

R. R. S.

Newsletter

(For the use of R.R.S. Staff only)

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NEW YEAR'S HONOURS

I am sure all members of the Station will wish to congratulate Mr. R. C. James, who has brought distinction to the workshops by the award to him of the British Empire Medal, and Professor Llewellyn-Jones who has been made a Commander of the Order of the British Empire while spending a year with us here.

I am particularly pleased that these honours go to the workshops, and to our panel of expert consultants, both of whose activities are so essential to the work of the Station.

A Station of this size, which cannot have a large independently run engineering shop, depends for its success on the skill of the individuals in the workshop and on their ability to collaborate well with the experimenters. Mr. Oakman's comparatively small team has always been most valuable in this way and throughout his 26 years here Mr. James has played a key part in many of our activities.

In a note about Professor Llewellyn-Jones which I wrote for the Newsletter of November, 1964 I mentioned the important part which Consultants played in the work of the Station and how valuable it was for us to have "the Prof" living with us here during his consultancy. Many of us have now got to know him so well, and see him so regularly, that we think of him as one of ourselves, and we are delighted that this Honour should have come to him while he is with us.

J. A. Ratcliffe

Mr. Nicolson and Winkfield

Members of the Station will wish to congratulate Mr. Nicolson on his appointment to the post of Chief Experimental Officer which has been established for the head of the Winkfield Minitrack Station.

That Station started operations, on a small scale, in 1964 under the control of Mr. Nicolson and he has been responsible for its steady growth until it now has a staff of 25 who maintain and operate it continuously, round the clock, year in and year out.

At a peak period during August-September 1964 nearly 600 telemetry, tracking and command operations, relating to 16 different satellites, were carried out within a fortnight.

The available information suggests that the operational load on Winkfield is greater than that on any other Station in the Minitrack network.

Winkfield plays a central role for Space Science on a world-wide basis, and for us here at the Radio Research Station. It is proper that its head should have the standing of a C.E.O. and, to all of us who know him Mr. Nicolson is outstandingly well qualified to be the first holder of the new post. We are delighted to have him there.

J. A. Ratcliffe

TARNISH AND TECHNOLOGY
or
SOILED SURFACES AND SCIENCE

1. At school (and even later) it has been impressed upon us how important it is for our scientific reagents or equipment to be scrupulously clean. My own chemistry master - himself a very religious man - used to commence his course by emphasising that "cleanliness was next to godliness, but more important in Chemistry". In modern ionization physics, work with the noble gases requires conditions of cleanliness in which an impurity content as low as one part in ten million can almost ruin an experiment. In the manufacture of solid state electronic devices, proportions of 'dope' even as low as one in 10^{12} are considered. It may therefore come as something of a surprise to find that in many important branches of technology the presence of impurities - in the form of tarnish surface film - is actually necessary for the proper operation of many machines or devices.

It is interesting to note, also, that until fairly recently, sufficient attention has not been paid to the actual surfaces themselves^{of} material bodies, more attention having been paid to their bulk properties. Surfaces, however, are really very important, because, after all, it is usually through their surfaces that many bodies interact one with the other.

Electrically or optically speaking, the surfaces are often far more important than the interior, as they determine absorption or reflection of much radiation, their reaction to electrons or ions, and certainly secondary electron emission, whether thermal or due to the incidence^{of} radiation or charged particles. Let us now consider some examples from everyday life.

2. Electro-technology is a fruitful field of interest in this connection. For instance, there is a considerable amount of power loss from overhead high-voltage transmission lines by incipient electrical discharges, even when the geometry and voltage are such that sparking is unlikely. Such loss is most severe in industrial districts with polluted atmospheres, and photographs taken at night distinctly show corona discharges particularly in conditions of rain, fog or dust. Trouble due to electrical breakdown has also been found in modern high-voltage gas-filled cables, such as those used for underground or under-sea transmission of power.

Now, let us look at the opposite extreme - a perfectly clean, sealed vacuum reed switch. Sometimes, with copper electrodes, for instance, the switch is good for only a single operation - that of one closure, because the two clean electrodes cold-weld together, and, to be opened they have to be torn apart! Thus, we have one case when the presence of tarnish surface layers leads to power loss, while on the other, the absence of such films also leads to trouble!

The cases of moving or rubbing electrical contacts are intriguing. Examples of great technological importance are those of the slip-ring of an alternator, the commutator of a d.c. motor, or the pantograph collectors of

overhead electric railway systems. These, for instance have operated successfully during speed tests on the S.N.C.F. near Dijon when two different types of French electric locomotives exceeded 200 m.p.h.⁷. In all these cases the essential requirement is that high currents must be able to pass from a stationary to a moving electrode with the minimum of loss. If the contact has a resistance R when passing a current I , the heat developed RI^2 can be considerable for currents exceeding, for instance, 1,000 amperes, so that R must be extremely low if the metals are not to be burnt up at the contacts. Thus the "metallic" contact must be good.

On the other hand, when one electrode is pressed upon another with considerable force and dragged along at high speed, a "good" contact between the two inevitably involves one gouging out tracks in the other. Clearly, this is not a good thing to happen to, say, an expensive commutator in a high-power motor at high speed! Consequently, in practice the "mechanical" contact of the two electrodes must be bad. Now these two requirements may appear to be mutually contradictory, and, indeed, would be so if only pure, clean metals were used.

In the early days of the last war Spitfires were sent up on high-flying tests, at first with unmodified electrical equipment. It was found that their electrical systems often completely failed, and on return to ground it was seen that in some cases the commutators had been torn to bits! Something similar has also been experienced on polar scientific expeditions, when their electrical generators appeared to fail although they were perfectly good when leaving Britain.

Again, some of us have witnessed the testing of power cable insulators at high voltages ≥ 1 MV produced by an impulse generator. The spark gap electrodes in such cases are often large metal spheres placed a few feet apart. On closing the circuit switch a sharply rising voltage pulse is created and rapidly applied across the gap. Within an extremely short time interval spark breakdown often takes place. Now the initiation of this discharge requires the presence near the cathode at the right instant of an initiating electron, and the question naturally arises of where this comes from so readily, rapidly and conveniently. Some years ago it was the practice often to cite "cosmic rays" as the universal provider of necessary electrons when it was not quite clear where they really did come from! Actually, it is much more likely that these came from the surface films of the cathode when the field applied is 10^4 V/cm, and indeed this can be demonstrated.

We all know of the classic experiment of Hertz in actually generating electro-magnetic waves (at the time many scientists were not inclined to believe Maxwell's theory). Hertz produced a spark by applying a pulse of voltage to the gap between the two halves of a small di-pole radiator. Sometime recently, an attempt was made to reproduce this experimental set-up as a demonstration for educational purposes, but naturally using modern

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highly-finished, polished, and beautifully turned out (and expensive) apparatus. In fact, the sparking ends of the di-pole were gold plated sharpened steel gramophone needles. However, there was some consternation when it was found that this either did not work at all, or only badly and spasmodically. Hertz, it is thought, actually used two bits of dirty wire which happened to be lying around!

3. What is the explanation of all these, perhaps unexpected, phenomena, and what has this got to do with tarnish and surfaces? In fact, these cases have all been cited simply because the presence of a thin tarnish or insulating surface film is of the greatest scientific importance in the fundamental physical processes involved in each technological application.

A great deal of research has been done since the last war on 'cold' electron emission from metal electrodes under applied electric fields. (Cold, in the sense that the electrode as a whole is at room temperature). It is, of course, well known that electrons can be extracted from clean, smooth metal surfaces in vacuo by applying electric fields as high as 10^7 or 10^8 V/cm. Actually, until recent work with single crystals in ultra-high vacua was done, the experimental evidence was not very reliable, as, in practice, with traces of residual gas and ordinary unde-gassed surfaces, such high fields cannot be established. Wave mechanics gave a satisfactory explanation of this 'cold' field emission based on the narrowing of the surface potential barrier to atomic dimensions and the resulting leakage of the electron waves through the narrow wall. The presence of a ψ -wave outside the metal implies the existence of the probability $\psi^* \psi$ of there being an electron in that region, which of course is promptly whisked away by the field. However, all this can only happen to any significant extent in electric fields greater than 10^7 or 10^8 V/cm, but in all those practical cases described above the electric field was only about 10^4 or 10^5 V/cm, i.e. two or three orders of magnitude lower than that necessary to produce cold emission on the Fowler-Nordheim (quantum) theory.

This result naturally led to a detailed study of 'cold' emission of electrons from ordinary metal surfaces as found in technology, i.e. those with surface tarnish film $\lesssim 10^{-5}$ cm. thick, or even with adsorbed gas layer only $\sim 10^{-7}$ cm. thick. In such cases, it has been established that significant electrons mission can in fact be produced with applied fields as low as about $\sim 10^4$ or 10^5 V/cm, and the precise mechanism or mechanisms of the process have been the subject of considerable research.

At least two mechanisms have been found. In one, positive ions play an important part in so-called 'clean' electronic equipment by producing positive charges residing on a partially insulating thin surface film $\sim 10^{-7}$ cm. thick. The resulting high electric fields $\gtrsim 10^7$ V/cm, then modify the potential barrier. Without the film, Auger processes occur.

With thicker ($\gtrsim 10^{-5}$ cm.) surface films, on the other hand, as found with ordinary exposed metals, adsorbed water vapour can exert a profound influence.

It is thought that negative ions of water (and perhaps of oxygen as well) can act as a source of electrons which are pulled off by the applied field when this is no greater than $\sim 10^5$ V/cm. This explains a great deal which is otherwise mysterious, a mechanism of this kind can, quantitatively, account for the production and supply of the initiatory electrons which lead to corona discharge loss from power overhead transmission lines or gas-filled underground cables, and for the rapidly induced breakdown sparks of testing gear.

The action of such surface films, too, help to explain why moving contacts work at all. If a thin surface film of material, which in bulk may be insulating, mechanically separates two electrodes in relative motion, the friction can with suitable material be satisfactorily minimised. Further, if this film is thinner than, say, 10^{-7} cm., it can permit high fields ($\sim 10^7$ V/cm.) to be established across it at low voltage which can permit cold field-emission through the apparent insulator, and in this way resolve the paradox of all moving contacts of having good electrical contact yet bad mechanical contact.

It is thought that carbon atoms are suitable for this role, but absorbed gas film can also have this property - especially water vapour. When water vapour is removed from the brushes of a commutator, or a slip ring, the mechanical wear rapidly rises and may soon destroy the electrodes. This is, in fact, precisely what happened in the early high-flying tests and - to a less extent - in the electrical equipment of polar expeditions, on account of the extremely dry atmosphere encountered in both cases.

Thus surface tarnish films, including absorbed water vapour layers, play a very important part in modern electrical technology - all the more, perhaps, because so long unsuspected. Indeed, it may be interesting and profitable to contemplate how much more of our modern technological society fundamentally depends on water vapour or on much-maligned 'scientific' dirt.

F. LLEWELLYN-JONES

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VISIT TO POMPEII

Naples was one of the ports of call for the "Cathay", the ship on which Ted Hammond, Tim Bevan and I returned from Singapore a few weeks ago. We docked there in the late evening and sailed the following night. For the entertainment of passengers several coach trips were organised to nearby places of interest; amongst these were visits to Pompeii and Vesuvius.

The coach for Pompeii left the dockside at about 9 a.m. and after meandering through the docks and the south eastern suburbs of Naples (most of which seemed to be an oil refinery) turned on to the Autostrada. This is a toll road which runs along the coast. Several miles outside Naples we made a slight deviation from our journey to visit a cameo factory. Here a brief visit to the small workshop was followed by a very much longer visit to the display and sales room.

/Eventually

Eventually we left the factory and a few more minutes ride brought us to an entrance to Pompeii. Pompeii, which is about 16 miles from Naples was, until 79 A.D., a flourishing Roman city. In that year the volcano Vesuvius, which is about 6 miles away, violently erupted and, in the course of a few hours, buried the city and some of its inhabitants beneath many feet of hot ash and cinders. The excavation of Pompeii has been taking place over the last two centuries but it is not yet complete.

We entered the wall around Pompeii through a long rising passageway and emerged a short distance from the Forum. The Forum was the centre of the city and was surrounded by large buildings which have been reconstructed as far as the remains found allowed. Our guide was eager to show us as much as possible in the rather limited time and so all our visits to the most interesting places tended to be fairly short. From the Forum we were taken to see some of the baths. These were well preserved; one of the bath houses had a form of central heating. In the other bath house were displayed the plaster casts of several people who had been unable to escape from the city and had been buried beneath the falling ashes.

Several private houses or villas were also visited. A tile mosaic on the entrance floor of one villa depicted a large, fierce dog and beneath it visitors were warned to "beware of the dog".

Some of the private dwellings contain paintings and these buildings have been partly reconstructed to shelter the pictures. Other areas of Pompeii resemble a bomb site as all that remains are grey stone and brick walls. In these areas grass and brambles have sprung up and have had to be cut back to prevent the ruins being reburied by vegetation.

The roads of Pompeii are paved with grey stone and there are somewhat narrow pavements on either side. Because the streets were not provided with underground drains they flooded and to enable pedestrians to cross them in wet weather, large, raised, stone blocks were set at intervals across the roads to act as stepping stones. At one crossing place the guide pointed out the deep ruts cut by wagon wheels in the road surface. (Could not the Romans have cut ruts to guide wheels past the blocks?) Unfortunately there was not enough time to see as much as many of us would have wished as we had to return to the ship by lunch. Our tour was concluded by a short visit to the museum which contained articles discovered during excavations.

After seeing Pompeii in the morning it seemed rather logical to take the afternoon trip up Vesuvius to get a closer look at the prime cause of Pompeii's destruction and, in a way, preservation.

Vesuvius is about 10 miles from Naples. The coach trip there initially followed the same route as the morning trip, including a stop at the same cameo factory! The volcano is, at the moment, almost dead and from a distance resembles a large, reddish, grey-topped cone that has had the tip removed. The lower slopes of Vesuvius are cultivated but vegetation becomes increasingly sparse as one ascends the twisting paved road. The orchards of the lower

/slopes

slopes give way to plantations of small, brilliantly-green pine trees growing amongst huge jagged outcrops of solid lava. The road becomes more and more tortuous as one ascends and contains numerous hair-pin bends. One of these was so sharp that our coach failed to negotiate it at the first attempt and had to run back a little way before finally getting round it. After climbing for about half an hour we reached the lower chair-lift station. The chair-lift takes visitors the last several hundred feet to the summit because the road ends at the station. Vegetation also ceases at this height. At one time there was funicular railway to the summit but that was destroyed by an eruption in 1944 and the chair-lift was built to replace it.

The chair-lift consists of pairs of covered chairs fastened to a frame which, clipped to a moving cable and suspended from towers, travels up to the summit.

The journey to the top took only a few minutes and was made in almost complete silence. It also gave one a chance to get an unobstructed aerial view of distant Naples.

From the upper station it was only a few feet to the rim of Vesuvius. Any visions one might have of looking down into a vast pit filled with red hot bubbling lava are utterly dispelled on reaching the rim. Instead, one sees an enormous crater some 1,500 feet in diameter with, in places, almost vertical sides coming to a rock-filled bottom several hundred feet below. The rock is grey-red and the area is utterly devoid of vegetation.

It was very cold on the summit (nearly 4,000 ft. above sea level) and the guide, who has by order to accompany each party of tourists, was well wrapped and seemed not to notice our shivers as he picked the most exposed points at which to recite his pieces of information.

The guide led us a little way around the rim and down a small path that descended on the inside of the crater. This ended after a few yards beside some rocks. From fissures in these steam drifted out. We put our hands into the cracks but alas, even here the steam smelt steamy and not of fire and brimstone!

Carefully we climbed back up the path and took the chair-lift down to our coach which was waiting to take us back to the welcome warmth of sea level Naples and of tea on the Cathay.

M. CHIVERS

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STAFF NEWS

Welcome to:-

New Staff

Mr. A. P. Lawson	T/Driver
Mr. J. J. Cubbin	T/A.E.O.

Resignation.

R. L. T. Street	College-based Sandwich Course Student.
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