors and five resistors assembled onto a 25 mm square ceramic substrate. See if you can pick the individual components.

This is done by using the device in combination with other active and passive elements to form complete circuit combinations that become our required basic amplifier blocks. Such circuits are either built from individual components — the discrete circuit; or alternatively they are purchased ready designed and manufactured as hybrids — a discrete circuit packaged into one unit. A third alternative is the integrated circuit (the IC) in which all active and passive elements are fabricated on a common substrate. Figure 7 shows several modern amplifiers based on the transistor amplifying element.

AMPLIFIER CHARACTERISTIC CURVES

The various types of individual amplifier elements behave differently, have different signal-level handling ability and have different input-to-output signal ratios (gain). Furthermore, the gain may depend upon the amplitude of the input signal and on what is connected to the output.

The information, needed by a designer on device characteristics is commonly provided by graphs known as characteristic curves. We met the simplest form of curve when we discussed the light-dependent resistor in Part 2 of this course. In that case there was only one relationship — that of resistance versus light level.



The problem of presenting characteristic curves for amplifiers is more complex than for that light-dependent resistor, for there are an infinite number of describing curves. To understand this, consider the relationship between the supply current (I) flowing into an active element (Fig.6) and the voltage developed at the output (Vout). It is not possible to draw a unique single

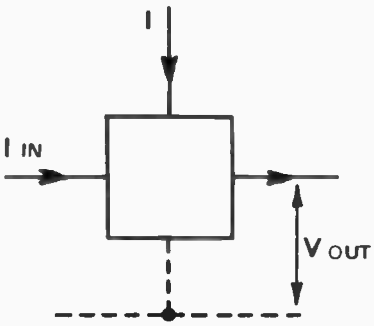


Fig.8. How characteristic curves are used to describe the performance of an active device.

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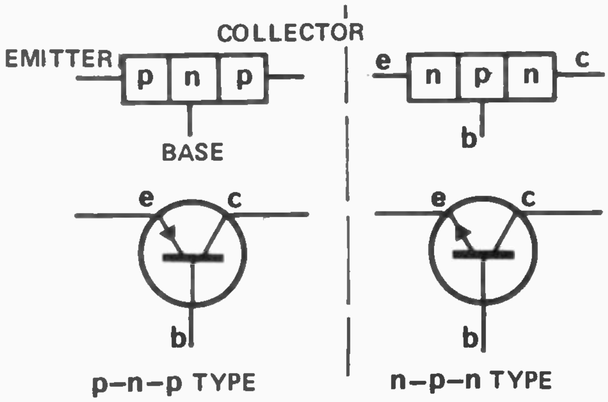


Fig.9. The basic structure and symbols for the two elementary transistor types.

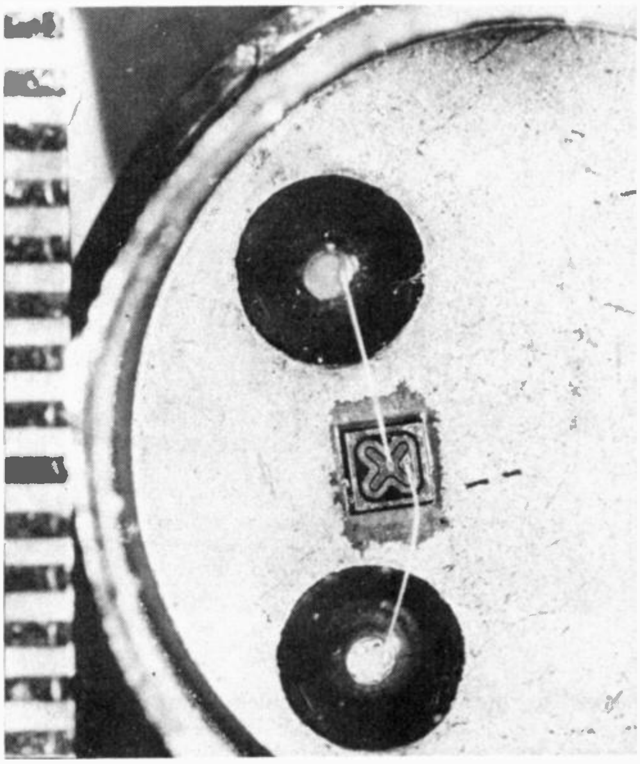
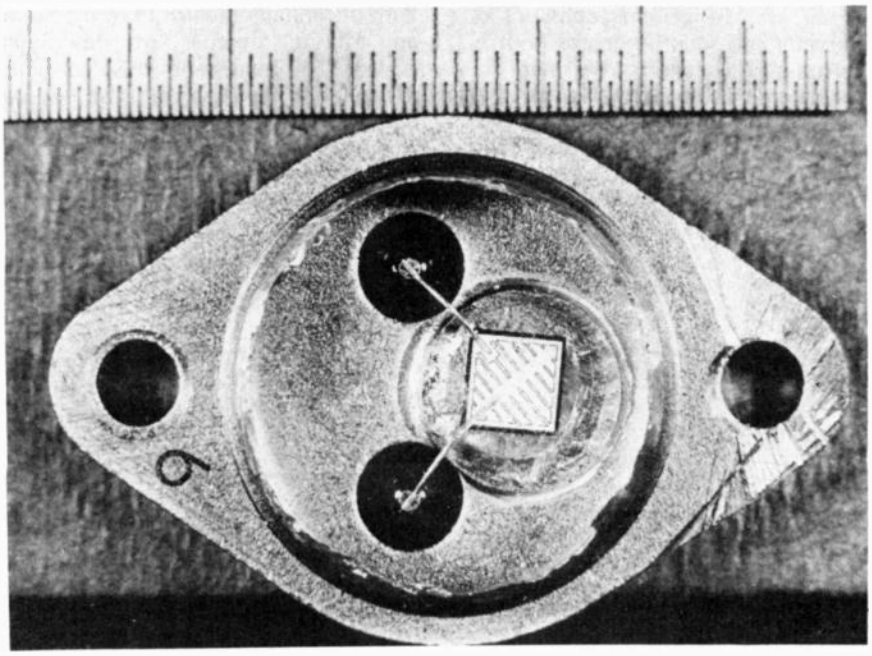


Fig.10. The actual transistor chip is indeed tiny – as these enlargements show. The scales at left half millimetre divisions. The smaller chip is a high-frequency small-signal transistor, mounted in a TO5 case, the other a power transistor mounted in a TO3 case.



graph, as the relationship depends upon the signal current into the input terminals – call it I_{in}. For each value if I_{in} there will be a specific graph of I versus V (out).

A convenient way of representing what happens is for us to draw individual curves at evenly-spaced, realistic values of I_{in}. The result is a family of curves as depicted in Fig.8.

A little thought shows that other families can be constructed also output-voltage versus input-voltage for various values of input current is one. Furthermore the fixed parameter – could be input voltage instead of current – as is the case for valves.

The characteristics of both valve and transistor devices can be visualised this way (as indeed can any type of three terminal amplifier) and these curves are of great value to designers.

Most people engaged in electronics do not need to measure the characteristic curves for themselves; they are provided in manufacturers' data sheets. It is important for us to understand these curves, for they help explain how the non-ideal characteristics of active elements (discussed above) are overcome in practical circuits. Before discussing how this is done we need to know more about the transistor itself.

THE TRANSISTOR

Transistors are made from two basic materials – germanium or silicon. These two materials are known as semiconductors because they are neither good insulators, nor good conductors. That is, they are somehwere in between.

Germanium was used for early transistors, but has largely (although not entirely) been replaced by silicon in modern devices. Although there are some important differences between transistors constructed from these two materials, the basic theory, as follows, is the same.

The basic pure material is modified by adding a controlled amount of impurities called dopants, to form two new materials, one (called P type) having a deficiency of electrons and one (called N type) having a surplus of electrons.

If two pieces of these differently doped materials are intimately joined we have what is called a PN junction. Such a junction of P and N materials will conduct current more readily in one direction than in the other – it is in fact a rectifier, or in other words, a semiconductor diode.

Current flow occurs when the P type material is made more positive than the N type material. The physics involved in this phenomenon are complex, but of little interest at this stage. We are only interested in the fact that it happens.

To make a transistor we add a third layer of material to form a three-layer sandwich in either NPN or PNP format. We refer to the transistors in this way — as a silicon NPN or PNP type etc. The symbols for the two types are shown in Fig.9. Each terminal is given the name as shown, the base being the centre connection, the emitter the one marked by an arrow and the collector unmarked. Note particularly that the direction of the emitter arrow denotes whether the transistor is a PNP or NPN type also that the symbol is the same for both germanium and silicon devices.

In actual manufacturing processes the three layers are formed by selectively growing N and P crystal layers, or by diffusing P and N impurities into the opposite sides of a pure, silicon or germanium crystal.

The actual transistor chip may be extremely small, often pin-head size and is generally a tiny fraction of the total packaged volume of the device. This is illustrated in Fig.10 which shows the inner construction of different types of transistor. From this we see that although small, a conventionally packaged transistor wastes a relatively enormous amount of space. Integrated circuits, where both active and passive components are made and connected by layering and diffusion processes, are logical developments from transistor technology — it is just as easy to fit 20 or 100 transistor in a T05 case (Fig. 4) as it is to fit one.

The main problems in integration are in limiting power dissipation within a given chip or case, and in fabricating resistors and capacitors.

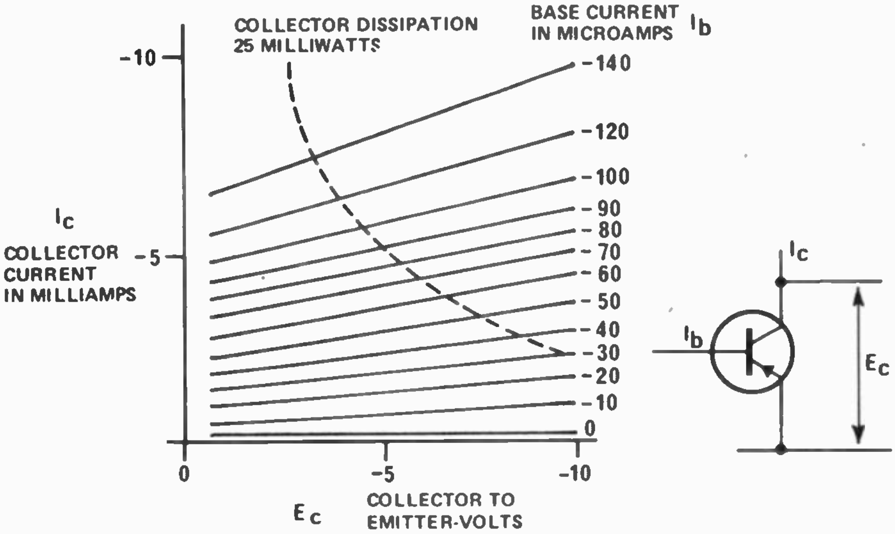
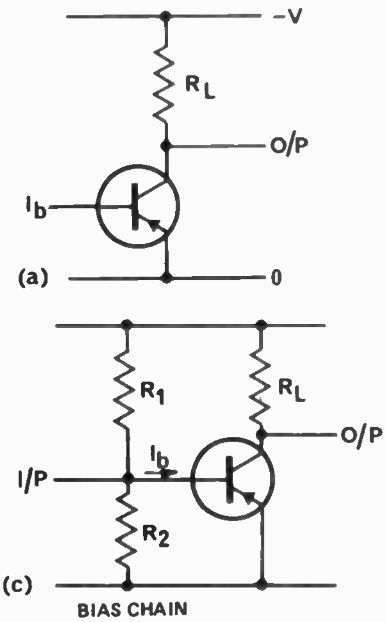
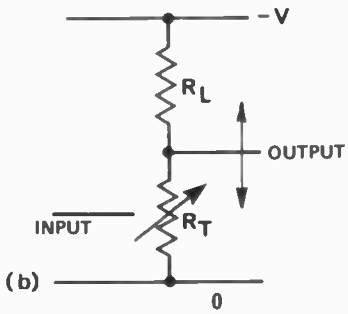


Fig.11. Typical characteristic curves for a small signal PNP-transistor.





$\frac{R_1}{R_2} \approx 4$ $\frac{R_1}{R_L} \approx 10$

Fig.12(a). To use a transistor as an amplifier we first need to insert a load resistor RL. (b) The load resistor together with the resistance of the transistor become a voltage divider. (c) To amplify ac signals we must use a bias current to offset the operating point.

SYMBOLS

As we go further in electronics we must use shorthand methods of expressing things — otherwise explanations tend to become unwieldy. For example, in our discussion of transistor parameters we will be considering the currents, voltages and impedances etc. associated with each lead of the device. To avoid having to write for example, "current in the collector lead" we simply write I_C. The main symbol I tells us we are concerned with current and the subscript 'C' tells us that it is the collector lead we are talking about.

Thus E_b = base voltage
E_c = collector voltage
I_b = base current
E_{ce} = voltage between collector and emitter.

Now that we have established our shorthand we are in a position to examine the practical characteristics of transistors.

CHARACTERISTIC CURVES

Let us examine what happens if we hold the collector-to-emitter voltage, E_{ce}, constant at -5 volts and then vary the base current, I_b from 50 to 60μA we find that we have a corresponding I_c change of 500μA (0.5 mA). Thus we have a gain, β of 500/10 = 50.

Note that corresponding changes in I_b at other points (e.g. 90 to 100μA) does not result in the same gain. In fact, there is non-linearity at extremes of I_b which would result in distortion of the signal.

In practice it is not necessary to perform these calculations, the manufacturer tells us the gain in his data sheet. This is referred to as β or Hfe (don't worry about interpretation of this latter symbol) and is the ratio of the change in collector current resulting from a small change in base current.

That is $\beta = \frac{\Delta I_c}{\Delta I_b}$ (Δ means small change in)

Values of β range from 5 or so for early transistors to several hundred, or even thousands in modern components. Manufacturing tolerances don't allow all transistors of any type to have the same β and the manufacturer usually specifies the limits within which the device current-gain will fall.

For example the BC108 is a popular audio transistor specified as having Hfe (β) greater than 125 but less than 900 at I_C = 2 mA and Vce = 5 volts.

Referring back to Fig.11, we find a dotted line across the curves which represents the maximum permissible

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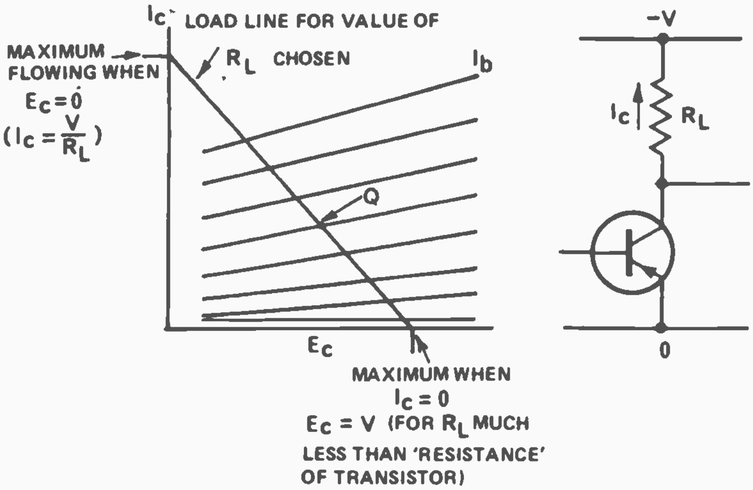

Fig. 13. Output impedance of the stage is equal to the value of R_L. R_L is generally chosen to be about one-tenth of the input impedance of the following stage provided that $(\frac{V}{2})^2 R$ does not exceed the rated device dissipation. The load line is then drawn and operating point Q determined as detailed in the text.

power dissipation for the device. This is determined by the maximum heat that can be dissipated without the chip being destroyed, unless the device is cooled by a heat sink or with forced air circulation.

For example if the transistor of Fig.11 has an E_{ce} of 5 V, then the collector current must not exceed 5 mA if the dissipation is to be less than 25 mW. Thus the user must check his design to ensure that under worst case conditions (component tolerances, power supply voltage etc.) this dissipation is not exceeded. The device must never be operated at any point above and to the right of the dissipation curve.

Thus we see that much information can be extracted from the characteristic curves.

THE BASIC AC AMPLIFIER

Used alone, the transistor cannot amplify ac waveforms. The two main limitations are its inherent rectifying action and an effect known as thermal runaway. In addition we must devise a way of taking an output from the transistor.

The transistor may be considered as a resistor whose value is varied by the input base current. Hence, if we place a resistor in series with the collector lead of the transistor, we will have a voltage divider as shown in Fig. 12. The collector current, as it changes in response to changes in base current, will produce an output voltage across the series resistor. This series resistor is called the 'load' resistor and is denoted by the symbol R_L.

Note that to drive more current into the base we must raise E_b towards the collector supply voltage. The resulting increase in I_C will cause the voltage at the collector, E_C, to fall. Thus the output voltage will be the inverse of the input. In other words, the transistor connected in this fashion, changes the phase of the input voltage by 180°.

BIASING

If a sine wave were to be applied to the base of the transistor in Fig. 12a, the negative half cycles would be clipped off – the waveform would be rectified as previously explained. We can overcome this by applying a dc 'bias' current to the base such that the input signal either adds or subtracts from this current but *never* drives the base current to zero.

Hence the collector current will also be biased away from zero and will follow the variations in base current. In practical circuits it is not feasible to have a separate battery or power supply to provide bias, so it is usually derived from the collector supply. The most common method is by using a voltage divider as illustrated in Fig. 12c.

Biasing can also be illustrated using characteristic curves. For any chosen R_L value, there will be corresponding pairs of I_C and E_C values – Ohms law again. This means for any value of R_L we can draw a line – called the load line – across the characteristic curve as in Fig. 13. The importance of this curve is that the input signal, I_b moves up and down this line. If we do not add a bias current to I_b we would be operating at the bottom end, where I_b = 0, and only negative swings of I_b would be amplified. By adding a *quiescent* bias current we put the mean operating point at a place midway (this is called the Q point) along the load line and both half cycles of our input signal will be amplified linearly.

The degree of distortion is decided by the extent to which the input signal varies I_b up and down about the Q-point. Small signal changes will be undistorted but not large ones. One cause of this is that the gain I_c/I_b will change at the limits.

Secondly, if the input signal increases still further, the peaks of the sine wave will be clipped, at one end by the base current reaching zero, and at the other by the collector voltage being driven to zero (this latter condition is called saturation). Hence it can readily be seen, from the characteristic curves and load line, what maximum input signal can be applied without distortion occurring.

Note that the load line must always lie below the maximum power dissipation curve.

THERMAL RUNAWAY

As well as the currents I_b and I_c that are designed to flow in the transistor there is leakage current through the normally reverse-biased, collector-base junction. Some of this current will flow through the base-emitter junction (actually all of it if the base is not connected) appearing as a normal signal. The apparent signal current will be amplified causing an I_c of βI_b.

Now here is the danger – the leakage current is proportional to temperature. So the increased I_c heats the transistor, the leakage current increases, I_c increases still further – and the process may continue until the transistor destroys itself.

The actual process is more involved than we have described but the explanation suffices for our purposes.

With silicon transistors leakage current is very small and of little importance but silicon has another temperature effect that produces similar, although not as serious, thermal runaway. This is that the E_{be}

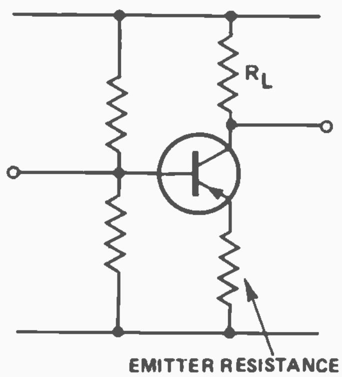

Fig. 14. The amplifier is stabilized against the effects of thermal runaway by adding an emitter resistor.

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of a silicon transistor, required for a certain collector current, falls with temperature. Hence with a fixed input voltage the resultant I_c causes a rise in temperature, which causes a decrease in E_{be} required, and hence a further rise in I_c — result thermal runaway.

Silicon transistors can be used over a much wider range than can germanium but thermal runaway must be compensated for with both types.

Fortunately this potentially damaging effect is easily overcome, in both cases, by adding a resistor into the emitter path as shown in Fig. 14. Its effect is as follows.

As the collector current rises (due to leakage current) the voltage dropped across the emitter resistor, Re, increases thus reducing the base-emitter voltage V_{be}. This reduces the base current, and almost restores the collector current to its original value. Mathematics tells us the ideal conditions to achieve stability and show that an emitter resistance roughly one sixth of the collector load resistance is about right. The bias chain values must be readjusted for this and again there are complex mathematical expressions for optimizing the values. In practice a good choice is that the chain has values in the same ratio as the collector chain but about ten times larger.

BYPASSING

Having overcome thermal runaway conditions we now find the amplifier is nicely stable but lacks gain. This is because the same collector current flows through the emitter resistor as through the load resistor. Hence the gain can only be equal to the ratio of R_L to R_e, that is, in our case 6. And this is completely independant of β. We can restore our gain by adding one more component— a capacitor across R_e.

Thermal effects occur slowly by comparison with ac signals (10 Hz and above) so a capacitor connected across the emitter resistor will act as a low impedance to ac signals (thus restoring ac gain) but as a non-existant component to dc. Hence we get the best of both worlds — thermal runaway is eliminated and ac gain is maintained. The capacitor is chosen such that its reactance is about one tenth the value of R_e at the lowest frequency of interest. ●

Further reading:
"Understanding Solid State Electronics" Texas Instruments Learning Centre, 118 Great North Road, FIVEDOCK, N.S.W.
"A Course in Radio Fundamentals" American Radio Relay League, obtainable from most technical bookshops.

ELECTRONICS – in practice

THE CIRCUIT of a typical ac amplifier, for audio frequencies, is given in Fig. 15. The input signal is coupled in via a capacitor that provides dc isolation between the preceding stage and the bias network.

As the capacitor needs to be fairly large (X_c less than one tenth the resistance from base to ground at lowest frequency) it is usually an electrolytic. An electrolytic may be used as long as the positive terminal is connected to the most positive dc potential.

The circuit uses a readily available, inexpensive transistor and may be put to work (and tested) by adding the components as shown in Fig. 16.

In effect we now have a light intensity meter which can be used to monitor the modulated content of the radiation from a fluorescent-light tube. Note that it does not measure the steady-state light radiation.

The light dependant resistor, type ORP12, provides a small amplitude 100 Hz signal when excited by the light from a fluorescent tube. The amplifier increases the signal amplitude by about forty times. The output from the amplifier may then be half-wave rectified to provide a dc output proportional to the level of the 100 Hz light signal. This may be measured by a normal multimeter, or alternatively, the ac signal may be fed directly to high impedance headphones. You will then hear the 100 Hz tone from the light radiation.

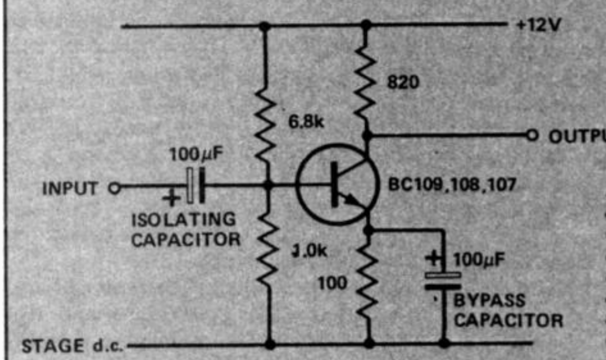

Fig. 15. The addition of a bypass capacitor restores ac gain and an input capacitor provides isolation for the input. We now have a complete ac amplifier. Two or more stages can be used in series of more gain is required.

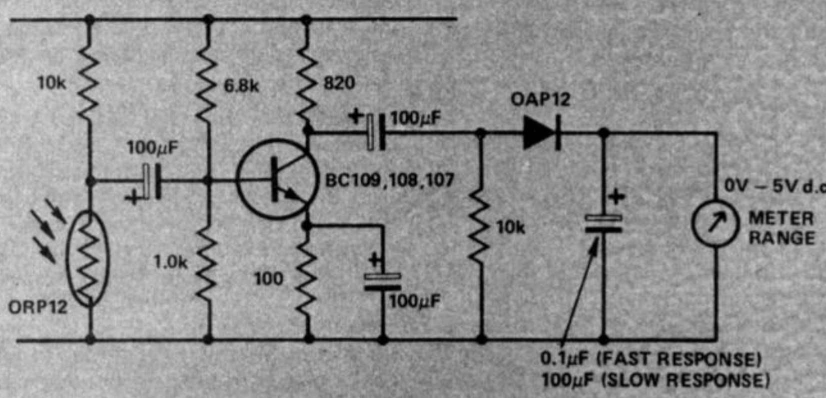

Fig. 16. The modulated light output from a fluorescent lamp may be amplified and measured by adding just a few more components. This also provides a simple test of correct amplifier operation.

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6. Abbreviation for an input socket.
7. The Deepest sound.
8. A basic part of tapes or fishing rods.
11. Sansui offer a complete Hi-Fi ....

CLUES DOWN:
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4. They produce the sound and enhance your room.
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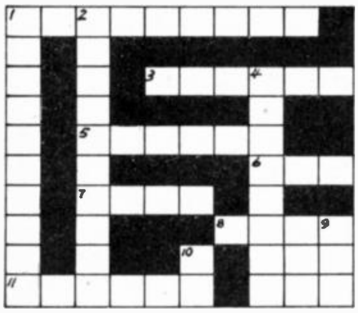
10. The new modulation code which is incorporated in Sansui Stereo Tuners.



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AMATEUR RADIO

Roger Harrison VK2ZTB

THE STATE OF THE ART

NEW APPROACHES TO SSB TECHNIQUES

SINGLE SIDEBAND as a communications technique has been in common use, both by amateurs and commercial users, for quite some time now and is the predominant mode on the amateur VHF bands.

Its penetration into VHF practice has lagged that of HF, partly due to technical and economic problems and partly due to conservatism.

But now, on the VHF scene, things are certainly changing. According to a recent assessment made by Kerry Adams VK5SU(1) over 70% of stations on 52 MHz use SSB. The two metre band is dominated by FM net activity, but, excluding this, SSB is slowly replacing the traditional AM tuneable activity.

The two common methods of SSB generation are the *phasing* and *filter* methods. There is a so-called "third method" that employs a combination of these two techniques, but to date, it has not enjoyed widespread use. By far the most common technique used is the filter method.

The phasing-type SSB generator has enjoyed a resurgence of interest of late, particularly with its advantage of simplicity and low cost; witness the New Zealand-produced "Tucker-Tin" project (1972) and a more recent article by Doyle[2] who described a *passive* phasing-type SSB generator! This last was based on an article by Van Heddegem[3] describing an audio phase-shift network for use with transistorised SSB generators.

This design of the audio phase-shift network is certainly the most difficult problem to solve in a phasing-type generator as off-the-shelf audio phase-shift networks are no longer available. The methods described in references 2 and 3 provide an excellent solution. The author has constructed the phase-shift network described, using standard values in series/parallel trimming arrangement and achieved excellent results. The complete generator described by Doyle is shown in Fig. 1.

The balanced modulator is a basic building block of all the SSB generation methods. In the past, these have been constructed of discrete components and balanced 'in-situ'. With the current availability of matched pairs and quads of diodes (particularly hot-carrier diodes) as well as encapsulated and monolithic ring-diode balanced modulators, these should see ready usage in SSB generators. Also available are IC active balanced modulators, often offering extremely good performance, having wide bandwidth which are also readily applicable to SSB generators. (See the MC1496/LM1496 or Plessey SL640C/41C integrated circuits).

With the phasing method, unwanted sideband suppression is greatly affected by phase-angle errors and amplitude variations in both the RF and audio phase-shift networks. The degradation, in dB, of sideband suppression with variation in these quantities is easily calculated from the following formulae:—

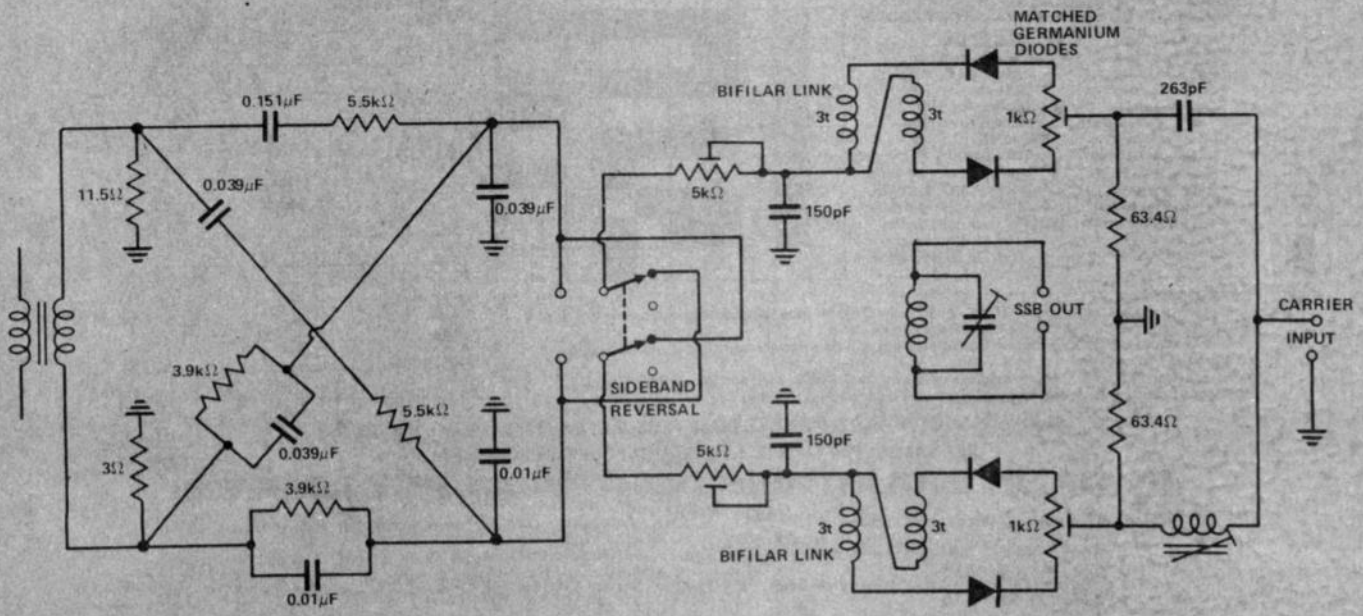
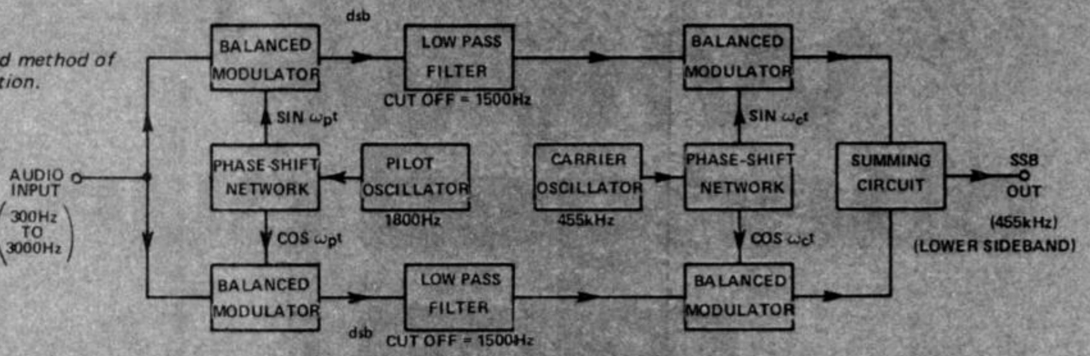


Fig. 1. Passive phasing SSB generator (by W. Doyle W7CMJ).

Fig. 2. Third method of SSB generation.



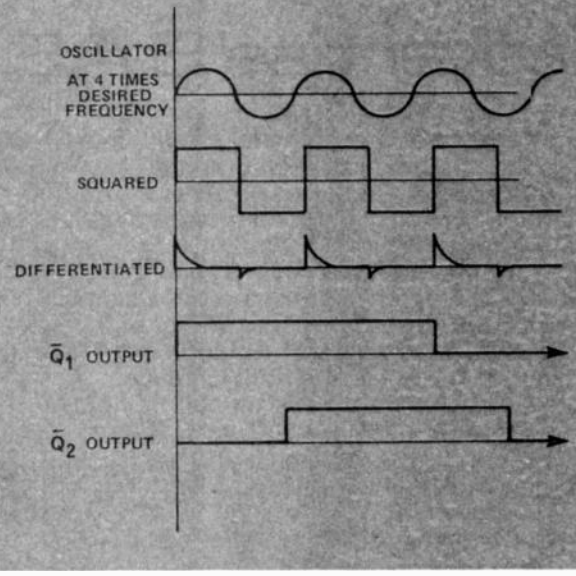


Fig. 3. Production of quadrature square waves.

- Unwanted sideband suppression
  $$\approx 20 \log \frac{\cot \Phi}{2} \text{ dB}$$
  for phase-angle error, where Φ = total phase-angle error.
- Unwanted sideband suppression
  $$= 20 \log \frac{200 + A}{A} \text{ dB}$$
  for amplitude variation, where A = difference in audio channel amplitudes as a percentage.

Thus, for a 1° phase error in either the audio or RF phase-shift networks, the maximum unwanted sideband suppression would be 40dB. For a 2° error, it's 35dB! Acceptable, but only if you have (a) a low power rig or (b) no amateur neighbours!

For a 2% difference in the outputs of the phase-shifted audio channels, the maximum unwanted sideband suppression would be 40dB. Same comments!

The stability and accuracy of the phase shift networks is thus seen to be of major importance in phasing-type SSB generators. The audio phase-shift network problem has largely been solved, but RF phase-shift networks employed to date usually necessitate accurate setting up and frequent re-alignment. However, a technique suggested in the following method neatly overcomes this problem with an elegant, and modern, digital technique.

MODIFIED "THIRD-METHOD"

I won't go into the theory of the third-method of SSB generation here, suffice to give the block diagram (Fig. 2) which will be of assistance shortly. For those wishing to pursue the subject, see the original paper by Weaver[4] and a good descriptive article in the RSGB Handbook.

The advantage of the third method over the phasing and filter methods are:—

(a) no costly, highly selective filter, (which introduces a loss of quality) is necessary.

(b) wideband phase-shift networks with their attendant problems are not necessary.

(c) imperfections in filtering and phasing do not result in unwanted sideband products *outside* the bandwidth of the wanted sideband. This is obviously important in crowded bands or strong signal situations (eg stations in close proximity, ionospheric focussing of signals etc). Regardless of these considerations, it results in a technically superior signal.

However, the problem of the accuracy of the phase-shift networks remains. It isn't too great a problem at the pilot oscillator frequency, but the carrier frequency is a horse of a different colour. At 455 kHz it is critical enough; it's worse at 10 MHz and you might as well scrap the idea above that if conventional techniques are to be used.

Now, here's where we pull the rabbit out of the hat! A paper by A.J. Turner in the Sept. 1973 issue of Wireless World[5] considers how two cross-coupled JK flip-flops can be used to produce quadrature signals.

An oscillator at four times the desired frequency is first squared and then differentiated. The differentiated signal is then applied to the clock input of the cross-coupled pair of JK flip-flops. The resultant Q_1 and Q_2 outputs will be 90° out-of-phase. The waveforms are shown in Fig. 3. The use of a common TTL IC (7473) is shown in Fig. 4, along with the accompanying Q_1 and Q_2 outputs. The quadrature output is very

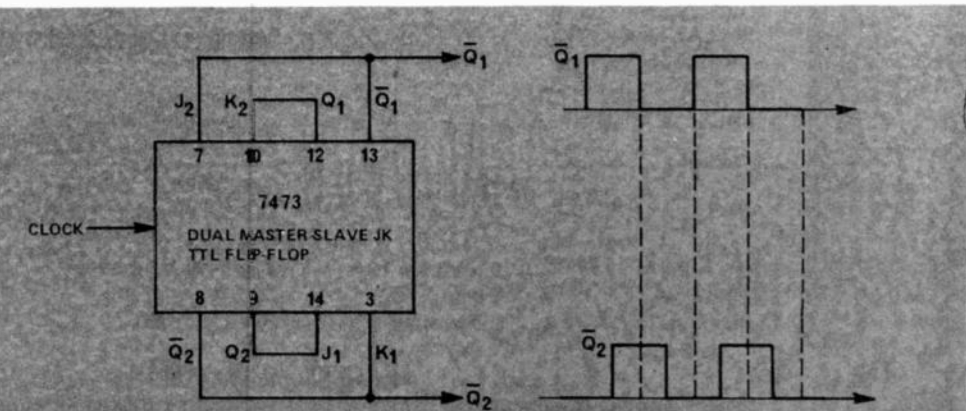


Fig. 4. Common TTL ic used to produce quadrature sqaure waves.

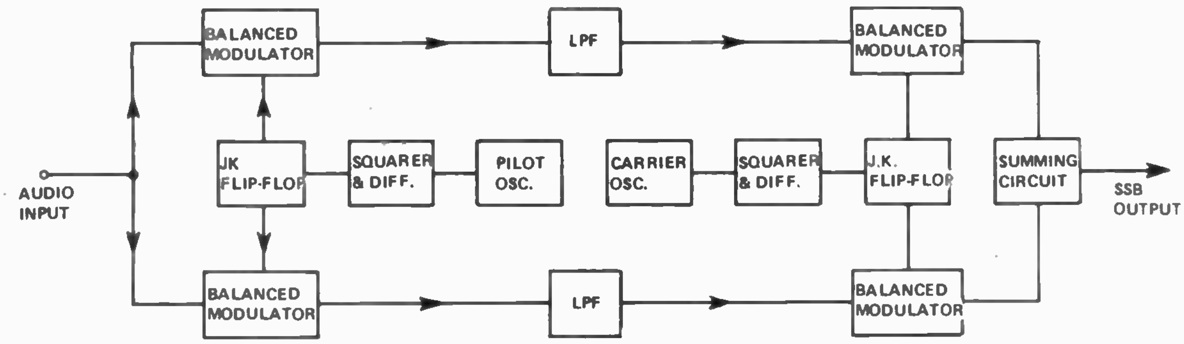


Fig. 5. Modified third method.

accurate, needs no alignment and does not drift.

It is not necessary to convert the square waves back to sinewaves before applying them to the balanced modulators. A square wave contains energy at the fundamental and odd harmonics only. Thus, in the case for pilot oscillator the higher order outputs will be removed by the low pass filters following the balanced modulators, filtering being used to remove the higher order harmonic products. The audio information is in no way affected. Figure 5 gives the block diagram.

As Turner points out, there is a hidden advantage in using square waves. The harmonic components of the quadrature square waves also form quadrature pairs and these can be selected by the summing circuit and true SSB at the harmonic frequency is obtained. Thus, higher transmission frequencies can be reached without heterodyning as is the current practice.

A high speed device such as the 95H29 (about $4 each), which can be clocked up to 210 MHz, is capable of producing SSB directly on 52 MHz! Or, using the same device and a clock frequency of 192MHz, 48MHz SSB can be produced. The third harmonic of the quadrature carrier is thus 144 MHz. Instant two metre SSB! I might be optimistic, but it's worth a try!

Further, the carrier oscillator need not be fixed. It can be varied over a fairly wide range, no other tuning being necessary.

REFERENCES

(1) 6UP, February 1974, p.8.

(2) W. Doyle W7CMJ, Ham Radio, April 1973, pp 22-25, "Phasing-type SSB Generator".

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(4) D.K. Weaver, Proc. IRE (USA) 1956, vol. 44, part 12, pp 1703-1705, "A Third Method for the Generation of Single Sideband signals".

(5) A.J. Turner G3UFP, Wireless World, Sept. 1973, pp 453-455, "Single Sideband, Suppressed Carrier Generation". ●

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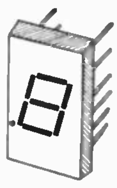

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This kit provides a highly sophisticated display section module for clocks, counter or other numerical display needs.

The RCA DR-2010 Numitron display tube supplied with this kit is an incandescent seven-segment display tube. The .6" high number can be read at a distance of thirty feet. RCA specs. provide a minimum life for this tube of 100,000 hours (about 11 years of normal use).

A 7490 decade counter IC is used to give typical count rates of up to thirty MHz. A 7475 is used to store the BCD information during the counting period to ensure a non-blinking display. Stored BCD data from the 7475 is decoded using a 7447 seven-segment decoder driver. The 7447 accomplishes blanking of leading edge zeroes, and has a lamp test input which causes all seven segments of the display tube to light.

Kit includes a two-sided (with plated through holes) fibreglass printed circuit board, three IC's, DR-2010 (with decimal point) display tube, and enough Molex socket pins for the IC's.

Circuit board is .8" wide and 4 3/8" long. A single 5-volt power source powers both the IC's and the display tube.

CD-2 Kit Complete Only $10.95
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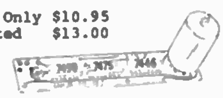
Board Only $2.50



RCA DR2010 NUMITRON

RCA DR2010 Numitron digital display tube. This incandescent five-volt seven-segment device provides a .6" high numeral which can be seen at a distance of 30 feet. The tube has a standard nine-pin base (solderable) and a left-hand decimal point. Each $4.00
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This kit is similar to the CD-2 except for the following:

a. Does not include the 7475 quad latch storage feature.
b. Board is the same width but is 1" shorter.
c. Five additional passive components are provided, which permit the user to program the count to any number from two to ten. Two kits may be interconnected to count to any number 2-99, three kits 2-999, etc.
d. Complete instructions are provided to pre-set the modulus for your application.

CD-3 Board Only $2.25
IC's, 7490, 7447 $2.75
RCA DR2010 tube $5.00

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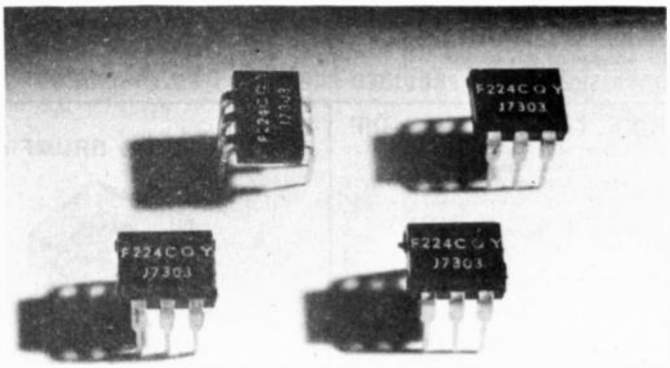

Philips latest photocouplers in 6-pin DIL encapsulation include the types CNY47, CNY47A and CNY48. The CNY47 and 47A have high dc current transfer ratios of 20% and 40% respectively, and low saturation voltages of 0.4 V.

They provide a high degree of isolation between input and output circuits, being tested to 2800 V peak at 50 Hz for one minute. The CNY48 has a Darlington receiver which gives an exceptionally high transfer ratio of 600%.

These photocouplers are ideal interface components because they effectively shield voltage sensitive elements from spurious operation. Applications include the protection of line relays on telephone systems, thyristors, and the coupling of computers to their peripherals.

Further details: Elcoma, 67 Mars Rd., Lane Cove, NSW. Mr. David Rake 42 1261.

NEW AGENT FOR ALLEN-BRADLEY

Morganite Australia Pty Limited announce their appointment as sole Australian Agent for electronic components manufactured by the Allen Bradley Corporation, Milwaukee, U.S.A.

Allen Bradley are best known for their potentiometers and attenuators which are available with either moulded carbon or cermet tracks. Wattage ratings range from 0.5 to 5 watts with a mechanical life of up to 1 million rotations.

Potentiometers and attenuators are readily available in single up to quadruple gangs with or without switches and concentric shafts.

A range of trimming potentiometers in either linear or rotary motion are also available in both moulded carbon or cermet tracks.

In addition to their "Hot Moulded" Carbon Fixed resistors, Allen Bradley have introduced a new "Cermet Film" resistor having a tolerance of ±1% and a low temperature coefficient of ±100ppm/°C. This resistor has the approval of the United States Department of Defence under MIL-R-10509/7F.

Cermet Film resistors are now available in Australia as a result of Morganite Australia's appointment.

Allen Bradley have utilised cermet resistive elements to manufacture cermet resistor networks. There are two basic types of networks available, precision thin film having an absolute tolerance as low as ±0.01% and a temperature coefficient of ±5ppm/°C. whilst the cermet thick film has a tolerance as low as ± 0.5% and a temperature coefficient of ±100ppm/°C.

Further information: Morganite Aust. Pty. Ltd., 65 Bourke Rd., Alexandria NSW 2015. Tel: 669 5711

PIEZOELECTRIC CERAMICS APPLICATIONS

The latest edition of Philips Application Book "Piezoelectric Ceramics", first published in 1968 has now been completely revised, updated and extended to cover the latest PXE materials and their applications.

The book opens with the basic theory of piezoelectric effects in ceramic materials and surveys the principal properties of present grades of PXE.

The problems of gas ignition are then

considered and different forms of igniters are described.

PXE flexure elements have a wide range of application as electrical-to-mechanical transducers in addition to their more familiar role in pick-up cartridges, strain gauges and accelerometers; these applications are fully discussed and much new material is included.

Ceramic resonators have many advantages in electrical filters and details are given of their use in various types of filter networks.

Sound and ultrasound air transducers are described in a very comprehensive chapter which gives numerous practical circuits for remote control and intruder detection.

The application of ultra-sound transducers to echo sounders is covered in a separate chapter.

PXE high intensity transducers in ultrasonic cleaning require no introduction. The book, however, gives a very thorough treatment of the subject, including constructional details of two transducers. Finally, a chapter is devoted to PXE delay lines and the design of a delay line for PAL colour television receivers is given.

Further details: Elcoma 67 Mars Rd., Lane Cove, NSW.

FAIRCHILD ADDS 2136 TO LINEAR CIRCUIT LINE

Fairchild has announced it will serve as an alternate source for the 2136 FM IF amplifier and detector.

The 2136 is a three stage IF amplifier, which incorporates a quadrature detector and a built in voltage regulator in a single integrated circuit.

Compared with conventional ratio detector designs for FM and TV sound systems, the quadrature detector requires only a single tuning coil. This greatly simplifies alignment procedures, since the coil is adjusted for maximum audible output without using an oscilloscope or signal generator.

A ceramic filter can be used in place of the tuning coil. A complete FM IF strip with no alignment requirements can be constructed by using the 2136 in conjunction with Fairchild's uA753 FM gain block, which uses two ceramic filters as selectivity elements.

The internal voltage regulator in the 2136 eliminates the need for external decoupling networks.

Further details: Fairchild Aust. Pty. Ltd., 420 Mt. Dandenong Road, Croydon, Vic. Tel: 723-4131.

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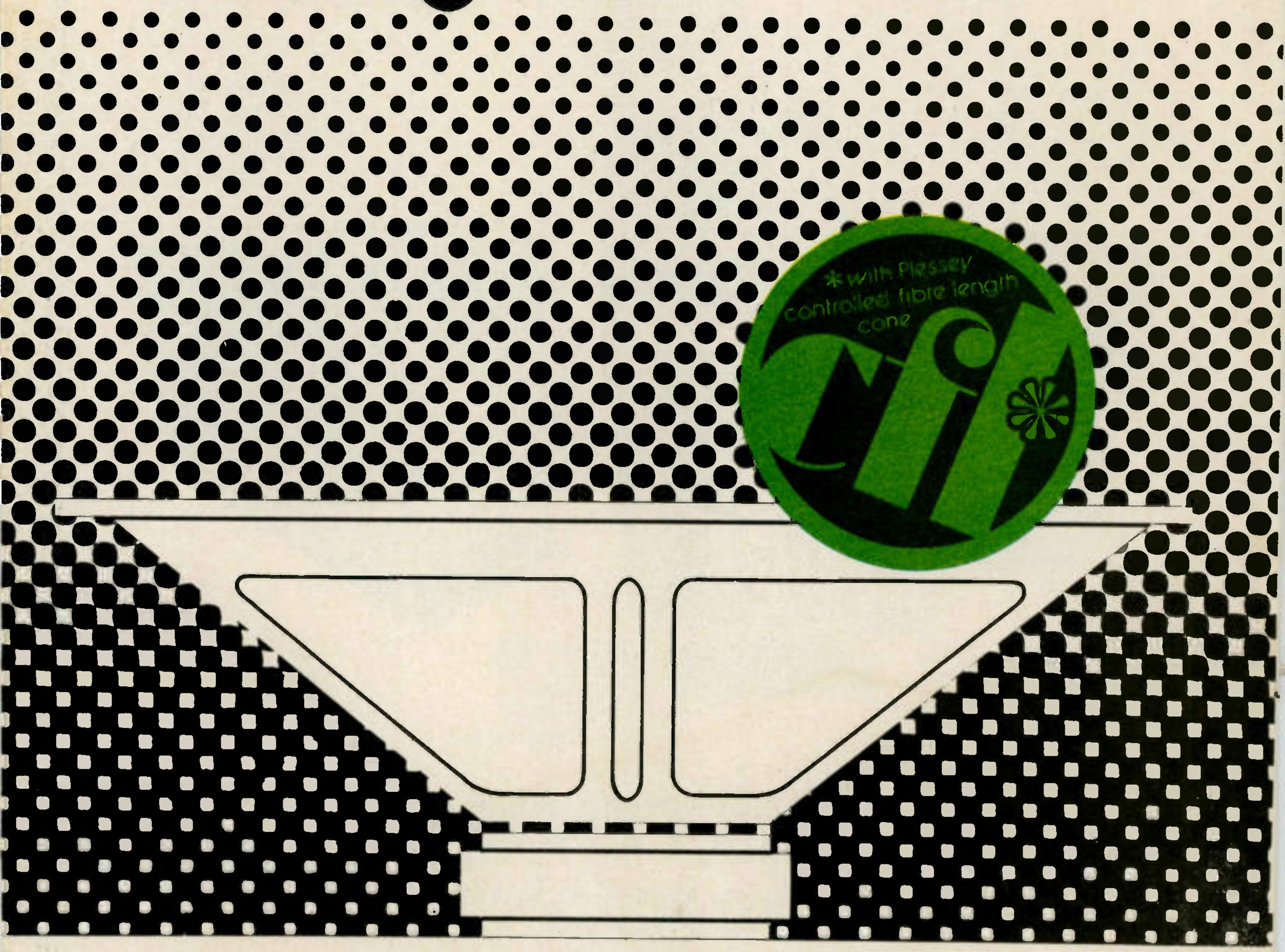

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SENSORS ON by Talus

Does the cleverness of man improve?

WITHOUT doubt our civilisation is changing in dramatic ways. There is the information explosion, the data processing revolution, the increased acceptance of the technologies, more advanced and specialised training for a livelihood. It is surely becoming more and more complicated due to the ever increasing bent to become more sophisticated.

All of this may tempt us to superficially regard ourselves as being brighter, more intelligent and cleverer than those we regard as less fortunate, who played their parts before us in the creation of more advanced civilisation.

Man has been around for roughly 40,000 years – having made a transition from caves to penthouses in that time.

But have things changed at the root of it all? People today can still be amazed by modern achievements, just as the automatic peacock of de Gennes (A French General who built it in 1688) must have stunned the locals when it went about its pre-programmed walk picking up corn from the ground before it digested it, dropping a trail of realistic excrement.

The sobering realisation is that man can only make what is possible, there is really no mystery about achievement, merely a lack of adequate understanding.

We look back and exclaim how peculiarily the medieavals thought about things. For instance in 1601 AD a horse (yes a horse!) was condemned to death by burning because it could perform a number of tricks. Who knows what *we* do that will seem so backward to our future historians – perhaps it could be fishing and meat eating. After all if it is cruel to hunt deer with dogs surely it is just as cruel to jag a fish by a hook for hours!

Maybe we will be looked upon as a Grey age that started the emergence from the Dark ages and not anywhere as bright and startling as it seems to us now.

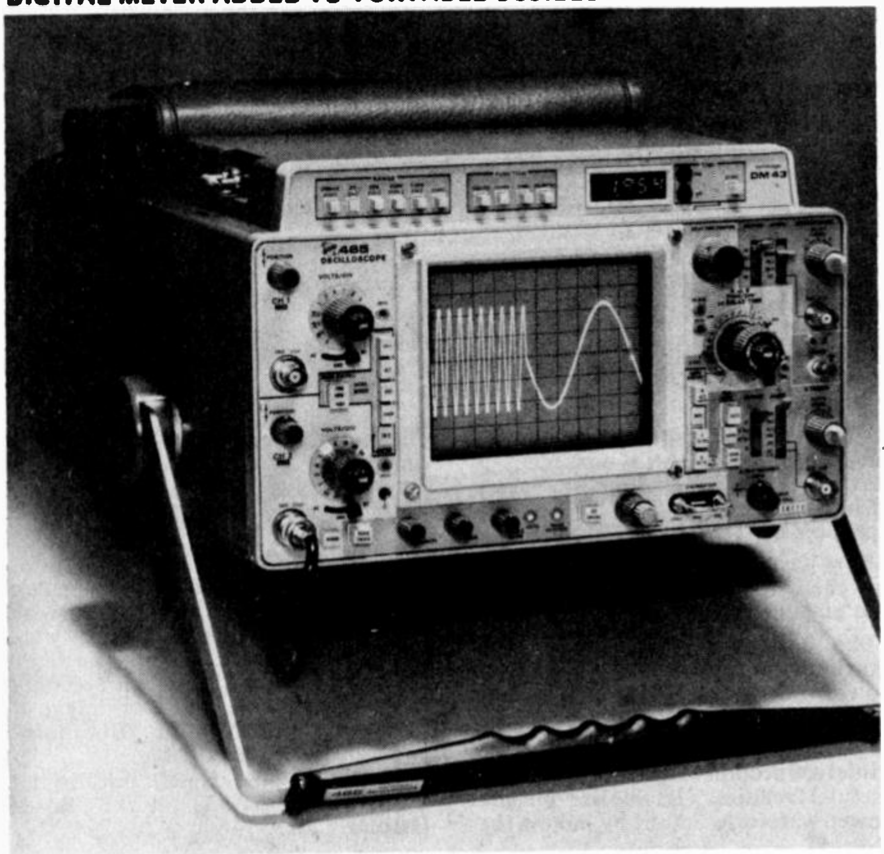
Cleverness is hard to judge, for the very term is subjective and difficult to measure. Perhaps one criteria is to judge the scope, breadth and creative ability of a person's endeavour. From this point of view those who have had a greater chance to use resources in abundance could appear to be more outstanding. Alexander the Great, Julius Caesar, Ghengis Khan, the Pharaohs, even Hitler each shared extreme cleverness (there is no reason to regard cleverness as being for our *good*).

Today the complexity of a powerful computer, a military early-warning and ICBM system, the electronic pocket computer are each astounding. But are they more complex than the design of the great Gothic cathedrals; the Baroque churches; the mechanical automats that could write letters and play trumpets; the war schemes of the conquerors? These earlier achievements were made without the modern sophistications of drawing offices, computing facilities, numerical control tools, electric power, and, of course, electronic techniques.

We will probably never know if Julius Caesar had the cleverness to design a data processor. In fact, about all we can be certain of is that our efforts certainly do not overshadow the brains of the bygone greats. It is a sobering thought that can only increase our measure of humility. ●

EQUIPMENT NEWS

DIGITAL METER ADDED TO PORTABLE OSCILLOSCOPES



Tektronix Australia announces a built-in precision digital multimeter for its model 465 and 475 Portable – Oscilloscopes.

The meter, called the DM43, offers 5 voltage ranges from 200 mV to 1200 V, 6 ohms ranges from 200Ω to 20 MΩ, temperature probing capability from -55° to +150°C, and accurate differential time delay measurements between any two points on a waveform displayed on the crt as a digital number.

Resolution is increased by a factor of 10 over what could be read from the precision delay time dial. The operator needs to make no mental calculations to determine the correct value.

Time measurements are made by selecting the first of the two points by means of the oscilloscope's delay time position control. The meter is set to zero at this point. Next the delay time position control is used to select the second point and the delay is read out directly on the meter.

Since the DM43 is mounted on an oscilloscope, signal waveforms for the power component can be monitored at the same time.

Test leads for the DM43 and DM40 are independent of the oscilloscope into which the meter is incorporated.

Convenient pushbuttons provide separate selection of function and range. Readout consists of five 7-segment LED's.

Multimeter Specifications

DC Voltage
Ranges: 0 - 200 mV, 0 - 2 V, 0 - 20 V, 0 - 200 V, 0 - 1200 V.
Resolution: 100 μV
Accuracy: Within 0.1% of reading, ±1 count
Response Time: Within 0.5 sec.

Resistance
Ranges: 0 - 200 Ω, 0 - 2 K, 0 - 20 K, 0 - 200 K, 0 - 2 M, 0 - 20 M
Resolution: 0.1 Ω
Accuracy: Within 0.75%, ±1 count
Response Time: Within 1 sec for 200 Ω - 2 M ranges, Within 5 sec for 20 M range.

Temperature
Range: -55°C to +150°C
Accuracy: Within 1.1°C from - 55° to +125°C. Within 2.1°C from -55° to +150°C.

Differential Time Delay
Accuracy: Accuracy of the oscilloscope ±1 count.

Further information: Tektronix Aust. Pty. Ltd., 80 Waterloo Rd., N. Ryde. 2113. Tel: 888-7066.

SINGLE CHANNEL PROFESSIONAL AMPLIFIER

The Acoustical Manufacturing Company of the United Kingdom have produced a single channel amplifier designed for broadcast recording and other applications in the audio industry, and in industrial and research applications, called the QUAD 50E.

Distortion within the useful part of the audio range is stated not to exceed a small fraction of one per cent.

Overloading with any load will not significantly affect long time constants, ensuring immediate recovery and minimum distortion resulting from such overload.

If misuse is such as to cause excessive heating, the maximum power will reduce as necessary, restoring automatically when more normal conditions prevail.

The input is 0.5 Vrms unbalanced via a pre-set gain control, with provision for 600 ohm line bridging by means of an internal plug-in transformer, available as an optional extra.

The output is isolated and provides up to 50W continuous power into almost any impedance from 4 ohm to 200 ohm.

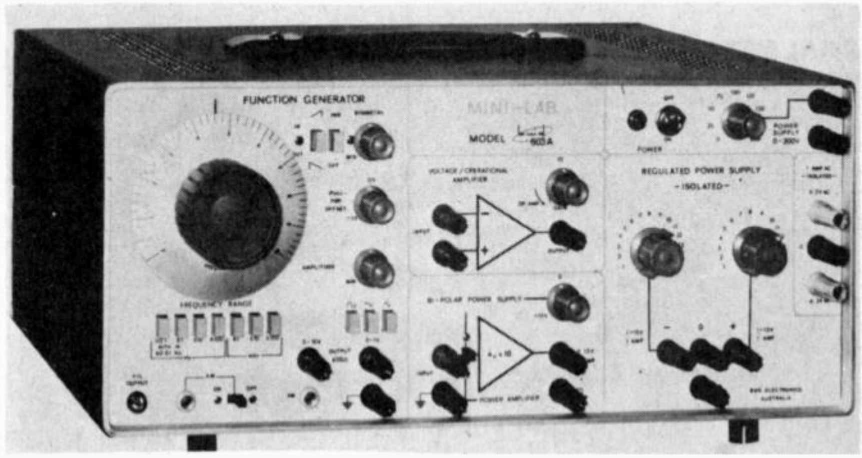
The multiple output windings of the QUAD 50E terminate in a multiple output socket. Choice of matching is obtained by various connections in the output plug which is part of the installation itself.

The QUAD 50E together with the 600 ohm input bridging transformer Model 278Q is now available ex stock. Further details: British Merchandising Pty. Limited, 49 York Street, Sydney (Telephone 29-1571).

BWD MINILAB UPGRADED

B.W.D. Electronics Pty. Ltd. have now completely redesigned their MINI-LAB composite instrument model 603.

EQUIPMENT NEWS



Described as a 'super' version of the original Model 603, the new 603A is claimed to have almost every characteristic upgraded, in many instances by factors of X10.

New features such as TTL output, switched offset and wide range ramp and pulse are incorporated.

The 603A provides function generator, operational amplifier, power amplifier, bi-polar power supply, high voltage power supply, and two low voltage power supplies.

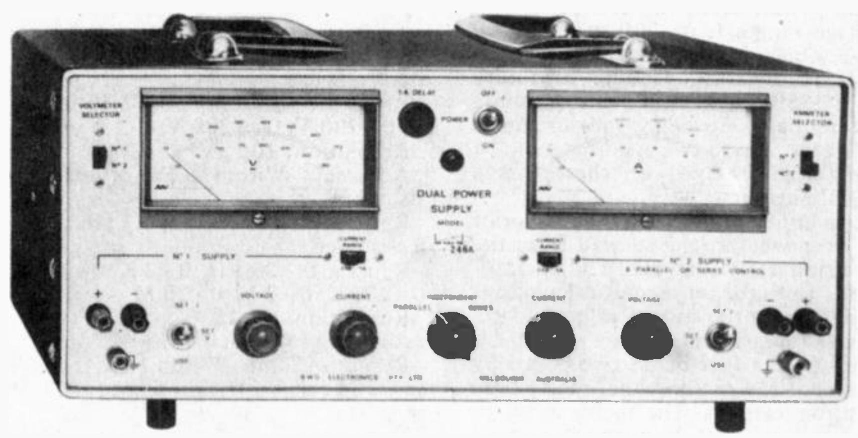
Interconnection provides many useful facilities. Examples include power waveform output by linking the function generator to the power amplifier: AM or FM modulation simultaneously: high sensitivity power with op. amp. linked to power amp. etc.

Sharp pulses and unusual waveforms such as half sine, truncated triangular, long curves etc. can be obtained with various combinations of the wide range of facilities.

A comprehensive handbook describes many experiments, and a full range of accessories suitable for educational experiments is till available.

Further details: B.W.D. Electronics Pty.. Ltd., 331-333 Burke Road, Gardiner, Vic. 3146.

VERNIER VOLTAGE CONTROL STANDARD ON P.S. RANGE



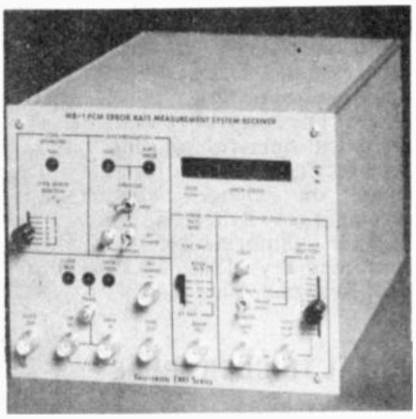
B.W.D. Electronics Pty. Ltd. now include a vernier voltage control, previously an optional extra, as standard equipment on three of their power supplies without additional charge.

The models affected are the 216A dual output 400V, the 242A dual output (36V and 72V), the 272A triple range (12V, 25V and 50V), and the 246A dual output (36V and 72V).

The 10 turn vernier control permits fine, precise adjustment of voltage. A matching digit dial is still available as an option.

Further details: B.W.D. Electronics Pty. Ltd., 331-333 Burke Road, Gardiner, Vic., 3146.

NEW BALANCING TRANSFORMERS



New balancing transformers available from Hewlett-Packard provide a balanced output from a single-ended input, or a single ended output from a balanced input.

Impedances available are 70 ohms unbalanced to 124, 135, 150 and 600 ohms balanced. Frequency responses is ±0.5 dB over 20 Hz to 50 kHz for the 600-ohm models; 2kHz to 2MHz for the 135-ohm and 150-ohm models, and 5 kHz to 5MHz for the 124-ohm version.

The transformers can be used with Hewlett-Packard 3040A/41A/42A Network Analyser Systems when making transmission measurements.

Other applications include measuring balanced responses with single-ended detectors, obtaining a balanced output from a single-ended oscillator and as a balancing network for repeater amplifiers.

A plated heatsink fabrication technique achieves intimate thermal contact between the junction and the heatsink. Thermal resistance is rated at 5.5°C/W.

Further details: Hewlett-Packard Australia Pty Ltd, 31-41 Joseph St., Blackburn, Victoria 3130. Tel: 89-6351.

"BERT" BIT ERROR RATE TESTING

TAU-TRON is introducing a high performance, BERT system. The BERT operates in 1 bit to 75 megabits per second and provides bit error and block error measurements along with a burst error indicator.

The transmitter is the MN-1 Pseudo-Random Data Generator. It creates pseudo-random codes, from 63 bits to over 1 million bits per period.

EQUIPMENT NEWS

There are 6 codes in all and selection is made directly on the front panel.

The receiver section of the BERT is the MB-1 unit, PCM BERT. It automatically synchronizes its local code generator to the received sequence independent of path propogation delay. Bit error and block error rate measurements are displayed on a four digit LED display. A burst error LED monitor is also provided. Additional conveniences such as indicators and controls for correct input amplitude and clock/data phase differential simplify operational usage.

Supplementary modules such as the MM-1 may be used to provide error injection, preamble insertion, and variable position frame sync output pulses.

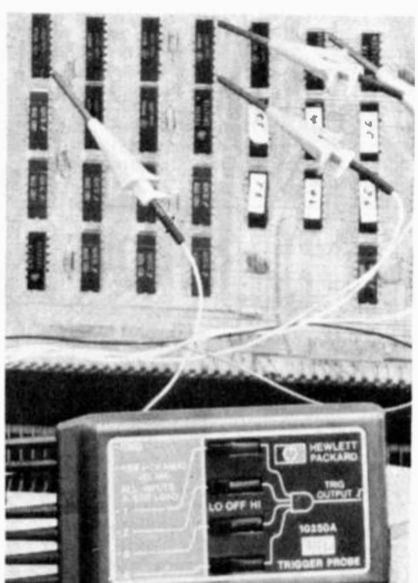
The MN-1 may also be used to encode and decode and thus may also function as a BER monitor.

For further details: Arlunya Pty. Ltd., P.O. Box 113, Balwyn, Victoria 3103

MINIATURE DIGITAL MULTIMETER

Despite a front panel measuring only 14 x 4½ cm, a depth of less than 9 cm, and a weight less than 0.6 kg, the Data Precision Model 245E digital multimeter is claimed to compare favourably in performance with the larger laboratory DMM's.

Available from Kennedy Electronics Pty. Ltd., the 245E has a full 4½ digit, 0.005% resolution readout, 21 range versatility with 100% overrange for AC & DC voltage, AC & DC current, and five resistance ranges.



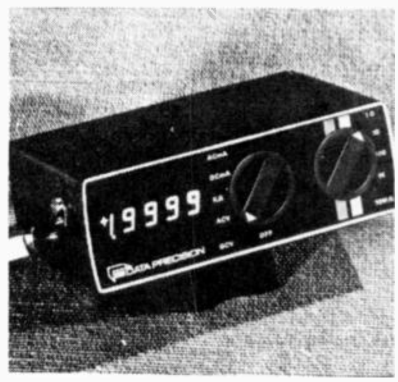
Input impedance on the ±1.0 range is greater than 1000 Megohms: all other ranges, 10 Megohms. Accuracy (24 hours, 23°C) ±0.03%.

The instrument is built in a high impact moulded case. Its 0.6 kg weight includes a battery module which contains six NiCd batteries for six hours of operation.

Where line power is available the instrument operates on this without disconnecting the batteries, which remain on charge whether the instrument is switched on or off.

Further information: Kennedy Electronics Pty. Ltd., 142 Highbury Road, Burwood, Vic. 3125.

DIGITAL TRIGGER PROBE



Electrical analysis of digital signals is eased with a new TTL Trigger Probe (Hewlett-Packard Model 10250A) that derives its power from the circuit under test, and triggers any oscilloscope when it recognises a predetermined pattern of four simultaneous logic states.

The device consists of a small control box with four logic leads, to be connected to appropriate points in the tested circuit, and a trigger output to be connected to an oscilloscope or other externally-triggered test equipment.

Each logic input can be switched to HI, LO or OFF (don't care) for convenient selection of the desired trigger point. The Trigger output signal goes high when the preselected trigger word occurs; it remains high so long as trigger conditions are present.

Standard TTL levels operate the probe; bit rates to 10 MHz are accommodated.

For further details: Hewlett-Packard Australia Pty Ltd., 31-41 Joseph St., Blackburn, Victoria 3130. Telephone 896351

New!

Now available in Australia

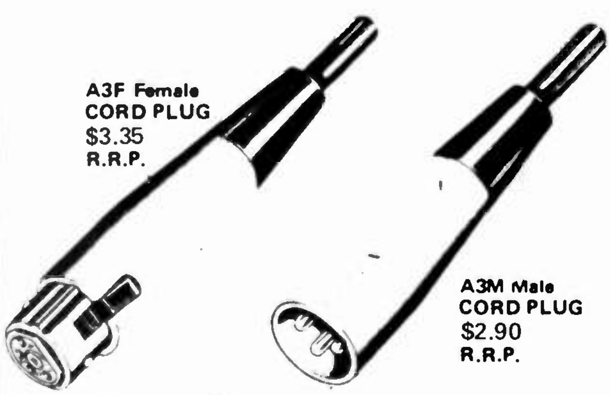
SWITCHCRAFT INC.

"Q-G" Audio Connectors

Field proven in a wide variety of critical applications such as microphones, stereo equipment, test equipment instrumentation etc., these Audio Connectors have exclusive "Ground Terminal" and "Ground Contactors".

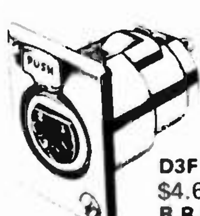
EXCLUSIVE SWITCHCRAFT FEATURES

- **Style:** to enhance the most modern equipment.
- **Construction:** Rugged die-cast zinc, satin nickel finish.
- **Insert Insulation:** High dialectric strength plastic.
- **Dual Pressure Plates:** Secure cable lock for all sizes.
- **Cable Entries:** Neoprene cable strain relief bushing.
- **Wiring:** Unique soldering cups make wiring easier.
- **Polarisation:** Impossible to make connectors incorrectly.



A3F Female CORD PLUG $3.35 R.R.P.

A3M Male CORD PLUG $2.90 R.R.P.



D3F $4.60 R.R.P.

Receptacle for panel or chassis mounting

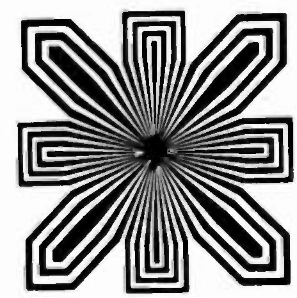
D3M $2.75 R.R.P.

Receptacle for crowded panels

New!

Just arrived from U.S.A.

wendell GRILLE fabrics



These superb Wendell fabrics are woven entirely of synthetic fibres which do not absorb sound, moisture or dirt. Colour cannot wear off. Available in a wide range of designs, weaves and colours.

Wendell fabrics are well known for their accoustical qualities which make them uniquely suitable for a wide variety of applications including Hi-Fi equipment, T.V. sets, pianos and organs as well as distinctive decorative wall coverings.

FEATURES

- Unobstructed, distortion-free passage of sound.
- Fire resistant, dust resistant and fire proof.
- Minimal fading.
- True, uniform pattern lines.
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- Strong – will not sag or buckle.

75 patterns to choose from.
Standard width .813m (32")
From $3.00 Metre (R.R.P.)

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AE083/FP

INPUT GATE

LETTERS FROM OUR READERS

POOR RECORD QUALITY

I have been prompted, by your recent editorial referring to the lack of quality records available in Australia, to write and express my dismay at a situation which must annoy many music enthusiasts.

I agree with your comments that Hi-Fi equipment sold in Australia is generally of a high standard. Although the cost of my "middle of the road" Hi-Fi system seemed high at the time of purchase, over a period I consider it one of the cheapest and most enjoyable forms of relaxation.

However, the poor quality of some records which I have purchased disappoints me. To find that records which cost $6.50 are often inferior to others which cost less than half as much makes me think that the record buying public are being taken for an expensive "No Refund" ride.

As an alternative, I have purchased an 8-track cartridge deck, which offers good reproduction of most modern music. Although the recording ability of these units is limited, I find that the pre-recorded tapes have more to offer at this time than records. The slightly higher cost is easily compensated for; as the tapes are easily stored, safe from damage when in the hands of the inexperienced and most important able to give quite reasonable reproduction of music without the nasty little clicks and pops found on so many records.

Thanks for a great magazine.
Yours Sincerely,
Dennis Lee Kolberg.

ELECTRONICS IT'S EASY COURSE

Do you intend to reprint your current 'beginners' course in book form? If so I'm sure that it would attract a lot of sales. I have tried ploughing my way through other so-called beginners' courses before but yours is the only that seems pitched at the right level — you assume the reader does not understand electronics but don't make the usual error of assuming that means he is also stupid!

B. Langly,
Merrylands, NSW

Thank you for your kind remarks. We certainly will be producing the course as a handbook in due course. Details will be published in ETI as soon as further details are known.

QUAD TERMS

Your ridiculous phony four-channel glossary of terms (ETI Aug p.47) is one of the silliest things I've ever read.

If the author (M. Gerzon) or your staff had done their homework they would have known that not all four-channel systems are bad. At least one, 'Ambisonics' works very well. Why not save your silly sneers for a more worthy target — or at least one you know something about. Of course you won't print this letter.

J. Daniels,
Melbourne, Vic.

WHO hasn't done his homework! Daniels, don't you know that Michael Gerzon, the author of that glossary is one of the two people who invented Ambisonics!

CAN'T STOP LAUGHING

Congratulations on printing Michael Gerzon's hilarious send-up of four-channel terms. Two days later I'm still laughing.

G. Grovenor.
Paddington, NSW.

Apollo Hi-Fi Centre

283 Victoria Road, Marrickville, N.S.W.
Telephone: 560-9019

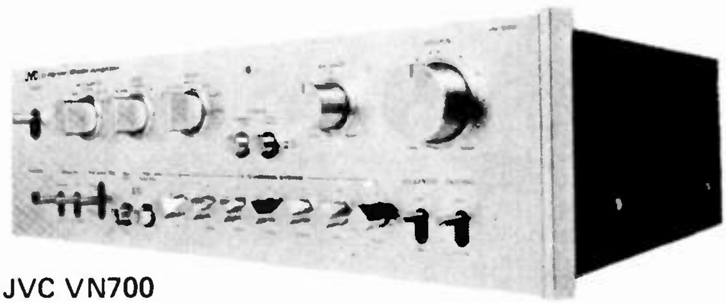
JVC SK12

40W (RMS) 6 Speaker 4-Way system

This high class speaker system is the result of JVC own intensive research programme. The SK 12 has a 12" free edge woofer, two 5" mid range speakers, two 2½" tweeters and horn super tweeter. Together these speakers give a total coverage with a flat frequency response over the whole audio range. A continuous lever control for the high frequency sounds makes the SK 12 match any room acoustics. The front grilles are removable so that the cabinet has no side edges to reflect high frequency sound. This heightens the smooth response to 25-22,000Hz

JVC SK12

Here is the purists delight with 70 watts (RMS) of output and specifications that are very impressive. In figures this means a frequency response of 20-50,000 Hz and a THD factor of 0.25% plus the feature of JVC's SEA tone control system that gives you ultimate control over sound at 40, 250, 1000, 5000 and 15000 Hz. This unit will connect up to two pairs of speakers, two tape recorders, turntable and three auxiliary components.



JVC VN700

"4-channel ready"

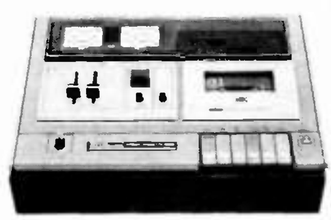
A look at this precision component will tell you its different, but a closer look will prove it. Notice how the TH universal tonearm houses a 4/2-channel compatible cartridge. And how the turntable's 4-pole synchronous motor and belt-drive system combine to give it the precision required for reproducing discrete 4-channel stereo records: wow and flutter of less than 0.1% WRMS and an S/N ratio of better than 5-db. In addition, auto-stop-return mechanics with anti-skating device and cueing lever. In fact, all that's required to convert the SRP-87 to immediate discrete 4-channel status is JVC's 4DD-5 demodulator and stylus (4DT 10X).

JVC-SRP 87

Stereo Cassette Deck with ANRS

The professionalism of the open reel deck is combined with the convenience of the cassette in this high-performing compact, a 'must' for any serious stereo enthusiast. Built-in Automatic Noise Reduction System (ARNS) Tape Selector Switch, long life head and electrically-governed DC motor enable the unit to offer frequency response of 30 to 13,000 Hz (±3 dB), a signal-to-noise ratio of 50 dB and low wow and flutter characteristics of 0.15% RMS. For optimum recording, the unit features a pair of large VU meters, separate sliding volume controls and convenient pushbuttons for all recording and playback functions, including one for Pause and Eject. For professional monitoring with headphones, a headphone level switch is included.

JVC 1667 V



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RECORDINGS

classical

Reviewer: Tanya Buchdahl

BARTOK: Violin Concerto No. 2 (1937-38). Zoltan Szekely (violin); Concertgebouw Orchestra Amsterdam/Willem Mengelberg. Hungaroton Bartok Edition (mono) LPX-11573 ($3.50). Distributed by Avan-Guard.

How many of us wonder how the first performance of a work by Beethoven, Bach, Mozart, Brahms would have sounded, what the performing style would have been. No chance of finding that out, but on this record we can hear as best we are able how Bartok wanted his second violin concerto to sound. As part of (supplement to) the Complete Bartok Edition, Hungaroton has issued this remarkable document of the first performance, played by the man who commissioned it.

The one disadvantage of the record is of course the terrible surface noise. It was cut from a shellac pressing which was in the possession of Szekely's son until 1971 when he sold it to Hungaroton (for quite a price too, I hear). Though the orchestral tone comes across surprisingly clearly in the main, especially for a live recording, the surface rasp may render this edition unacceptable for some people.

For once I find the audience applause (which would have been very difficult to remove) quite unobjectionable. Though it's usual to think that music like Bartok's was misunderstood and rejected on first hearings, the Dutch audience who heard this obviously didn't do so. They burst into spontaneous applause at the end of the first movement, and the delighted consternation at the finish is something worth hearing – not all due to Bartok of course, but Szekely's uncriticizable playing and Mengelberg's customarily unaffected support.

The Bartok Edition in fact offers two Second Violin Concerti (this one being the supplementary one), the other being a version by the marvellous Denes Kovacs (with the Hungarian Radio Orchestra; Hungaroton SLPX-11350, $3.50), which not only contains some bonus rhapsodies but has a Grand Prix du Disque to boot. I might add that the price of records in this series has recently come *down* 12%, from $3.98 to $3.50 which makes them even better value. So there you are – you have the choice of an excellent and historically interesting performance, or an excellent performance with the benefit of modern recording techniques; or even both of them for only slightly more than a single full-price record. It's up to you – and I'm glad it's not my choice. – T.R.B.

BEETHOVEN: Symphonies 1-9. Agnes Giebel (soprano), Grace Hoffmann (alto), Helmut Krebs (tenor), Fritz Ollendorf (bass); Chorus of Radio Frankfurt, Chorus of the Frankfurt Caecilienverein. Nos. 1, 4, 9: Frankfurt Radio Orchestra/Walter Goehr; Nos. 2, 3, 7, 8: Vienna State Opera Orchestra/Michael Gielen; No. 5: Hamburg Symphony Orchestra/David Josefowitz; No. 6: Vienna State Opera Orchestra/Hans Swarowsky. Audio Fidelity FCS-71 (7-record set) $24.50. Distributed by Carinia.

The set is one of the cheapest, but not the cheapest, versions of the Beethoven symphonies currently available. As the price may well be a deciding factor for those intending to buy a complete set, I think I should mention a few others to start with. If you are a Klemperer lover, then read no further; his Beethoven cycle is available with the overtures thrown in, on a nine-record set (SLS788) for $22.50. A version performed by the Cleveland Orchestra under Szell will be appearing later this year for (so I am told) under $20.00, originally CBS but now on the Avan-Guard label. The Walter cycle is presently available in the form of single records at $2.95 each on Classics for Pleasure, but a boxed set was released in England a few months ago, consisting of five (five!) records at a price which usually translates to around $13.00 here (I understand that two or three of these records are not the same Walter performances as appear on CFP). It remains to be seen whether the set is released here by CBS, and at what price, but it could be worth waiting for. As for the present set, it contains some fine performances, some of which are spectacular, but it suffers from poor surfaces which date from 1959 (these aren't re-pressings either, as far as I can see), sometimes so obtrusive that I feel the price of $3.50 per record can't really be justified. Not for someone with a middle-of-the-road or better stereo system, anyway – but if your system isn't choosy you may find this set perfectly adequate.

These records must have been produced in the very early days of stereo (these are genuine stereo, not re-processed, I am glad to say), and it is painfully obvious at least at the start of the final movement of the Ninth that the engineers were quite defeated by the technical problems of dealing with so many performers at one time. Tape editing isn't all it could be either – the trumpets at the end of the section "... und der Cherub steht vor Gott" in that movement are vilely flat, and that should never have seen a record groove. One or two other discs are eccentric pressings, the worst of which is No. 8, which has an obnoxious rasp most of the way through and some painful pitch distortion right at the end. That's the worst of it, and rather paradoxically some of it is as good as I have heard on record. The balance in most of the symphonies is very good, with the wind well forward but not unnaturally so; the kettledrums in the second movement (*Scherzo*) of the Ninth are balanced better than I have heard on any recording, modern or otherwise, and the sweetness of tone produced by the strings in the slow movement of the same symphony has to be heard to be believed. The performance of this slow movement, too, is quite the loveliest version of it I have yet heard, and one of the best things I have heard on record in quite a while.

The rest of the symphony isn't as good. Goehr, like so many other conductors, doesn't seem to realize the full value of the first movement, but at least here it is not because all the attention has been given to the last movement. The only really marvellous first movement I have heard is Horenstein's on an ancient Vox record (Lipp, Hoengen, Patzak, Wiener; Pro Musica Wien. Vox STPL 510.000 $3.50) that is still available but in a lousily-reprocessed stereo form. For sheer scale and grandeur of conception this performance is unsurpassed, though it is lacking in some places in details. Horenstein's first movement is a really moving experience – and, I might add, one of the most erotic things I have ever heard in music. This movement can be not merely sensual (a word often delicately used to describe Mozart's music and the like), but plain erotic, even orgasmic if you are lucky (for example, bar 493 to the end). Don't dismiss this claim too lightly – if people will speak of the great music capturing the mind, the imagination and the emotions, I can't see how the erotic can be excluded.

Of the other symphonies, the ones that stand out are the First, Second, parts of the Third, and the Fifth. The last movement of the First is a truly great performance. The Fifth is not ideal, but then I'm still waiting to hear a really first rate Fifth on record. Josefowitz should have been shot for leaving out the first repeat of the first movement – I don't care what timing problems were involved, and I don't think there were any, that repeat is absolutely essential. The remaining symphonies are by no means bad, and in fact all have a delightful directness about them, but they are spoilt by bad surfaces. Balance is the problem for the majority of the choral movement of the Ninth, where the engineers patently didn't know what to do with the choir. Consequently it sounds like only a few voices are singing in some patches, notably the first entry of the choir on the word "Freude!" where they sound about as interested as if they had been singing "Omo".

I have done more criticizing than I meant to – my general impression of the set was favourable, largely I think because of the marvellous directness the performances impart, an almost forgotten quality which was still present in 1959 it seems. There's a lot to be said for collecting historical recordings.

Packaging here is rudimentary; details of movements, timings and performers are printed on the bottom of the box, but there are no notes provided. I must say that in these days of world-wide paper shortages I don't see this as a disadvantage to the set in any way, considering the popularity of the works and the ready access of public libraries as well. More serious is the fact that the lid is not hinged but removes completely and very easily. If you are used to the normal sort of record box you may find this one very easy to drop. There are no interior plastic sleeves provided, either, only paper covers, and one or two of the records in my set were plain filthy. There's no excuse for this – what's the point in sealing the whole box in plastic if most of the dirt is inside?

All the same, if you are not very fussy about the quality of sound but prefer a cheap set which is ingratiating and quite often exciting to listen to, you should consider this one. Either that, or contemplate a more expensive set which may be up to twice the price, or wait to see what the rest of this year brings, or investigate single records. Just to make your task easier – I counted all of 204 Beethoven symphonies in the British catalogue – I couldn't face the American one. T.R.B.

BEETHOVEN: Symphonies 1-9, Overtures (*Prometheus, Coriolan, Egmont*). Gwyneth Jones (soprano), Tatiana Troyanos (alto), Jess Thomas (Tenor), Karl Ridderbusch (bass); Vienna State Opera Chorus; Berlin Philharmonic Orchestra/Karl Boehm. DGG Anniversary Edition 2720-045 (9 – record set with notes) $42.40.

I'm reviewing this set rather late in the piece, but it seems an appropriate time as a new shipment of them arrived not very long ago, along with the last of the other sets in the Anniversary Edition. If you buy any of these recent sets (including a recent import of the Beethoven) you will find along with the notes an immense catalogue of selected DGG issues. Every page contains a full-colour reproduction of a painting, whether of a composer or just general interest; my social conscience tells me I should deplore such rank extravagence in these days of world-wide paper and other resource shortages, but the production is so fine that I can reconcile my objections by regarding it as an art book instead of a catalogue.

As you would expect, Boehm has produced a fine set of performances, the way one can some of the Toscanini or Walter performances, because they are just too mannered. Not everywhere, but in obtrusive places where the direct approach (as often happens) is the best one. There is a difference between shedding new light on what a composer may have meant, and diverging from a customary way of playing something so that the listener is impressed by the conductor's (rather than the composer's) originality. Superimposed interpretation is obscurantism, not edification.

Nevertheless, there are some very fine moments in these recordings. The best of them are probably numbers Four, Six, most of Seven and the last half of the Ninth. Numbers One, Two, Three, Five and Eight are by no means bad, of course, but they don't stand out as the others do. It is the Ninth which will make or break a set like this; the present Ninth doesn't really do either. I don't think that this symphony can ever be performed as it should be, and then the last movement is such a let-down. Choral music was never Beethoven's strong point – he should never have listened to his friends when they tried to convince him to write a choral finale instead of the fugue he intended. Beethoven could write spectacular (if not particularly academic) fugues in almost any medium (for example, the *Great Fugue* String Quartet Op. 130, the final movement of the Piano Sonata Op. 110, and the final section of the *Credo* in the *Missa Solemnis*. "Et vitam venturi . . . ") – imagine a massive orchestral fugue at the end of the Ninth! For that reason I think that the last movement as it now is, is the least important of the four, and yet it is amazing just how many conductors concentrate on the choral finale as the central or most impressive movement. Boehm seems to me to be one of these, Solti another (Decca Silver Jubilee recording; 6BB. 121/2, two records $6.50) – his first movement strikes me as very laboured, and yet the first movement is at least the most revolutionary of them. In these days of the super-sound it seems that so many conductors of the Ninth strive to produce ever more precise, ever bigger and better final movements – thus getting things all out of proportion, it seems to me.

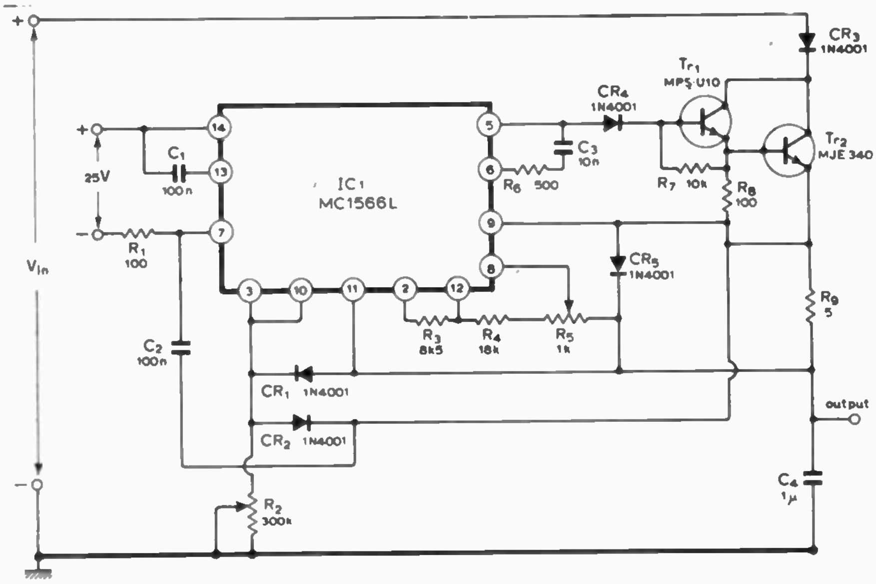
So it is with Boehm's Ninth. The first movement is unexceptionable but unexciting, and similarly with the second movement (but when will recording engineers recognize that kettledrums are kettledrums and not cannons?). The third movement is one of the better ones I have heard, but it is the last movement that is the real showpiece. Quite apart from the precision and balance of the orchestral parts, the choral and solo parts are quite the best I have heard on record. Ridderbusch's "O Freunde! Nicht diese Toene" should curdle the most sluggish blood, and the first cries of "Freude!" by both Ridderbusch and the choir have a true ring of joy in them.

Sound quality is excellent, quite distortion-free, but not as full-blooded as it could have been. Some of the best sound is given to the fill-up overtures (the playing here is marvellous). It's a pity there aren't more overtures, as there is certainly room for more – maybe a *Leonora* or two? Perhaps the wind could have been more forwardly placed, especially in the *Pastoral*, but the balance is generally well-arranged.

This is an excellent choice if money is no object and you want a complete set as well. There are plenty of cheaper sets available and shortly to arrive, and there even more cheap and good single versions around; if you already have a few, I wouldn't recommend this set (as I would the Beethoven Piano Sonata cycle with Arrau, Philips 6747-009, 13-record set $32.50, to those with a few sonatas already) – I suppose I should say that it is a very well-produced and thoroughly unexceptionable, safe version with some very fine moments. T.R.B. ●

TECH-TIPS

HIGH VOLTAGE CONSTANT CURRENT SUPPLY



WHEN a constant current source is required and the various advantages offered by the use of IC's are to be exploited, an input voltage limit of 40 or, possibly, 50 V is normally necessary if the IC's are not to be damaged.

Neil Wellenstein, an applications engineer working in Motorola's Phoenix, Arizona, laboratories, discovered a means of obtaining a variable constant current supply with input voltages as high as 750 V using a standard regulator IC. In fact, the input voltage is limited only by the breakdown voltage of the series pass transistors employed.

The IC used by Wellenstein was the Motorola MC1566L which has the ability to "float" on its own output voltage. However, when used conventionally, a voltage sensitive error occurs in the constant current mode and this is large enough to prevent the device from being used as a precision constant current source. Normally the constant current feature of the MC1566L would only be used to provide short circuit protection when the device is employed as a voltage regulator. The magnitude of the current error is small enough to be of no consequence in this application.

The MC1566 contains a current sensing and a voltage sensing amplifier which "float" on the output voltage and which are supplied from an on-chip regulator. The on-chip regulator receives its input from an auxiliary 25 V supply external to the chip.

When used conventionally a constant 1 mA flows from pin 3 through a resistor to ground to establish the reference voltage for the voltage sensing amplifier. The error voltage appears between pins 8 and 9. When the device goes into the current limit mode (short circuit conditions) part of the 1 mA output from pin 6 can flow through a diode to pin 9 thereby upsetting the error voltage and producing a voltage sensitive output current error.

Wellenstein discovered by reversing the roles of the voltage and the current sensitive amplifiers, he could eliminate this problem altogether. The net effect is that any portion of the reference current that appears in the load must pass through the current sensing resistor (R9) which cannot be bypassed as was previously the case.

The maximum input voltage to the circuit is limited by the series-pass transistor. In the case of the MJE340 shown, the maximum input voltage is 300 V. The circuit provides a constant current output which is adjustable from 200 µA to 100 mA; above 10 mA take care not to exceed the ratings of the MJE340. At both the 200 µA and the 1 mA settings, output impedance exceeds 20 M ohms.

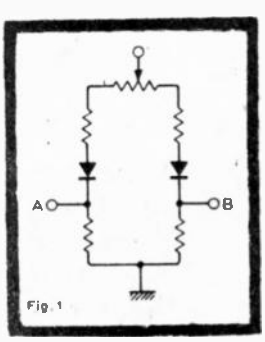
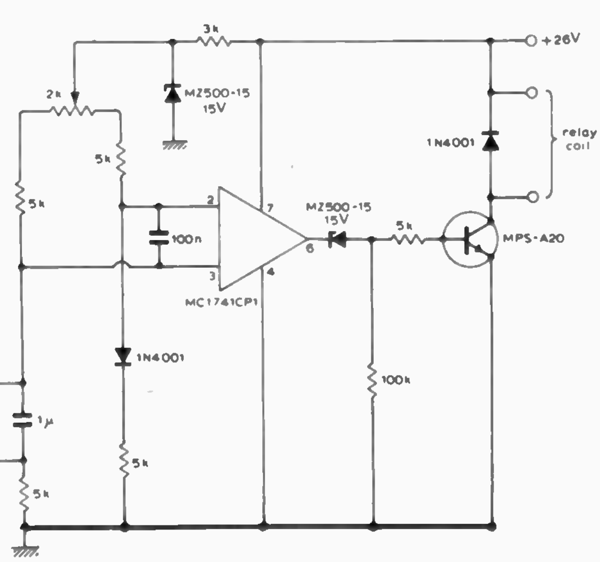


Fig. 1



(Fig. 2).

DIFFERENTIAL TEMPERATURE CONTROL

THERE are many occasions when it is necessary to detect a difference in temperature between one point and another and to take some action should the temperature differential rise beyond some pre-set level. An application that immediately springs, to mind is the control of cooling fans in equipment cabinets in response to the difference between the internal temperature of the cabinet and ambient.

Here is a simple, inexpensive circuit for just this purpose, which has a resolution of about 0.15°C and a differential range of 5.5°C.

Temperature measurement is performed by general purpose silicon diodes (1N4001) which have a temperature coefficient of about 2 mV/^{o}C over a very wide temperature range. When two of the diodes are connected in the bridge configuration shown in Fig. 1, a voltage appears between terminals A and B which is proportional to the temperature difference between the two diodes. The potentiometer provides a variable offset current giving a temperature offset range of about ± 5.5^{o}C.

The bridge output of 2 mV/^{o}C temperature differential must be amplified before it can perform a power switching function. A standard low cost operational amplifier was chosen for this purpose (see Fig. 2), used open-loop to provide a gain of some 100 000 times. A temperature differential of 0.15^{o}C will therefore cause the output of the amplifier to swing almost the whole power supply voltage of 26 V.

The output current capability of the op/amp (5 to 10 mA) is insufficient to drive most power relays, so a buffer transistor is included in the circuit for this purpose. A zener diode provides the necessary level shifting between the output of the op-amp and the input of the buffer. ●

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7406	.39	7460	.19	74155	1.19
7407	.39	7464	.39	74156	1.29
7408	.25	7465	.39	74157	1.29
7409	.25	7472	.36	74161	1.39
7410	.19	7473	.43	74163	1.59
7411	.29	7474	.43	74164	1.89
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7415	.39	7476	.47	74166	1.65
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