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Vol. XIII Part 3

TORQUAY

Natural History Society

Transactions & Proceedings

For the Year 1960-61

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PRINTED FOR THE SOCIETY
BY WOODLAND PRINTERIES, PAIGNTON

Distributed gratuitously to subscribing members and to corresponding Societies.
At the Museum, 529 Babbacombe Road, Torquay

1962

eaten, those taken on July 1st and August 1st usually being the heaviest. They do not eat on wet days, nor on cool ones early or late in the season. We bring Panhard and Daimler in every night to their boxes in the house. Their diet consists principally of dandelions, lettuce (especially liked if bolting), sow thistle, the younger leaves of cabbage and other Brassicas, pea and both runner and broad bean leaves, spinach, beet, and as a treat, peas. They are particularly fond of yellow flowers, buttercups, hawkweed, birds'-foot trefoil and charlock being their favourites, and they prefer the yellow wallflowers to the red. Once a friend was wearing a flower-patterned dress, and Daimler tried to eat the buttercups off it! Their tastes vary too. Daimler seldom eats pink clover which the others love, though all eat the leaves. They are extremely greedy over fruit and it seems immaterial whether thoroughly under-ripe, or over-ripe and going rotten. If they get a chance, they will also eat certain ornamental plants such as delphiniums, lupins and petunias.

MAN-MADE DIAMONDS

By A. R. LANG, M.Sc., Ph.D.
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The hardness and inertness of diamond have been recognised since ancient times, but the full beauties of its fire and lustre were only revealed in the 17th century with the development of the form of cutting known as the brilliant. Diamond then became established as the most prized of all gemstones. In nature diamonds occur much more abundantly than many other gems less esteemed. However, the close regulation of diamond production and marketing, the comparative fewness of stones of the first water, and the labour and expense of proper cutting, combine to ensure that first-class cut diamonds hold their value as gemstones by their rarity as well as by their beauty and durability. Yet it is the humbler diamonds, coloured yellow, brown, or even quite black, that are the mainstay of the modern diamond industry, for they also possess the qualities of extreme hardness and freedom from wear that make diamond pre-eminent as a cutting tool. Deeper oil wells and mine shafts being drilled through tougher rock, faster machines cutting and shaping new hard ceramics and alloys, for all these a supply of industrial diamonds is essential. Sizes range from one-tenthousandth of an inch for polishing pastes, through one-hundredth of an inch for cutting wheels,

to about a quarter-inch for mining drill bits. Diamonds in the various size grades are sold by weight, the unit being the metric carat, one-fifth of a gram and about 1/150 of an ounce.

Industrial diamond output from Africa is now valued about £100 million per annum. The United States of America, with no workable diamond resources of its own, is the largest importer from Africa, and has understandably strong motives for making itself independent of overseas supplies of such an essential material.

The two crystalline forms in which the element carbon can exist, diamond and graphite, exhibit a great contrast in physical properties. Graphite occurs as very soft, black, scaly crystals, specific gravity about 2, whereas diamond, transparent when pure, is by a large margin the hardest known natural crystal. Its high specific gravity, 3.5, shows that it is the form stable at high pressures. It is in fact only metastable at atmospheric pressure; but to transform it to graphite, heating to about 1,500 degrees C. is required (in absence of air, so that it cannot burn). A very good prediction of the conditions of temperature and pressure under which diamond is the stable crystalline form of carbon, and under which it might possibly be crystallized from carbonaceous material, was made a few years ago by Dr. R. Berman and the late Sir Francis Simon, at Oxford, and has since been confirmed by experiment. The requirements are a pressure of 20,000 atmospheres at room temperature, 50,000 atmospheres at 1,500 degrees C., and 90,000 atmospheres at 3,000 degrees C. Various factors, including the slowness of diamond formation at the lower temperatures, necessitate working in the range of the higher temperatures and pressures. Only during the last decade have techniques been developed for holding a reasonable quantity of material at such intense pressures and temperatures, and in the light of what is now known of the practical difficulties of diamond synthesis the success claims of earlier workers must be viewed with extra scepticism.

The mode of formation of natural diamond is still a mystery. Static pressures under which diamond would be stable are reached only at depths greater than 50 miles below the Earth's surface. The large pipes in which diamond is found in situ bear evidence of eruptions of an extraordinary explosive type. It is possible that through gas or crystallization pressure conditions suitable for diamond formation may have been temporarily maintained in the pipes themselves, and that the diamonds were not brought up from far below the Earth's crust. In any case, nature gives little positive guide to the would-be maker of diamonds.

Claims of successful production go back about 125 years, but the first of real significance, and still the most controversial, dates from 1880. In that year, on February 20th, a letter to the Editor of "The Times," from Professor N. Story-Maskelyne, Keeper of the Mineral Department at the British Museum, announced that Mr. J. B. Hannay of Glasgow had produced small fragments of material that satisfied all the characteristic tests for diamond. Hannay had performed a long series of experiments in which carbonaceous material (paraffin spirit and bone-oil) together with an alkali metal (of which only lithium was found to be effective) were enclosed in an iron cylinder of gun-barrel construction and heated in a furnace to a dull red-heat for fourteen hours. There were many shattering explosions, and only three out of eighty experiments yielded small amounts of hard black "diamantiferous material" when the tube was opened. About twenty years ago there was found in the Mineral Department of the British Museum a glass slide bearing 12 minute specimens, labelled as diamonds prepared and presented by J. B. Hannay in 1880. These were examined by Professor Kathleen Lonsdale, D.B.E., who obtained their X-ray diffraction patterns. Such patterns nowadays serve as unique fingerprints for every mineral species. Eleven out of the twelve little crystals were found to be undoubted diamonds, adding support to Hannay's claim. But second thoughts have now crept in. With much experience gained in the last few years on X-ray and optical examinations of synthetic diamonds from U.S.A., Sweden and South Africa, Professor Lonsdale and her colleague Dr. Judith Milledge now consider that the eleven crystals are so similar to natural diamond fragments, and so completely unlike synthetic material, that they are not man-made after all. There is a slight possibility that the slide was wrongly labelled. More likely, perhaps, some person, as a hoax or through exasperation at repeated failures and explosions, surreptitiously added natural diamond fragments to the material scraped from inside Hannay's tubes.

The experiments of the French chemist Moissan are often quoted. In the early 1890's he dissolved carbon in iron melted in an electric furnace, then quenched the molten mass so that it formed a solid crust While solidification proceeded towards the interior of the ingot, Moissan believed that through the expansion of iron on solidification such intense pressures would be built up that diamond could be formed. After each experiment, the iron mass had to be laboriously leached away with acid, and the small residue of insoluble material examined. Small, hard, transparent and optically isotropic crystals, of specific gravity similar to diamond, were recovered, but it is now believed that they were spinels rather than diamond. These experiments were, of course, performed before the X-ray diffraction fingerprint was available for identifying minute and imperfect crystals. Moissan's experiments were later repeated by Sir William Crookes, and during the first two decades of this century Sir Charles Parsons spent no less than £20,000 on fruitless experiments, trying Moissan's, Hannay's and other novel methods.

Modern research at high pressures is based almost entirely upon the work of one man, the late Professor Percy Bridgman, of Harvard University. At the conclusion, about 1950, of his career of active research he had built apparatus which would subject several grams of material to pressures of 30,000 to 40,000 atmospheres over the temperature range 1,000 degrees C. to 3,000 degrees C., and at room temperature he could squeeze small quantities of material to a pressure of around 400,000 atmospheres (equivalent to a depth of 650 miles below the Earth's surface). Yet in the higher temperature range needed for reasonably rapid diamond formation, Bridgman had not succeeded in reaching the pressure of the graphite to diamond transition. At this point the problem was tackled by an energetic group at the Schenectady Laboratories of the General Electric Company of U.S.A. In four years these men, Drs. Bundy, Strong, Tracy Hall and Wentorf, not only successfully produced diamonds, but also prepared several interesting new high-pressure modifications of other materials and effected notable advances in ultra-high pressure techniques. Their achievement, first announced in 1955, was based upon two developments, a new design of high pressure apparatus and a particular configuration and choice of material for inclusion in the diamond-producing reaction cell. High pressure cells used by Bridgman usually took the form of a thick-walled cylinder, closed at one end, into which a hardened steel piston was driven in order to compress the material under investigation. The upper limit of pressure was set by shattering at the base of the relatively slender piston. Later, Bridgman developed the "anvil" technique, in which small quantities of material were squeezed between the truncated apices of a pair of opposed conical members. Such a truncated cone could be regarded as a piston with a wide, flared base. When pressed into a suitably shaped depression in hard material, using soapstone or a similar substance as a packing gasket round the piston, it formed a high pressure cell free from the difficulties of piston failure since the piston tip was broadly supported by the flared base. This was the idea of Tracy Hall. Subsequently, he developed it in a more symmetrical design in which two tapered pistons with wide flared bases were pressed from either side into a suitably shaped central hole in a disc of very strong material. In this hole the reaction cell was placed and could be heated to a high temperature by passing an electric current through it from one piston to the other. Such a design, called the " belt," doubled the range of pressure attainable in the high temperature region and was used in all the G.E. experiments on diamond synthesis.

The second development by the G.E. group, an essential for the commercial practicability of their process of diamond synthesis, involved an interesting discovery in mechanisms of crystal growth. Direct transformation of amorphous or chemically combined carbon to diamond is very sluggish, even when the necessary high pressures are maintained. In fact, rapid transformation of graphite to diamond only occurs at pressures of hundreds of thousands of atmospheres. Also, when carbon is crystallized from solution in molten metals at appropriate high temperatures and pressure, diamond is formed with difficulty. However, if only a small quantity of molten metal is used, so that it forms merely a thin film between the growing diamond and the mass of carbon to be transformed, then crystallization of diamond proceeds surprisingly rapidly and quantities of several carats can be made in each run of the high pressure apparatus. These diamonds are never colourless, and rarely larger than a few hundredths of an inch in size, so they offer no competition to natural stones as gems. However, the size and shape of synthetic stones can to a considerable extent be controlled during manufacture and chosen to best suit industrial applications, in which synthetic diamond now competes actively with the natural material.

Since the General Electric Company of U.S.A. first produced diamonds, success in this field has been announced from various quarters. Other American laboratories, the A.S.E.A. Laboratories in Sweden, and the Diamond Research Laboratories in Johannesburg have made diamonds within the last two or three years. This year diamonds have been made for the first time in Britain. But as an example of successful research, meeting the long-standing challenge to scientists to synthesise one of nature's most interesting products and, at the same time, creating a new supply of an industrially valuable material, the work of the group at Schenectady is outstanding.

THE SWINGING SIGN

The street was dusty
And the street was dull.
Relentlessly the noonday sun
Beat on its pavèd way.
The huddled houses hemmed each other in
Till all the air seemed stagnant
And the place had settled into meanness,
Without hope. 'Twas in this mood
The traveller slowly trod its road
When, suddenly, he saw
'Twixt earth and sky a lovely thing,
A thing so beautiful it seemed
It must have stepped out of another world ;
A simple sign, in iron wrought,
But with each curve complete and perfect ;
In design so exquisite
It radiated harmony and peace,
And sweet content, setting the spirit free
To wander in the paths of fantasy ;
For here in this sad, sordid place
A craftsman's love had set a thing of grace.

V. I. Phillips.

OSLO CITY HALL ON A WET DAY

Have you sat barefoot in a City Hall
  to ease the burden from your squelching shoes ?
I found chill marble warmed my sodden feet
  and shuffled out their water-logging ooze.

So many tourists passed without a stare
  while I sat pensive in a plastic mac
And watched their lives meet echoes from the walls,
  a tempera and fresco almanac.

Armitage Hargreaves.