zirconium, etc. These processes are generally carried out on a much smaller scale than those already described, and it should not be necessary to go into details. There is, however, a growing interest in these more "rare" elements, and the future will no doubt also bring improved and rationalized methods of production.

The possibilities for large-scale expansion of the metallurgical industry in India are almost inexhaustible. A good start has already been made by the proposed plans for increased production of iron and steel by the electric process. Carbide and ferro alloy furnaces are also under consideration. Furthermore, projects have been drawn up for several large hydro-electric power plants, and many districts are favourably situated with regard to further harnessing of water power.

The Indian industry should, therefore, be in a position to attain a high standing in the electrometallurgical field.

* The cost of publishing this article has been met from a generous grant from the National Institute of Sciences of India.

AN ACCURATE PRESSURE GAUGE EMPLOYING MEASUREMENT OF SURFACE STRAIN ON DIAPHRAGMS

J. C. GHOSH, M. V. C. SASTRI AND K. V. CHINNAPPA
(*General Chemistry Section, Indian Institute of Science, Bangalore*)

THE simplicity and accuracy with which surface stresses can be measured by means of bonded wire strain-gauges prompted us to investigate whether the measurement of surface-strains produced on diaphragms (as distinct from the customary deflexion measurements) could be adapted to accurate measurement of high pressure. The preliminary results obtained in this investigation are set out here and it can be seen from these results that the method proposed is indeed capable of high accuracy.

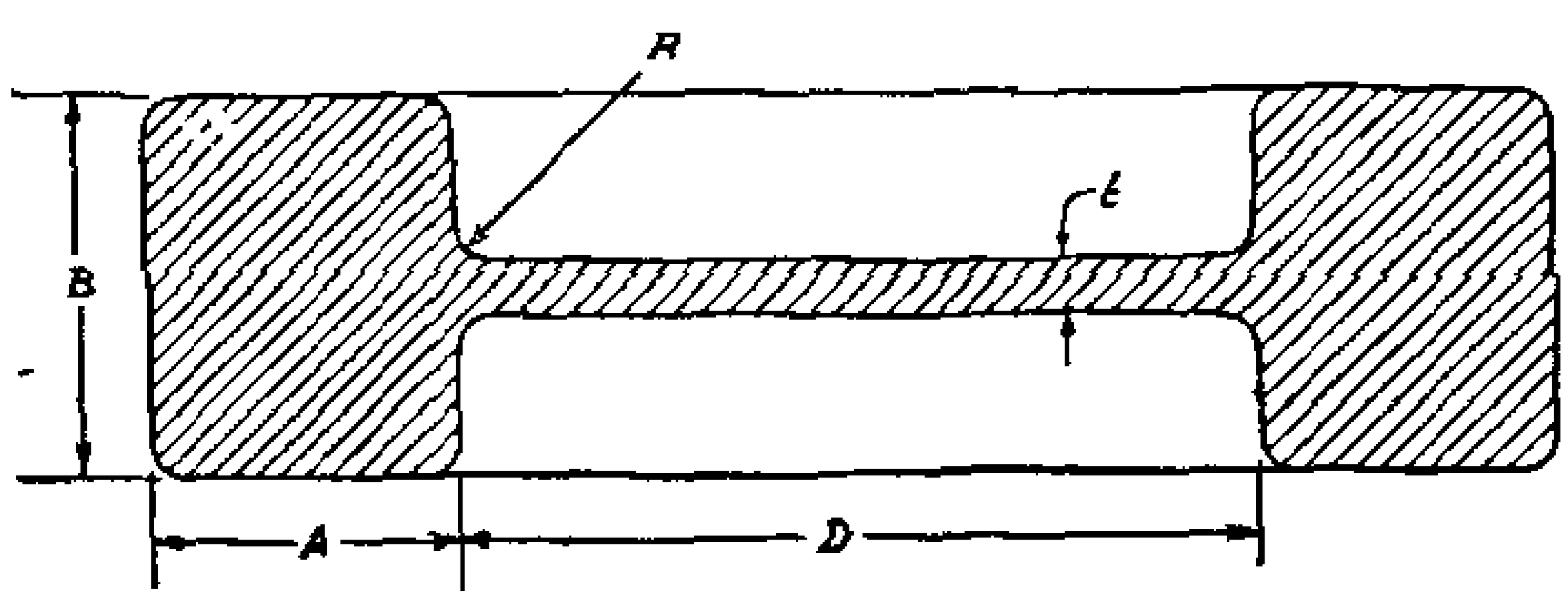

FIG. 1

As plain discs, clamped at the edge, did not yield reproducible results, diaphragms with integral holding-rims and appropriate fillet radii, as shown in Fig. 1, were employed. These were accurately machined out of thick plates of spring steel, clamped at the rim in high pressure unions and work-hardened *in situ* by subjecting them repeatedly to cycles of high and low pressures. The dimensions of the diaphragms employed and their maximum service pressures are given in Table I.

Two well matched strain-gauges (Tinsley's) each of about 200 ohms resistance, were mounted with Durofix, one almost centrally on the diaphragm to measure the strain and the other on the union-nut to compensate for variations in ambient temperature. The variations in the resistance were measured to within 4×10^{-4} ohms with a direct-current bridge of the Callendar-Griffith type, using as null indicator a Moll reflection galvanometer of high sensitivity. With this equipment surface strains could be measured correct to ± 1 micro-inch per inch.

As reference gauge a Budenberg Standard Test gauge with ten-inch dial and reading up to 2,000 lb. per sq. in. was employed. The

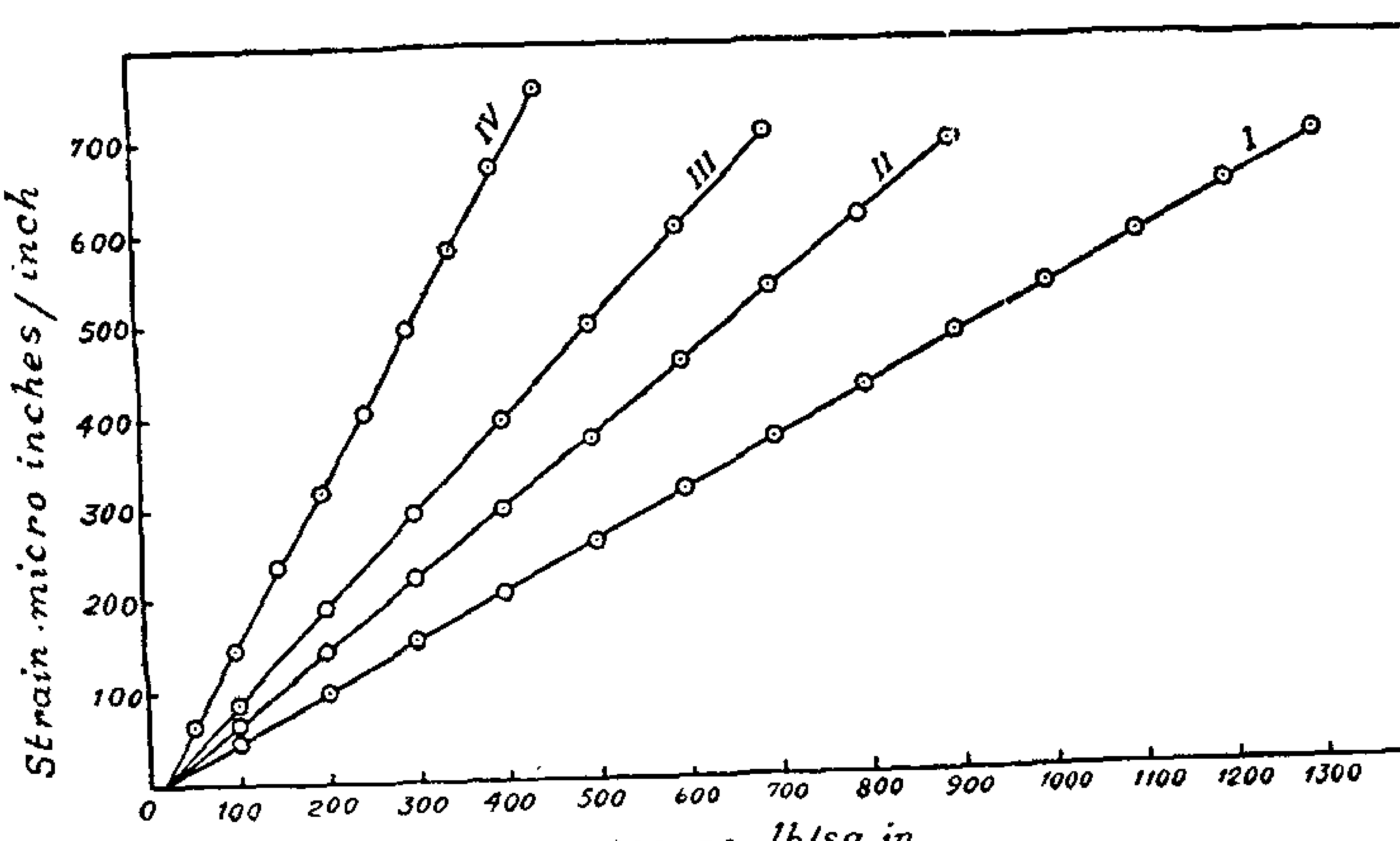

FIG. 2

pointer of this gauge was set by the makers to read the absolute pressures directly on the dial. The gauge calibrations were checked with a dead-weight tester and were found to be correct to ±1 lb. per sq. in. up to 1,500 lb. per sq. in.

TABLE I

Dimensions of the diaphragms and their maximum service pressures

Diaphragm No.	I	II	III	IV
Thickness over flat portion (*t* in.)	0·0945	0·0735	0·0640	0·0420
Diameter of diaphragm (D in.)	1·250	1·226	1·250	1·25
Fillet radius (R in.)	0·04	0·05	0·06	0·15
Radius of flat portion (D/2 − R)	0·585	0·563	0·565	0·475
Width of rim (A in.)	0·21	0·22	0·21	0·21
Thickness of rim (B in.)	0·20	0·19	0·18	0·25
Maximum Service Pressure (lb./sq. in.)	1300	900	700	450

The results obtained are shown graphically in Fig. 2. In each case, the plot of strain *vs.* pressure gave a straight line. Within the limits of maximum service pressures given in Table I, the diaphragms were perfectly elastic and responded to rising and falling pressures without lag and without hysteresis or creep. The pressure *vs.* strain calibrations were remarkably stable and the slope of strain to pressure was maintained even after the diaphragms had been dismantled and reassembled.

Table II shows a typical set of data obtained in four calibrations with Diaphragm III, on which a strain-increase of 1μ in./in. corresponds nearly to an increase 1 lb./sq. in. in the pressure. It is evident from the table that the largest average deviation from the mean values is 1·25; *i.e.*, 1/6 per cent. of the full range value of 706 μ in./in. Even towards the lower end of the scale (*e.g.*, 100 lb./sq. in.) the average error is less than ½ per cent. of the mean value for that pressure, but less than 1/11 per cent. of the full-scale value.

TABLE II

Results obtained with diaphragm III in four runs

Pressure lb./sq. in.	Strain in μ in./in.					Average deviation from the mean	Percentage of Av. Devn. Av. strain
	1	2	3	4	Mean		
13·4	0	0	0	0	0	..	..
100	86	86	85	86	85·7	0·4	0·46
200	189	189	187·5	187·5	188·3	0·7	0·37
300	291	290	290	290	290·3	0·4	0·14
400	394	395	394	395	394·5	0·5	0·13
500	499	499	496·5	496·5	497·8	1·25	0·25
600	601·5	603	600·5	601·5	601·6	0·68	0·11
700	706	706	706	706	706	0·00	0·00

Apart from the accuracy, the method suggested above carries with it, all the advantages common to electrical methods, such as adaptability for remote control, wide choice of accessory apparatus, interchangeability of components, etc.

The variation of strain with pressure is being further examined.

Our sincere thanks are due to Prof. B. C. Carter, Head of the Department of Internal Combustion Engineering, for many helpful suggestions.

METALLOGENETIC EPOCHS IN INDIA

S. K. BOROOAH

(Department of Mines and Geology, Jodhpur)

CERTAIN relations between the formation of ore-deposits and other geological processes are now generally accepted, namely, that many metal deposits are closely associated with igneous activity, that igneous activity occurs in belts of strong folding and faulting in orogenic belts, and that ore depositions have been repeated through geological time resulting in rather definite periods in which metalliferous deposits have formed. These periods of metal deposition are known as metallogenetic epochs.

In Europe, four systems of folding or orogenic periods have been recognized, namely, Huronian (or Charnian), Caledonian, Hercynian and Alpine. Most of the metal deposits there result from igneous activity related to these periods of folding and faulting.

The Huronian movement is mainly confined to the great shield of Fenno-Scandia, to Sweden, Norway and Finland. The deposits carry mainly iron and copper. The rich magnetite deposit at Kirunavaara associated with a syenite porphyry is believed to be of this age.

The lead and zinc lodes of Leadhills and Wanlockhead in Scotland are attributed to the Caledonian folding as also the ores of copper, nickel, titanium and chromium of northern Norway connected with gabbros in the Cambrian-Silurian complex.

The Hercynian movement came between the Carboniferous and the Trias and resulted in great mountain chains extending east and west across Europe. In England, this is known as the Pennine-Armorican movement; and the formerly copper but now tin, and the lead and zinc lodes of Devon and Cornwall are genetically connected with the west-of-England granites. Although their direct association with any intrusive body is not obvious, the lead and zinc lodes in the Carboniferous limestone of the Pennine range at intervals from Derbyshire to Northumberland are connected with the Pennine folding.