THE PROPAGATOR

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MEETINGS ARE HELD ON THE SECOND TUESDAY OF EACH MONTH (EXCEPT JANUARY) AT 7.30 P.M. AT THE STATE EMERGENCY SERVICES BUILDING, MONTAGUE STREET, NORTH WOLLONGONG. VISITORS ARE WELCOME TO ATTEND MEETINGS.

LAST MONTH'S MEETING: This was held at 7.30 p.m. on August 15th in the State Emergency Services building, and about 50 members attended. In the absence of President Dave VK2DFL, Vice President Keith VK2OB officiated.

In General Business, Denis VK2DMR told the meeting that the S.E.S. have four M 100 teleprinters and ask for volunteers to get them up and running.

Paul VK2ZQT demonstrated the problems experienced with the wind generator blades of Channel 5 repeater at Mount Murray. It appears that hairline cracks are developing at the end of the metal inserts, allowing moisure to enter causing rust. The blades have then disintegrated. After repairs to the blades and motor, Paul with the help of Ian, Dave and Peter got the generator back in commission.

Lyle VK2ALU told us of the Channel 5A Yagis that VK5ZR has for sale, which are easily modified for 2 metres.

Denis VK2DMR then auctioned a UHF Dummy Load (5.5GHz), some rolls of carbon copy teleprinter paper, and a Kenwood TS 120V transceiver for which there were no offers.

This was followed by a talk on Amateur Fast Scan Television, which can be received at 7.30 each Wednesday evening in Sydney, Channel 34 UHF, under the Gladesville Amateur Radio Club callsign VK2BUN (previously under VK2DTK). John VK2XY then took over with a fascinating and at times hilarious description of the newspaper accounts (and subsequent visits from DOC) of the amateur TV transmissions. ERP is about 200 W and a 'Big Wheel' antenna design is used, which has a 9.2dB gain. We were then treated to videos which had been shown on Ch. 34 - one from AUSSAT Pty Ltd. and the other from NASA showing life aboard the space shuttle Columbia.

The evening concluded with lively discussion between members and visitors. This must be one of the most interesting and entertaining evenings that we have had. Our thanks to David VK2NH, John VK2XY, and Neil VK2ZTL for coming to our meeting.

PERSONAL NOTE: Ken VK2DOI wishes to make it known that he has run out of ideas for articles and unless he gets some suggestions to follow up, the article appearing in this Propagator is likely to be his last one. So how about it ???

NOTICE OF MEETING: The next meeting of the I.A.R.S. will be held on Tuesday, September 11th, in the S.E.S. building, Montague Street.

VIDEO SHOW. MIKE VK2DFK WILL SHOW VIDIOES FROM AUSSAT + NASA + OTHERS IF TIME PERMITS.

MINI AUCTION. BRING YOUR ODD BITS ALONG FOR AUCTION + REALISE SOME CASH. ANY BITS AROUND THE SHACK MAY BE WHAT SOMEONE ELSE NEEDS.

BIT, BYTE, BAUD.

The term 'binary' describes a way of counting. In the normal number system that we use every day, the right-most digit represents 1s, the next 10s, the next 100s, and so on. In binary, the right-most digit is 1s, but the next is 2s, the next 4s, then 8s, and so on.

In our normal system, each digit has ten possible values: 0, 1, 2, ... 8 and 9. In the binary system there are two possible values: 0 and 1. So one digit of a binary number represents the smallest possible unit of information - a choice between two possibilities. For example, the knowledge of whether a coin is heads or tails is one binary digit of information.

This term was found so useful (there is no other accepted way to measure an amount of information) that it became shortened to 'bit' (for Binary digIT). So a bit is the smallest possible unit of information. A choice between four possibilities is two bits (toss two coins, and you will get four possible outcomes).

After the term bit had been around for a while, it was realised that there was a need for a larger unit. This is the 'byte' (as a pun on 'bit'). A byte is eight bits, so a byte of information will give you 256 choices (that's two to the power of eight, for the mathematicians).

An extension of the use of the word 'bit' came in the transmission of information. The number of bits per second became the operative measurement. The measure of how many bits per second are being transmitted is the 'baud'. One baud is one bit per second. One kilobaud (as in kilometre) is one thousand bits per second.

In word processing applications, it takes seven bits to store a letter of the alphabet. This gives 128 possibilities, which may seem high until you consider that capital letters have to be catered for, as well as numbers, punctuation marks and suchlike.

Most computers are organised in terms of eight-bit units- bytes. So it's a fair approximation to say that one byte is equivalent to one character on the printed page.

The last piece of memory jargon is the 'K'. To convert the symbol for metres to that for kilometres, you add a 'k' - 'm' becomes 'km'. The 'k' means thousand. Similarly, a thousand grams is a kilogram - 'g' and 'kg'.

Now, inside the computer it is handier to multiply units by 1024 - which is two to the power ten. I won't go into the reason for this - it will become obvious to those of a mathematical bent. So one thousand and twenty four bytes become a 'Kbyte'. Simple!

Business Technology Yearbook 1983-84.

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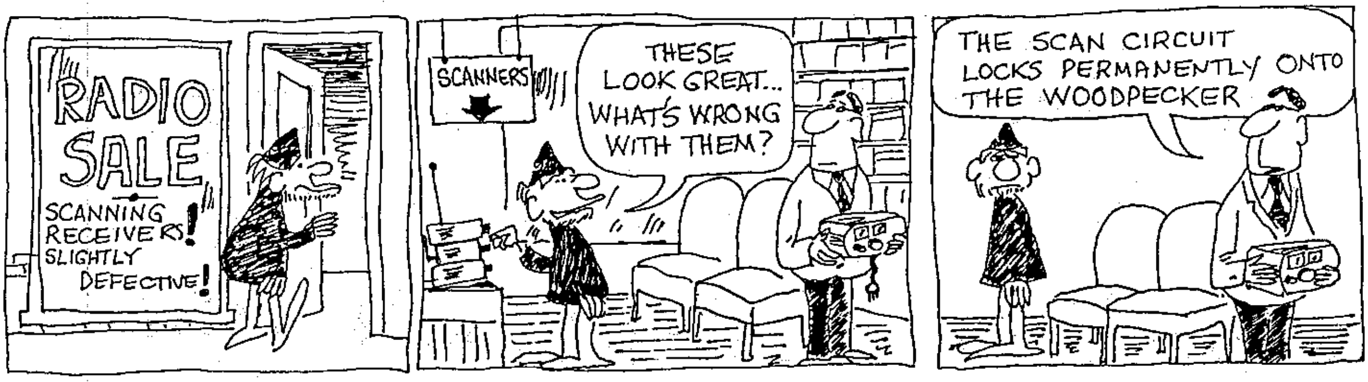

Moonbounce Report - September 1984.

The computer system to be used for tracking the movement of the dish in Hour Angle was installed by VK2KAJ and VK2ALU during last month. The computer interface unit was connected to the Hour Angle position sensing potentiometer by a multicore cable, but it was found that induced voltage in the cable affected computer operation. Replacement by shielded cable overcame the problem. The interface tracking characteristics have now to be adjusted to provide correct tracking data to the computer. It should then be possible to position the dish and to have it track the moon in Hour Angle movement without the need to first sight the moon.

A schedule of EME tests was received to cover the weekend of 18th and 19th August.and which included VK2AMW's operation with G3LTF, F2TU and HBØBM/P, which was HB9BM portable in Liechoenstein. On18/8 we had our first contact with HBØBM/P who was copied at 'M' signal strength. Unfortunately the scheduled periods for G3LTF and F2TU on 19/8 turned out to be after moonset at our end, but on 18/8 F2TU was heard calling CQ and we were able to complete our first contact with him, with '0' signal reports both ways. We had a second contact with HBØBM/P on 19/8. A sked. had also been arranged locally with ZL3AAD for this day but he was not heard.by our operators VK2's EXN and ALU.

A fault developed in the transmitter exciter after the tests on 19/8, which was subsequently found to have resulted from deterioration of the 3CX100A driver tube, which is a second hand tube donated by a sympathetic amateur in view of the high cost of new 3CX100A's. Output is now down to approx. 70 percent of normal.and its remaining life is unpredictable. It is hoped that the installation of low loss coax. between the exciter and input of the power amplifier stage will help to compensate for the drop in driver stage output. Beyond that, well if anyone happens to have a spare good quality 3CX100A tube laying around which they don't want, it would certainly find a good home in the EME exciter!!

Satellite Jottings.

The Oscar 10 satellite provides an excellent means by which Limited licencees (and others) may work DX over most days of the month.

During the past few weeks its slowly changing orbit has allowed contacts with stations in almost all the continents. Callsigns heard have included OH, UT5, JA, KL7, VE, KH6, W, P29, ZL etc., some of which have been worked. Its very nice to be able to sit down and have a long chat and not have to worry about the band 'dropping out' as the satellite stays in range for hours on end at the most favorable part of its orbit. With the right sort of antennas signals are good copy for a lot of the time and relatively low power is adequate for the 70cm. uplink. SSB and CW are the modes used by most stations but the more 'exotic' modes such as Packet communication are also advocated for the future. Anyone developing an interest in this fascinating aspect of our hobby is well advised to join AMSAT, if for no reason more than to receive their excellent publications covering equipment construction and operating advice etc. Its all part of the 'New Frontier' in Amateur Radio. Be in it.
PS. - If you would rather be in more sophisticated digital experiments then try Oscars 9 and 11 or if you have only simple gear on 2 metres and 10 metres then Oscars RS6 and RS8 could be your 'cup of tea'.

Lyle VK2ALU.

REPEATER REPORT

MT. MURRAY 6850 HAS HAD MORE THAN ITS SHARE OF TROUBLE IN THE LAST MONTH. THE WIND GENERATOR SUFFERED DAMAGE IN THE HIGH WINDS AND WAS REMOVED FROM THE SITE FOR REPAIRS. DURING THIS TIME THE REPEATER REMAINED ON THE AIR RUNNING ENTIRELY FROM THE BATTERIES. TO CONSERVE POWER THE REPEATER WAS SET TO TIME OUT AT APPROX. 20 SECONDS, THUS ALLOWING ITS USE AS A CALLING CHANNEL AND FOR SHORT QSO'S AND AT THE SAME TIME DISCOURAGING PROLONGED USE. THIS SEEMS TO WORK AS IT TOOK 2 WEEKS TO REPAIR AND RE-INSTALL THE GENERATOR AND THE REPEATER DID NOT FAIL BECAUSE OF LACK OF POWER DURING THIS PERIOD.

UNFORTUNATELY, A COUPLE OF WEEKS LATER THE GENERATOR FAILED AGAIN BECAUSE OF WIND DAMAGE, AND THIS TIME THE RECEIVING AERIAL MAST WAS BLOWN OVER DAMAGING THE RECEIVING DIPOLE. THIS PUT THE REPEATER COMPLETELY OFF THE AIR FOR A FEW DAYS. THE RECEIVE AERIAL MAST HAS BEEN RE-ERECTED AND A NEW CO-AXIAL DIPOLE MADE AND FITTED. THE REPEATER IS ON THE AIR AGAIN BUT THIS TIME RUNNING ONLY FROM THE EXCITER STAGE (5 WATTS) AND WITH THE 20 SECOND TIME-OUT.

IT WILL OPERATE IN THIS CONDITION UNTIL FURTHER NOTICE. THIS WILL GIVE US SOME TIME TO BRING THE PROBLEM TO THE NOTICE OF THE MANUFACTURER OF THE GENERATOR AND HOPEFULLY TO COME UP WITH A SOLUTION WHICH WILL PREVENT FUTURE PROBLEMS WITH BLADE BREAKAGES IN HIGH WINDS.

APOLOGIES ARE OFFERED TO THOSE WHO REGULARLY USE THIS REPEATER, AND WE SEE THE ABOVE ACTION AS THE BEST WAY TO KEEP THE REPEATER ON THE AIR EVEN AT THE EXPENSE OF CONVENIENCE OF USE. THE W.I.A. BROADCASTS WILL BE RELAYED AS USUAL ON SUNDAYS PROVIDED THAT THERE IS ADEQUATE CHARGE IN THE BATTERIES.

THANKS GO TO THOSE WHO HELPED OUT IN DIFFICULT CONDITIONS AT MT. MURRAY WHEN HELP WAS NEEDED.

NO PROBLEMS HAVE BEEN EXPERIENCED WITH THE OTHER REPEATERS, EVEN THOUGH THE AERIAL INSTALLATIONS ARE NOT NEARLY AS STURDY AS THE ONE AT MT. MURRAY. IT JUST GOES TO SHOW THE HARSHNESS OF WEATHER CONDITIONS THAT CAN EXIST AT THAT SITE.

WE HAVE OBTAINED THE REMAINDER OF THE MATERIAL NEEDED FOR THE CONSTRUCTION OF THE DUPLEXER CAVITIES FOR ONE 2 METRE REPEATER. CONSTRUCTION OF THE REMAINING CAVITIES WILL COMMENCE SOON.

WE HAD NO RESPONSE FROM THE APPEAL LAST MONTH FOR BNC PLUGS AND SOCKETS. TO PURCHASE THEM WOULD BE WELL BEYOND OUR MEANS AT THE MOMENT, SO IF YOU HAVE ONLY ONE OR TWO TO SPARE THAT YOU COULD DONATE THAT WOULD BE A HELP.

GRAEME VK2CAG

CHEAP GLASS RTTY

I RECENTLY ADDED A COMPUTER AND VDU TO MY EXISTING 'STEAM RTTY' STATION SETUP FOR LESS THAN $120. THIS HAS GOT TO BE ABOUT QUARTER OF THE COST OF MOST 'GLASS RTTY' SETUPS.

I USE A 'DICK SMITH' VZ200 COMPUTER AND AN OLD BLACK AND WHITE TV SET AND AN ORDINARY PORTABLE CASSETTE RECORDER. THE RTTY PROGRAM AND INTERFACING DETAILS ARE AVAILABLE FOR THE COST OF A BLANK CASSETTE PLUS RETURN POSTAGE PLUS $15.

THE VZ200 IS ON SPECIAL FOR $99 FROM DICK SMITH STORES. NO MEMORY EXPANSION OR PRINTER INTERFACE IS NECESSARY FOR THIS PROGRAM TO WORK. IF YOU ALREADY HAVE A TELEPRINTER IT CAN EASILY BE CONNECTED UP TO PROVIDE HARD COPY WHEN NEEDED. YOU CAN USE THE PROPER PRINTER INTERFACE AND PRINTER WITH THE VZ200 BUT OF COURSE THAT COSTS EXTRA MONEY.

THE RTTY PROGRAM PROVIDES 'SPLIT SCREEN' OPERATION WITH A 1000 CHARACTER TRANSMIT BUFFER AS WELL AS 9 SEPARATE MESSAGE MEMORIES. THE MESSAGES YOU STORE IN THOSE MEMORIES ARE SAVED ON CASSETTE TAPE ALONG WITH THE PROGRAM. THE SPEED IS VARIABLE BY KEYBOARD COMMAND FROM 45 TO 99 BAUD AS IS THE LINE LENGTH FROM 10 TO 99 CHARACTERS. INCOMING SIGNALS ARE DISPLAYED ON THE TOP OF THE SCREEN AND THE MESSAGE TO BE SENT IS AT THE BOTTOM, WITH A 'STATUS LINE' BELOW THAT GIVING THE SPEED INFORMATION AND MODE SELECTED.

THE PROGRAM IS SUPPLIED ON YOUR CASSETTE (RECORDED 3 TIMES) ALONG WITH 10 PAGES OF INSTRUCTIONS AND INTERFACING INFO, CIRCUIT DIAGRAMS AND SUGGESTED CIRCUIT FOR A COMPLETE RTTY MODEM USING THE XR SERIES CHIPS. T

THE PROGRAM IS WRITTEN BY ROSS ZL1BNV AND IS BEING HANDLED IN AUSTRALIA BY CLIVE VK3BUS, WHO TAKES NO COMMISSION FOR THE SERVICE.

THERE IS ALSO A MORSE PROGRAM AVAILABLE WITH SIMILAR CHARACTERISTICS TO THE RTTY ONE AND IS EASIER STILL TO INTERFACE.

FOR PROGRAMS AND INFORMATION SEND THE FOLLOWING TO

CLIVE HARMAN,
P.O. BOX 41
MACEDON,
VIC, 3440.

1/. ASTAMPED SELF-ADDRESSED JIFFY BAG (MEDIUM SIZE)
(I PUT $1.60 WORTH OF STAMPS ON IT AND RECEIVED THE REPLY IN ONE WEEK BY AIR MAIL)
2/. A BLANK CASSETTE, PREFFERABLY A C10 DATA CASSETTE OR GOOD QUALITY AUDIO CASSETTE. (EACH PROGRAM RUNS FOR LESS THAN A MINUTE).
3/. A CHEQUE MADE OUT TO EITHER CLIVE HARMAN OR ROSS KEATINGE
FOR $10 FOR RTTY ONLY OR
$15 FOR BOTH RTTY AND MORSE.

A WORD OF WARNING..... TROUBLE WILL BE EXPERIENCED WITH LOADING AND SAVING THE PROGRAM UNLESS A GOOD QUALITY CASSETTE AND RECORDER ARE USED. THE VZ200 IS FAIRLY TOUCHY REGARDING LEVEL SETTING ON PLAYBACK. SINCE I USE MY VZ200 ALMOST EXCLUSIVELY FOR RTTY I NEVER SWITCH IT OFF, AND SO I DONT HAVE TO RE-LOAD THE PROGRAM EACH TIME I GO ON AIR ON RTTY.

GRAEME VK2CAG

IT's PART OF AUSTRALIA's HISTORY

Unless they've been overseas, the majority of Australian probably take the ordinary 3-pin electricity mains plug and socket for granted. But anyone who has encountered the various non-interchangeable types of 2 and 3-pin plugs and sockets in use in Europe, the USA and the UK will be aware of Australia's good fortune in having a standard design throughout the country.

Shortly after the war, in about 1949, the UK adopted a 13A parallel 3 flat pin design which incorporates a fuse in the plug, but Australia had adopted its standard long before this. Tracing its history however, was more difficult than I had expected and involved me in some correspondence.

My first letter, to the Energy Authority of New South Wales, produced the information that "existing Authority records do not include the history of the origin of the standard three pin, flat pin plug and plug socket. Plug and plug sockets used in this country are required to comply with the requirements of Australian Standard 3112-1981 'Approval and Test Specification for Plugs and Plug Sockets' as published by the Standards Association of Australia. This standard was first published in 1937 as ASC112 and the Standards Association of Australia may have a copy of the original issue plus each subsequent revised edition in its library at Standards House, 80 Arthur Street, North Sydney, 2060.

A measure of control over the sale of certain "prescribed" and "proclaimed" electrical articles and fittings, including plugs and plug sockets, has been exercised in New South Wales since 1983. The initial scheme in 1938 operated under the provisions of the Local Govertment Act, 1919 and the present scheme operates under the provisions of the Electricity Development Act, 1945.

Plugs and plug sockets are "prescribed articles" pursuant to the Electricity Development Act, 1945 and as such, may not be sold, hired or exposed or advertised for sale or hire unless they have been approved by the Authority or the approving authority in another State and are marked with the allotted approvals marking. Similar legislation applies in each Australian State and Territory.

The approval marking takes the form of a letter identifying the State of origin approval eg. "N" for NSW, "V" for Victoria, "Q" for Queensland, etc. followed by a number (allotted by the approving authority) identifying the person or company to whom the approval has been granted.

The Standards Association of Australia told me that the background information on the origin of the three-pin, flat pin plug and plug socket was rather sketchy due to the time elapsed since its initial adoption. However, they supplied the following:

"a) The majority of the work would appear to have been carried out in Victoria by SECV with the help of Australian manufacturers.

b) The design is virtually identical to a pre-existing American configuration except that the pins are 2mm to 3mm longer.

c) The configuration was first published as an Australian standard in 1937 as ASC112. The current edition of this standard is AS3112-1981.

d) The current standard also covers 15 amp and 20 amp 3-pin flat pin configurations. Again, Australia is in a fortunate position as the system was designed so that any plug will fit a plug socket with the same or a higher current rating but not the reverse.

e) This system is also used in New Zealand, Fiji and New Guinea and to some extent in Argentina. "

The State Electricity Commission of Victoria was rather tardy in replying to my letter, but a follow-up 'phone call produced the following:

> "Archival records and minutes of meetings dating back to 1927 have been reviewed as staff have had an opportunity to do so, and, although some references were noted of comments on the three-pin flat pin plug system, there are no specific comments on the origin of same.
>
> Inquiries have been made of former Electrical Approvals Board members and other long serving personnel but to date no specific information has been unearthed. At the present time we are following two lines of inquiry with retired personnel, but as one has been on extended holidays we have not been able to get in contact with him."

The SECV also made the suggestion that "one possible line of inquiry which may be fruitful may be Mr K Gerard of Gerard Industries (Clipsal) in South Australia as that firm has manufactured three-pin plugs and sockets for many years, possibly over 50 years."

And here I struck gold! Mr Gerard was prompt in his reply and I cannot do better than quote directly from his letter to me:

> "Prior to World War 1 and during 1914-18, various plugs and sockets were imported from England and used in Australia.
>
> During the early 1920's it was difficult to import English plugs because of the shortage in production and at the same time it was noticed that a various assortment of plugs was being used in Australia and these plugs had round pins.
>
> Some American plugs, sockets and cord extension sockets were imported and these were of the flat pin type, ie. 2 pin flat pin plug with the pins parallel and the 3 pin flat pin plug which had the configuration of the present 3 pin plug. Late in the 1920's Ring Grip Ltd. of Victoria and Gerard Industries Pty Ltd. (Clipsal) made 3 pin accessories to interchange with the US designs.
>
> As Australia was committed to the "Earthing" system of supply, it was realised that a 3 pin plug was required.

About 1934 a meeting was called by the SECV who was the leading supply authority in those days, at which a representative of the SECV Standards Association Representative, Mr Tivey from General Electric, Mr Fred Sook from Ring Grip, and Mr Geoff Gerard (my brother) from Clipsal were present.

General Electric were importing their own 3 pin plug etc. from the USA at the time.

The meeting after reviewing all the plugs (English and American) being imported into Australia, decided to adopt the American 3 pin flat pin plug as an Australian Standard. The manufacturers Representatives considered flat pins were easier to make and their installation machines at the time, were capable of making flat pins better than round pins.

In adopting the USA configuration the pins of the Australian design were shortened by 3mm in length because of better safety standards against "wrongful" insertion into sockets that were then produced and also to lessen the probability of personal contact with the pins when inserting plug into socket.

A standard plug gauge was suggested, being similar to the one used by Clipsal in their plant and this was submitted to the Standards Association and was finally published in a Standard Specification ASC112 for plugs and sockets in 1937. This was adopted by all States Supply Authorities and hence this 3 pin plug manufactured in Australia by Ring Grip and Clipsal became an Australian Standard.

The design of 3 pin plugs have had a number of changes over the years since then, but the configuration of the pins has remained the same. People who travel to USA, UK, and Europe realise how fortunate we are to have a standard plug and socket throughout Australia. The 3 pin plug is standard in New Zealand, Fiji, New Guinea and a number of islands in the Pacific area."

Acknowledgements: I am indebted to all thos who went to considerable trouble researching on my behalf, to supply me with the information I have used in the preparation of this article.

Ken VK2DOI

Did you know?

Some puzzles in radio engineering fundamentals

by Epsilon

THE ART of radio engineering is now well into its second half-century; many of the fundamentals, probably once well understood, are perhaps too easily accepted today and seldom explained adequately in basic engineering courses. Take, for example, a capacitor. Readers will know that there are quite fundamental laws which describe its behaviour. These are the laws of charge and energy, and they are often used to solve certain problems in much the same manner as momentum and kinetic energy are used in mechanics.

A typical problem is shown in Fig. 1.

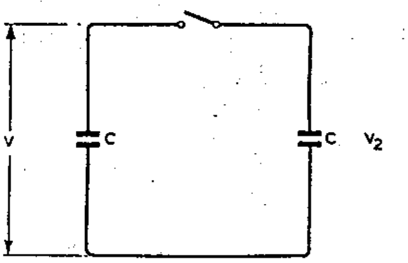

Fig. 1. *What is the voltage on the right-hand capacitor after the switch is closed?*

Here a capacitor of capacitance C is charged to a voltage V. At a particular time, the first capacitor is connected to a second capacitor, also of value C, but containing no charge. By the law of charge conservation, the charge before and after the connection is the same, and is given by

$$Q = CV = 2CV_2$$

and therefore the voltage V_2 is equal to $V/2$. But by the law of energy conservation,

$$E = CV^2/2 = (2C)V_2^2$$

and the voltage V_2 is equal to $V/\sqrt{2}$.

Now since capacitors are essentially lossless, energy cannot vanish without trace, and so the second answer should be the correct one. But this would imply that charge had increased by a factor of $\sqrt{2}$, thus violating the law of conservation of charge. The problem becomes really ridiculous if one capacitor is charged to $+V$, the other to $-V$. The net charge is then zero, and the use of one method would predict a final voltage of zero, the other a finite voltage of indeterminate sign.

Unfortunately, *both* conservation laws happen to be cornerstones of electrical engineering theory and are not to be discarded lightly. Some means must be found to reconcile the two laws, but how? No doubt readers will reassure themselves at this point by claiming that all real capacitors have resistance, and that the losses associated with this account for the discrepancies between application of the two laws.* A natural reply is to make the capacitors operate at superconducting temperatures and to reconsider the problem. Another ingenious way out might be to note that it is very difficult to discharge a capacitor without forming an arc (and hence getting rid of excess energy). Unfortunately for this suggestion, semiconductor technology does enable an arcless contact to be made, and so this explanation is at best a weak one. Accepting that simple measurements with a voltmeter show that the charge is conserved, what is the explanation of the apparent disappearance of the energy?

A second example, representing such an everyday feature of electronic equipment that its correct operation is taken for granted, is shown in principle in Fig. 2. A coaxial cable takes an r.f. signal from one part of a system to another. The system has a metallic ground plane which can be considered as being infinite in extent. Standard practice dictates that the outer braid of the coaxial cable is connected to the ground plane at both ends. An interesting question now emerges: what path does the return current from the load take? One answer (which is certainly true at d.c.), is that it takes the path of least resistance, or rather, it shares itself between the outer braid of the coaxial cable and the ground plane in the ratio of conductances. At a.c., the impedance between two points on a ground plane is effectively zero, whereas between the two ends of the outer conductor of a coaxial cable it is roughly

$$X = 0.21 f \log_e(2l/D)$$

where l is the length in metres, D is the braid radius, and f is the frequency in MHz. Clearly the impedance increases with length and frequency, and therefore most, if not all, of the return current does not flow in the outer conductor at all, but in the ground plane. Of course, this situation does not happen; if it did, the outer conductor would be redundant, the cable would be unscreened, and the concept of characteristic impedance would be quite meaningless. Obviously, no matter what the cable length or the frequency, *none* (well, almost none) of the current flows in the ground plane. Why?

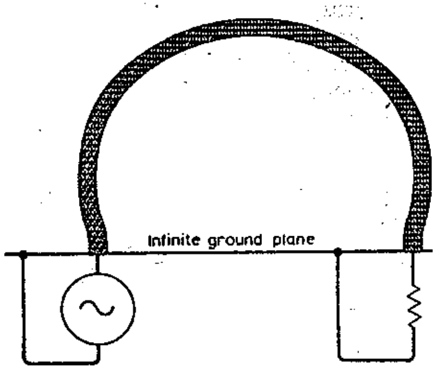

Fig. 2. *Does the return current from the load flow in the ground plane or the outer braid of the cable?*

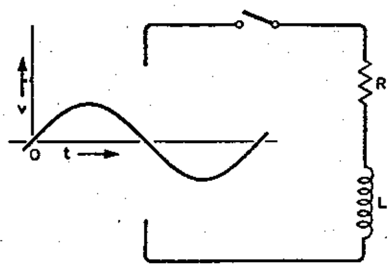

Fig. 3. *The switch is closed at t = 0. What is the current in the inductance?*

A third example is not so much one of fundamental principle as one of observed fact. It concerns switch-on surges in transformers. If a transformer (the larger the better) is connected directly to a mains supply, a distinctive hum is often heard which decays away over a period of tens of cycles. If the transformer is large enough it may blow a quite substantial fuse. Why? Those who have experienced the effect will mutter "switching-on surge," but that is a description of the problem and not a quantifiable explanation of its cause. A related problem, which will help to obtain the answer, concerns the circuit shown in Fig. 3. Assuming that the switch is closed when the applied sine wave is at zero and, for the present, that the resistance is zero, is the current in

*It so happens that this statement is exactly true for any finite value of resistance.

the inductance sinusoidal and does it have an average d.c. value of zero?

Before continuing to two more problems less related to real life, let us examine the answers to the questions already presented. The first example is an interesting one, if only because it is so fundamental. As a first step it can be noted that all capacitors must have physical size; *it is simply not possible to make a finite capacitance of infinitely small dimensions;* secondly, whenever a capacitor is discharged the current must flow through a finite distance, and thirdly, current flowing through a distance generates a magnetic field, which in practical terms means that every capacitor possesses a small inductance.

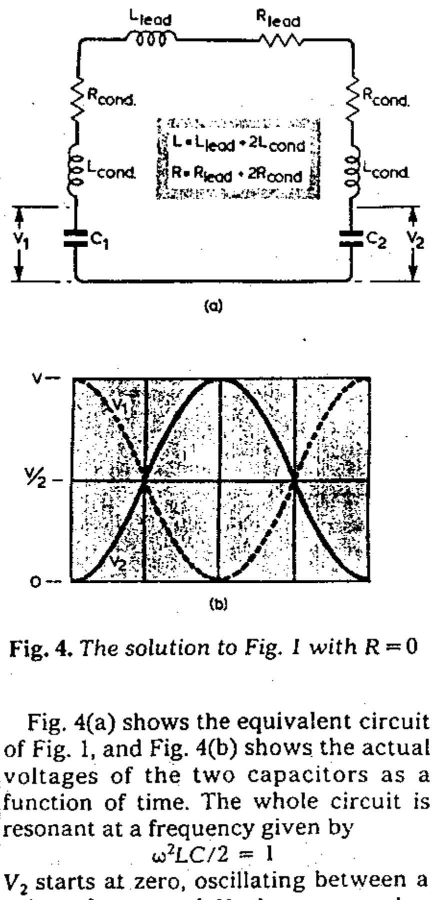

Fig. 4. *The solution to Fig. 1 with R = 0*

Fig. 4(a) shows the equivalent circuit of Fig. 1, and Fig. 4(b) shows the actual voltages of the two capacitors as a function of time. The whole circuit is resonant at a frequency given by

$$\omega^2 LC/2 = 1$$

V_2 starts at zero, oscillating between a value of zero and V, the mean value being $V/2$. V_1 has the same sinusoidal form as V_2 but starts at V and decreases down to zero. Both charge and energy can now be accounted for. The total charge in the two capacitors remains constant at $Q = CV$, thus satisfying the requirement of conservation of charge, but the charge in each separate capacitor oscillates from one to the other about the mean.

The energy flow is more complicated, there being a continual transference between capacitive and inductive storage. Thus, beginning at time $t = 0$ in Fig. 4(b) capacitor C_2 starts with zero voltage and zero energy. C_1 starts at V. One quarter-cycle later both capacitors have the same voltage $V/2$, and there is zero voltage across the inductance. Since the current in an inductance lags the voltage by a phase angle of 90°, the former is now at a maximum and it will be found that exactly one half the energy resides in the inductance. This accounts for the "missing" energy. One half a cycle later the voltage across C_2 is a maximum and equal to V, and that across C_1 is zero; all the energy has now been removed from the inductance and resides in C_2. The reader can follow the remainder of the cycle.

No matter how small the lead inductance, the oscillation just described is always present, and, taken with the steady voltage, it fully accounts for both the original charge and the energy. The reason that an erroneous result can be obtained, in this case by neglecting inductance, is because the laws of conservation do not tell us *how* charge or energy may be stored, only that they cannot disappear.

The explanation may now be developed a little further, to begin with by allowing a small series resistance to be present as shown in Fig. 4(a). The oscillation, instead of persisting indefinitely as before, now decays exponentially (the multiplying factor is actually $\exp(-Rt/2L)$) and leaves a steady state voltage of $V/2$ on both capacitors. This is, of course, the voltage measured by a d.c. meter. Taking a further step, just as a capacitor possesses inductance, so it also possesses radiating properties, and there will in general be an apparent resistive loss because of this. Taking a third step, capacitance, inductance and radiation resistance are not lumped circuit elements but are distributed, and so even the reasoning given above is at best an approximation.

The explanation of the screening properties of the coaxial cable concerns the self and mutual inductance of the two conductors of which it is comprised. Fig. 5 shows a longitudinal cross section of the cable, large letters being used for the outer conductor and small letters for the inner.

A current i flowing upwards in the inner conductor sets up a magnetic field whose lines of force go around it. As a simplification we shall assume that the conductor is straight and long, and then these force lines have a magnetic field strength of

$h = i/2\pi x$ ampere turns per metre

where x is the distance from the centre of the conductor (but note that this expression is not applicable when x is less than d). A current I flowing downwards in the outer conductor also causes a magnetic field strength, this time given by

$$H = -I/2\pi x,$$

where x is measured from the centre of the hollow tube which forms the outer conductor and I is distributed uniformly around the periphery. Inside the tube the field due to I is everywhere zero.

The magnetic fields cause back voltages to be generated in each conductor whenever they change with time. The current I causes a large back voltage to appear in the outer conductor (the self inductance term) but this is cancelled by the back voltage caused by the current in the inner conductor (the mutual inductance term). Now it so happens that the magnetic field *inside* the outer conductor does not have any effect, and the total back voltage is thus proportional to $(h-H)$ or $(i-I)/2\pi x$. If $i = I$, all external magnetic fields are exactly equal to zero (in other words, the cable is properly screened) and the back voltage is also zero. Each end of the cable is at exactly the same potential and no current flows in the earth plane; if it did, a potential in the correct sense to cancel it would appear along the cable. We can all breathe a sigh of relief at the result, because otherwise r.f. engineering would be impossible. However, at low frequencies, particularly audio, cable resistance starts to become important and screening against magnetic pick-up is not at all so easy.

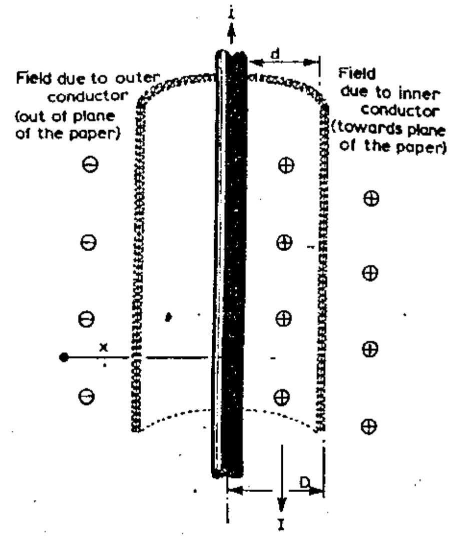

Fig. 5. *Fields due to the inner and outer conductors of a coaxial cable go around the cable. The left and right sides show the field separately.*

The full explanation for the third example can only be found satisfactorily by recourse to differential equations. Before giving the solution, it is as well to recall that the properties associated with inductance are expressed solely in terms of the back voltage developed when a current experiences a rate of change. Specifically:

$$V = L \times \text{no. of amperes changed per second}$$

It is important to realize that the voltage V is not a function of any constant current, which could be infinite without altering V in any way. With this in mind, the full solution for the current in Fig. 3 becomes understandable. It is

$$I = (E/Z)\sin(\omega t - \phi) + (E/Z/\exp(Rt/L)\sin\phi$$

$$\text{where } \tan\phi = \omega L/R \text{ and } Z = \sqrt{R^2 + (\omega L)^2}.$$

The solution will be seen to consist of two terms, the first being the one generally used in a.c. impedance calcu-

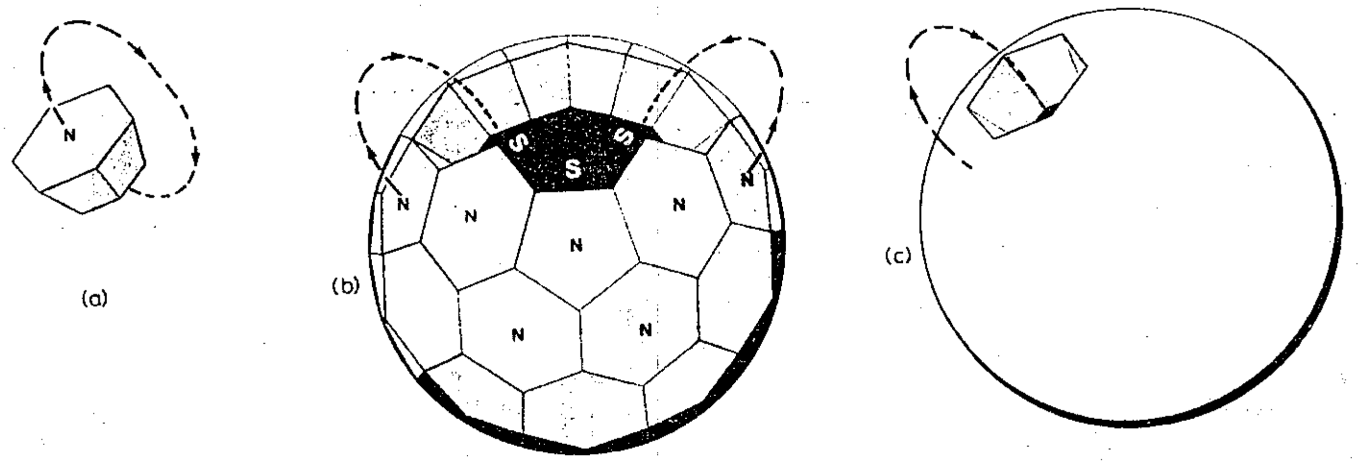

Fig. 6. *What is the external magnetic field when the last plug (a) is placed into the hole in the hollow sphere (c)?*

lations, the second being a transient term which is d.c. with an exponentional decay.

The solution for the case when R is zero is given by:

$$I = -(E/Z)\cos\omega t + (E/Z)$$

and there is thus a standing d.c. term equal in magnitude to the peak alternating current. The total current starts at zero and builds up to twice the value normally expected, but it never reverses in sign. There is a constant direct current circulating on a nominally a.c. supply and this persists indefinitely. In real life, resistance is always present and the d.c. term decays to zero; the lower the resistance, the lower the rate of decay. Knowing this, an explanation of why a switch-on occurs can now be given.

When a transformer is connected to the mains supply, a circulating direct current is set up as just described. If the switch-on occurs at or near the zero voltage point of the a.c. cycle, the d.c. is at a maximum, and the total current runs up to nearly twice the normal value given by $I = E/\omega L$. Twice the normal magnetization current is often more than sufficient to run the iron core of the transformer into saturation, and the laminations start to protest loudly. With the transformer iron saturated, the instantaneous value of L is grossly reduced and so the magnetizing current must increase to generate a back voltage which is equal to the mains supply. The effect persists until the direct current dies away or until the fuse blows.

After these questions and answers on rather everyday topics, here are two problems of a more thought-provoking nature.

A small bar magnet is launched into outer space, where it can be assumed to be free of any external influences. The magnet is set spinning about an axis which passes through its middle and is perpendicular to the line joining the two poles. What happens to the rotational speed of the magnet with the passage of time? No mechanical forces on the magnet (such as air resistance) need be considered.

Our second problem is also concerned with permanent magnets. Fig. 6 (a) shows a magnet made in the form of a six sided tapered plug. The lines of force of this magnet run from north to south (by convention). A number of these plugs† can be assembled as in Fig. 6 (b), and the result will be part of a hollow sphere. Lines of force will emanate from the outside of the sphere and will enter the inside as shown in Fig. 6 (b). The assembly of the sphere can continue until the situation in Fig. 6 (c) is reached, at which point lines emanating from the outer surface still return via the single hole to the south pole of the inner surface. A compass needle passed anywhere near the outer surface would record that it behaved as a magnetic north pole except near to the hole. The final plug is now inserted into the hole. What is the external magnetic field of the sphere at large, intermediate, and zero distances from the surface?

On a superficial level the two answers happen to be rather obvious: the spinning bar magnet slows down and the magnetic field outside the sphere is everywhere zero. The more quantitative explanations are as follows.

The spinning magnet generates an alternating magnetic field that gives rise to an electromagnetic effect and hence to radio waves. The power associated with these comes from the only available source, the kinetic energy of the spinning magnet, which therefore slows down. The explanation is rather an interesting one, because it shows that there is no reason why mechanical energy should not be turned directly into radiation without the use of electronic devices. However, I should point out that the idea is intriguing rather than practical!

To carry the explanation a little further, the magnet can be assumed to be replaced by a solenoid carrying a current I whose field matches that of a magnet. Next, the rotating magnetic field can equally well be created by two such solenoids fixed in an inertial reference frame at right angles to one another and carrying currents.

$$I_1 = I\sin(2\pi\nu_0 t),$$

$$I_2 = I\cos(2\pi\nu_0 t)$$

ν_0 being the speed of the real magnet in revolutions per second. By this substitution the problem has been reduced to one of radio engineering. Each solenoid acts as a small loop antenna, the radiation from which results in a circularly polarized radio wave. Now the radiation resistance of an electrically small loop is given by

$$R = 31,200\,A^2N^2V^4/c^4$$

where A is the area of the solenoid, N is the number of turns, V is the frequency in cycles per second, and c is the velocity of light. By equating the kinetic energy stored in the rotating magnet to the I^2R losses in radiation it can be shown that the speed after a time t is

$$\nu = \nu_0(1 + kt)^{-1/2}$$

$$k = 31,200\,(IAN)^2(2\pi\nu_0)^2/(c^4W)$$

where W is the moment of inertia of the magnet.

The explanation for the magnetic field outside the sphere being zero can be given by reducing the problem to absurdity. Since the sphere is perfectly symmetrical in a three-dimensional sense there can be no preferred axis of magnetization; if lines of force do exist, they can only be perpendicular to the surface and they must all have the same direction of flow. But then this is tantamount to saying that the sphere acts as if it were a unit magnetic pole. Now man has been searching for unit magnetic poles for a long time, and, like the philosopher's stone, they have never been found (except possibly at the subatomic level). Unless you believe otherwise, the only possible solution is for the field outside the sphere to be everywhere zero. A more formal proof exists.

†In practice, and in theory, a sphere cannot be assembled from six-sided plugs alone. To get a perfect fit it must be done with a mixture of six-sided and five-sided plugs (see Fig. 6 (b)), as in the truncated icosahedron. However, this awkward fact should not affect the author's discussion. — Ed.

THE ILLAWARRA AMATEUR RADIO SOCIETY - P. O. BOX 1838 WOLLONGONG 2500

Meetings: Second Monday of every month except January at 7.30 p.m. in the Congregational Church Hall, Coombe Street, Wollongong. Committee Meeting - 3rd Monday of each month.

Repeaters: VK2RAW - 6850 VHF Mount Murray. VK2RIL - 7275 VHF Sublime Point.

VK2RUW - 8225 UHF Hill 60 Port Kembla. VK2RIL - 8725 UHF Sublime point.

Broadcasts: On Sunday night prior to Club Meeting - 7.00 p.m. - RTTY on 6850 and 7275 VHF Repeaters; 7.15 p.m., Voice on 6850 VHF, 7275 VHF and by relay on 3.562 Mhz. Call backs BEFORE the WIA relay at 7.30 p.m.

W. I. A. Relay: On 6850 VHF at 11.00 a.m. and 7.30 p.m. weekly on Sunday.

Club Nets: 3562 MHZ SSB on Sunday at 8.00 p.m. and slow morse net on 28.440 Mhz on Tuesday at 8.00 p.m.

Newsletter: "The Propagator", published monthly to reach financial members in week prior to meeting. All articles, ads etc. to the editor, Dave Myers VK2DFL at 30 Highlands Pde. Bulli 2516. Telephone 84.9404. Copy deadline 3rd Tuesday each month.

Membership: The Secretary, I.A.R.S. P.O. Box 1838, Wollongong 2500. Full membership is $10.00 per annum; students and pensioner concessional members $5.00 per annum.

Awards: The award of the I.A.R.S. is "The Lawrence Hargrave" award. VK stations require 10 contacts with I.A.R.S. members; overseas stations require 5 contacts with I.A.R.S. members or contact with the Club station VK2AMW is sufficient in itself for the award. Band details - time, day, date, frequency, station worked + $2.00 or 4 I.R.C.'s to Award Manager, I.A.R.S., P. O. Box 1838, Wollongong 2500. No QSL cards required.

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