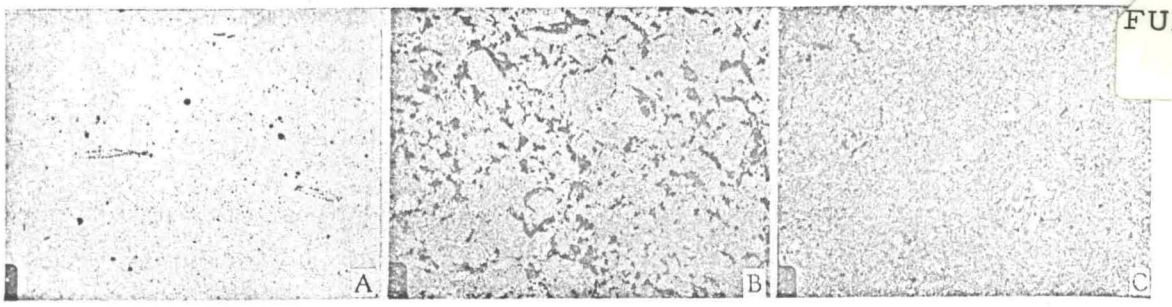

Fig. 1. *A*, Glassy carbon; *B*, normal graphite; *C*, high-density graphite. (All × 50)

Table 1. Some Properties of Glassy Carbon

	Impregnated carbon	Glassy carbon	
Heat-proof up to (° C.)	1,300	1,300	3,000
Apparent density (gm./c.c.)	1·75–1·92	1·46–1·50	1·43–1·48
Apparent porosity $(D^*-AD)/D$ (per cent)	8–15	0·2–0·4	
Hardness	45–55 (Shore)	4–5 (Mohs)	—
Flexual strength (kgm./cm.²)	400–500	500–1,000	—
Electrical resistivity (10^{-4} ohm, cm.)	9–11	35–50	30–35
Ash content (per cent)	0·2	0·1	0·05†
Gas permeability (cm.²/sec.)	10^{-5}–10^{-6}	10^{-11}–10^{-12}	10^{-9}
Thermal conductivity (kcal./m. hr. ° C.)	100–120	3–4	13–15
Coefficient of thermal expansion (10^{-6} ° C.)	2·0–2·5	1·8–2·2	—

* *D*, Real density by benzene immersion method.
† After high-temperature chemical treatment, the ash content of this was 0·05 per cent, consisting of 2·0 p.p.m. manganese, 0·1 p.p.m. magnesium, 0·12 p.p.m. silicon, 2·59 p.p.m. nickel, 6·4 p.p.m. aluminium, 140 p.p.m. iron, 13·0 p.p.m. calcium, 4·9 p.p.m. copper; boron, 0·08–5 p.p.m.

Table 2. Comparison of Oxidation-rate

	Reaction time (min.)			
Weight loss	70%	80%	90%	100%
Normal graphite	68	95	110	140
Pyro graphite	120	138	175	250
High-density graphite	160	185	225	275
Glassy carbon	205	255	270	365

($N_2 : O_2 = 81 : 19$ by volume) at 800 ± 5° C. Each sample was cut as large as 15 × 15 × 1 mm.

Pore-size distribution of the glassy carbon by mercury method was quite different from the normal graphite. For example, the pore volume percentage to the whole sample volume between 10^2 Å. and 7×10^4 Å. is as shown in Table 3.

Table 3. Pore-size Distribution by Mercury Method

	Total pore volume (per cent)	Pore-size distribution (per cent) 7×10^3–7×10^4 Å.	1×10^3–7×10^3 Å.	1×10^2–1×10^3 Å.	Maximum pore size (≦1,000 kgm./cm.²)
Normal graphite	32	27	4	3	7×10^4 Å.
High-density graphite	11	3·5	1·5	6	7×10^4 Å.
Impregnated impervious graphite	5	—	2·5	2·5	7×10^3 Å.
Glassy carbon	0·35	—	—	0·35	1×10^3 Å.

It is of interest that dependence on temperature of the internal fraction coefficient of the glassy carbon was observed similarly as in the case of the normal glass being different from many kinds of graphite which coefficient was independent of the temperature[2].

The photomicrograph of the glassy carbon is as shown in Fig. 1*A*, comparing with those of the normal *B* and high-density graphite *C*.

Shigehiko Yamada
Hiroshi Sato

Nagoya Plant,
Tokai Electrode Manufacturing Co.,
Horie-cho, Showa-ku, Nagoya.

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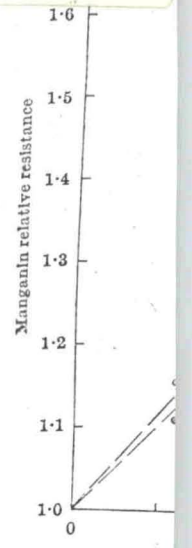
Electrical Conductivity of Manganin and Iron at High Pressures

The properties of materials at high pressures can be measured either in static compression apparatus or dynamically, using explosively induced shocks. Pressure measurement is indirect for static methods, but a reliable figure for temperature can usually be obtained. With dynamic methods, however, absolute pressures can be found from velocity measurements, but at the moment there are no known methods for the accurate determination of temperature. Resistance is probably the simplest measurement to make in static presses at high pressures, and it was thought that a useful contribution might be the extension of this measurement by dynamic methods.

A specimen in a static press is subject to approximately uniaxial compression with some variation of pressure along its length due to plastic flow and deformation of the anvil faces. In the corresponding dynamic situation the compression is initially uniform uniaxial, but is accompanied by a rise in temperature. For the more incompressible metals in the range 0–300 kilobars this rise in temperature is not expected to be very large—250° C. as a maximum.

Initially manganin and iron have been studied. Thin wires of each material were mounted between two conducting supports and embedded in a thermosetting resin, so that they were parallel to the plane of the shock front. This simple configuration eliminates tension effects which are difficult to avoid in static apparatus. Each wire was pulsed from a constant current supply starting a few microseconds before it was shocked. The change in resistance was calculated from high-speed oscillograms of the voltage across each wire as the pressure pulse passed over it. Conductivity in the resin was checked in separate experiments and found to be unimportant to 200 kb.

The resistance pressure curve obtained for manganin is shown in Fig. 1. This alloy, which has the composition 86 per cent copper, 12 per cent manganese, 2 per cent nickel, appears to have a linear relation between pressure and relative resistance up to 300 kb. Manganin is known to be unusual in that it has a positive pressure coefficient of resistance. Bridgman used it as a secondary pressure gauge statically, and has reported a linear resistance change to 30 kb.[1]. He also found that the pressure coefficient of resistance varied from batch to batch and this may account for some of the scatter in Fig. 1. However, the evidence is sufficient to indicate that the extension of Bridgman's linear result from 30 kb. to 300 kb. is justified, particularly if the same piece of wire can be used. Manganin would seem to represent a useful secondary pressure gauge, referring for absolute calibration to known transitions such as



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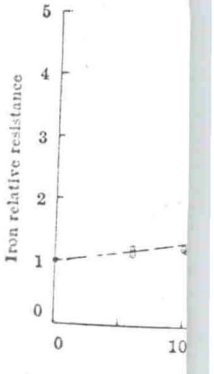

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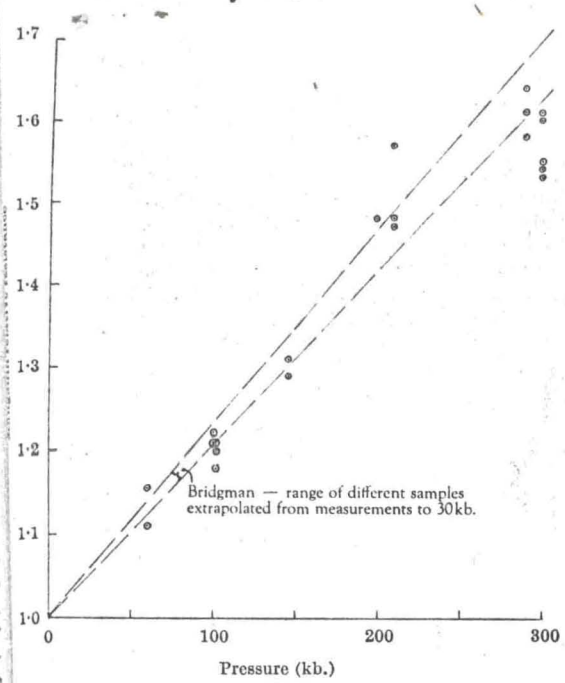

Fig. 1. Manganin relative resistance versus pressure

hose found in bismuth (27 kb. at 42° C.)[2] and iron 31 kb. at 37° C.)[3] determined from shock-wave sults.

A polymorphic transition in iron thought to be the to γ change has been observed by Balchan and rickamer as a resistance discontinuity statically at 3 kb. 20° C. (ref. 4) and dynamically by Bancroft, terson and Minshall as a volume discontinuity at 1 kb. and at a temperature of 37° C. calculated m thermodynamic consideration of the shock nt. Fig. 2 confirms a dynamic resistance tran-ion in the neighbourhood of 150 kb. 100° C. The mperature was estimated from the relative resis-nce after a correction for pressure taken from idgman's work on iron had been applied[5,6]. Work proceeding on the more accurate evaluation of the nsition pressure. This transition is almost certainly t previously observed at 130 kb. The relative ange in resistance at the transition point agrees th that found statically, and, as each point repre-nts measurements made within the first 0·1 μsec. of e pressure pulse being applied to the wire, Fig. 2

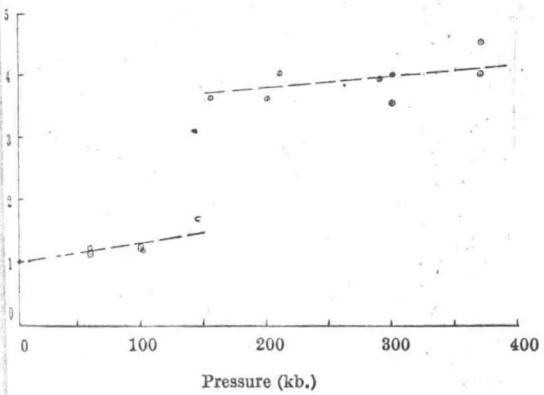

Fig. 2. Iron relative resistance versus pressure

implies that the α to γ transition takes less than 0·1 μsec. to complete. Duff and Minshall[2] have reported that the 27-kb. transition in bismuth under similar conditions takes less than 1 μsec.

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P. J. A. Fuller
J. H. Price

Atomic Weapons Research Establishment,
Foulness,
Essex.

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ENGINEERING

Convection-free Post-arc Gap Recovery

The recovery of the voltage breakdown strength of a gap subsequent to an arc discharge is of basic interest in the performance of circuit breakers. Experiments using the simplified condition of 'free recovery' (that is, no voltage is applied to the gap until the instant of measuring its breakdown strength) have been performed by Edels and Ettinger[1] during times 10–100 μsec. after current interruption, and by Crawford and Edels[2] for longer delay times. During the early stages of recovery the gap still has a finite resistance, and 'thermal breakdown' occurs on applying a suitable constant voltage, but at longer delay times the breakdown mechanism is that of a spark.

A square current pulse was used for the initial arc in the foregoing experiments, so that the gap conditions at the start of the recovery period were those of the steady-state arc, and any gas flow was determined solely by natural convection. Edels, Shaw and Whittaker[3] measured recovery characteristics with forced gas flow in the gap and found that the recovery was much more rapid for times 1–100 msec. after current interruption when using gas speeds of a few m./sec., through gaps greater than 3 mm.

In order to further the examination of the relative importance of the electrodes and gas flow on gap recovery, it was decided to make measurements in the spark breakdown régime under convection-free conditions, for by eliminating flow through the gap the gas would cool only by thermal conduction to the electrodes and surrounding gas—ignoring the small effect of radiation. Natural convection depends on differential pressure gradients, and these may be eliminated within an enclosed chamber by allowing the chamber to move solely under the action of gravitational forces. An arc chamber was constructed from a 'Pyrex' cylinder, 4 in. diameter and 4 in. long, with 'Duralumin' end-pieces sealed by 'O' rings. This could be projected vertically upwards by a spring, guidance being provided by wheels running on vertical rails. Electrical supplies to the chamber electrodes were provided via brushes sliding on vertical conductors, and the electrode gap could be varied by a micrometer head. After leaving the spring the chamber moves freely under gravity both upwards and downwards, apart from slight frictional forces