instruments industry and the chemical industry and applied products reported greater relative increases in the federally financed portion of their research and development performance between 1961 and 1962. The 3·8 billion dollars for Federal research and development projects in the aircraft and missiles industry and the 1·6 billion dollars in the electrical equipment and communication industry together accounted for 80 per cent of federally financed industrial research and development performance in 1962.

Research and development performance by company funds totalled 4·8 billion dollars in 1962, or 6 per cent higher than the 4·6 billion reported for 1961. Company funds for industrial research and development performance more than doubled between 1953 and 1962. Company funds as a percentage of total research and development performance funds, however, declined from 61 per cent in 1953 to 42 per cent in 1962, reflecting the large increases in Federal funds during this period.

Funds for basic research performance in industry amounted to 361 million dollars in 1962, an increase of 14 per cent over the 1961-level. During 1962, industrial basic research comprised 4 per cent of total industrial research and development performance. Basic research funds increased 205 per cent between 1953 and 1962.

EXPLORATORY DRILLING FOR OIL IN SUSSEX

NATURAL gas was first observed in a water well at Hawkhurst, just across the border in Kent, in 1836. It was met with in the two sub-Wealden boreholes put down by the Sub-Wealden Exploration Committee of the British Association for the Advancement of Science near Mountfield, in 1872–76. These classic explorations incidentally led to the discovery of gypsum in the Purbeck beds in Sussex, the freshly broken mineral in many instances then, and as mined to-day, smelling strongly of petroleum. In 1896 a borehole for watering the then London, Brighton and South Coast Railway locomotives was made at Heathfield Station; it was 377 ft. deep, penetrating 38 ft. of Purbeck beds, and resulted in no worth-while water-supply; to compensate there was a strike of natural gas which at the time issued at a pressure of 140–200 lb./in.^{2}; it was of sufficient volume to ignite to a flame 16 ft. high, but in 1922 the best it could do was 3–4 ft. high, although still at that time being used for some station lighting. It was this Heathfield strike which first directed public attention to natural gas possibilities in Sussex. During 1897–99 the original deep Penshurst borehole, near Tonbridge, Kent, also proved Purbeck gypsiferous beds, and it is recorded that: "The shales associated with the gypsum were often bituminous, and all the beds smelt strongly of petroleum" (Lamplugh and Kitchen, 1911). Prospecting in a commercial sense in Sussex may be said to have started in 1902 with trial boreholes put down in the Heathfield–Mountfield–Battle area, during the 1907–9 phase of operations by the South Eastern Development Syndicate, Ltd., near Battle. Natural gas was discovered in many of these attempts, but nowhere in commercial quantity. Thereafter, further exploration for this purpose was abandoned and it is only within comparatively recent years that oil and gas potentialities of the sub-Wealden rocks of the south-coast counties, in particular, Sussex, Hampshire and Dorset, have been prominent in the exploration programmes planned for Great Britain by oil companies. Among the deep boreholes constructed during 1936–38 was another at Penshurst; one at Grove Hill, Hellingly; one at Henfield; another deep-well site near Brightling was explored in 1957, and now in 1963 there has been completed the 8,000-ft. borehole at Bolney, near Cuckfield.

This Bolney well was only 'spudded in' in May 1963; its completion, actually to a depth of 8,006 ft., within a few months, is in itself a tribute to the efficiency of modern oil-well drilling equipment and especially to the highly skilled engineers concerned with this project. "By mid-August the well at Bolney had already passed a depth of 7,000 feet and was drilling through the remains of the world of more than 300 million years ago. It was cutting through what the geologist called a marine formation of the Devonian period, which means that it had reached the bed of what had once been a Palæozoic ocean". This is the only official hint of what geological formation was actually penetrated at 7,000 ft., and is contained in a brief article published recently in the *Esso Magazine* (autumn issue, 12, No. 4; 1963). This exploration well, actually at Broxmead Lane, 1½ miles north-east of Bolney village, was drilled by the Esso Petroleum Co., Ltd., to confirm results of geological and seismic surveys conducted in this part of Sussex during the past two years. Unfortunately, it appears to have resulted in a dry hole, only gas shows at a comparatively shallow depth, as might have been anticipated from previous knowledge, being so far reported. However, what this venture may have lost in money and commercial oil results, the information it must have provided will prove of the greatest value in ultimate stratigraphical and, it is hoped, tectonic interpretations of the vertical section here deep in the heart of the central Weald. That the results of this borehole will lead to a re-assessment of oil and gas possibilities in Mesozoic and Palæozoic rocks lying beneath Sussex, if not of farther afield, is a safe guess.

In due course we may hope that the detailed log of the Bolney well will be published. These sort of pioneer adventures may understandably be treated as highly confidential at the time, especially when competitive oil interests in southern England are considered. But results are apt to remain in these circumstances buried in the archives, then forgotten for long afterwards, until a future generation has reason to seek to disinter vital data in appropriate geological investigations. None the less, however, there are some intriguing deductions, if not 'pointers', stemming from the clue of marine Devonian strata at 7,000 ft., as affecting the stratigraphical succession and structure of the rocks below Bolney, even if actual or potential oil and gas horizons yet remain elusive. Writing on the "Concealed Strata—Palaeozoic Systems" of the Weald, F. H. Edmunds (1954) says: "At the present day the general surface of the Palaeozoic rocks is that of an inclined plane, with a slope southward of about 1 in 50, i.e. a little over one degree; Palaeozoic rocks beneath London occur at about 1,000 ft. below sea-level; at Hellingly about 3,250 ft., at Penshurst about 4,550 ft., and at Henfield 4,850 ft., respectively below sea-level". Again, "It is noteworthy that at Penshurst, Jurassic rocks rest on Carboniferous Limestone, whilst at Hellingly and Henfield, the Palaeozoic surface is probably composed of Upper Coal Measures; these facts point to an eroded surface of folded rocks". The north-east–south-west straight-line distance between Penshurst and Henfield is about 26 miles; Bolney site is 6 miles along this line north-east of Henfield. The Palæozoic floor (surface) would on the basis of the foregoing data be anticipated at around −4,780 ft. O.D. Thus interpreted, it would appear that, finishing at a depth of more than 8,000 ft., it presupposes a determined minimum penetration of some 3,000 ft. of Palæozoic rocks here in the search for oil, a most hazardous venture unless purely geological information be the motive. If this deduction is not valid, then the probabilities can only be explained by some completely unsuspected, major change in structure beneath this part of the central Weald with a corresponding dramatic thickening of the Jurassic formations overlying the Palæozoic sequence, including the much-sought-after Kimmeridge Clay oil-bearing horizons.

It is not difficult to understand the selection of the Bolney site for deep exploration as such. The location is on Cretaceous rocks (Hastings Beds : Tunbridge Wells Sand), here influenced by a strong anticlinal (plus much faulting), traceable at intervals from near Fernhurst (west Weald), eastward beyond Cuckfield, then from Heathfield to just north of Battle, again near Crowhurst east-south-east to the coast, thence if prolonged in the same direction across the Straits of Dover into the Bas Boulonnais region of France, a total distance of approximately 125 miles. This is tectonically the central Weald axis; the Bolney site is in much the same position structurally as are the rocks responsible for the shallow-gas showings at Heathfield, Brightling and Battle.

The delineation of buried anticlinal structures in the Mesozoic rocks of Sussex, equally in their counterparts in Hampshire and Dorset, is to-day largely the outcome of modern geophysical techniques, and many such surveys by the oil companies have in recent years produced most exciting and impressive geological indications, but, it must be generally admitted, little more than that so far as commercial oil-pools are concerned (perhaps one exception may be at Kimmeridge itself, Dorset, in 1960, British Petroleum Exploration Co.). In the long run, it is the existence of adequate source and reservoir rocks coincident with optimum structures which determines the location of commercial oilfields. Of all geological formations involved in this region, particularly in Sussex, the Kimmeridge Clay shales and sandy beds offer the best prospects and this formation has hitherto been in the forefront of oil-finding projects, although potentialities of other Jurassic (? Palæozoic) rocks have not escaped consideration. In the Heathfield district, my own work strongly pointed to Kimmeridge Clay shales as source of the natural gas, with overlying Portland sandy beds as primary container (Milner, H. B., "The Geology of the Country around Heathfield", *Proc. Geol. Assoc.*, 33; 1922). Little has apparently happened to disturb this theory. I have long held the view that the Weald, as a geological and structural entity, is barren as regards *commercial* oil supplies, including gas, extending even to offshore drilling, at least along this part of the south coast. The *Esso Magazine* article quoted here begins on this chastening note: "There are some sad facts that haunt the dreams of oil men: eight out of every nine wells ever drilled have proved dry, and only one well in forty has ever tapped a major source of oil or gas". From a purely geological point of view, may it be that Bolney has not proved a nightmare and that more explorations of this scope and calibre are in store for us in more likely places.

H. B. MILNER

A THREE-COMPONENT RADIO SOURCE CONTAINING A WELL-ALIGNED MAGNETIC FIELD

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MILLS, Slee and Hill[1] have suggested that the source 13–*33*, the subject of this article, may be identified with the galaxy *IC* 4296. This is an elliptical galaxy the photographic magnitude of which is given by Becvar[2] as 11·9 and the angular dimensions of which are 0·6′ × 0·6′. Assuming the absolute magnitude of elliptical galaxies which are strong radio sources is −20·4 as found by Maltby, Matthews and Moffet[3] and correcting for 0·4 magnitudes of interstellar absorption the distance of *IC* 4296 is 24 Mpc. The source was found to be extended by Mills, Slee and Hill using a 50′ beam at 85 Mc/s. With the 210-ft. reflector of the Australian National Radio Astronomy Observatory operating at a wave-length of 11·3 cm the source is resolved into three clearly distinguished components. It consists of two extended components and a central one containing 30 per cent of the flux which is barely resolved with the 7·35′ beam. Details of the 11·3-cm positions, fluxes and observed angular widths of the sources are given in Table 1 and are illustrated in Fig. 1. The absolute positions are believed to be accurate to 0·5′ in each co-ordinate and the relative positions of the components are accurate to 0·2′. The position of the central source is in close agreement with the position of *IC* 4296 ($\alpha = 13^h 33^m 48^s$, $\delta = -33° 43'$ (1950)). The source structure is similar to that of Centaurus *A* (*NGC* 5128). At a distance of 24 Mpc the overall extent of 13–*33* is 240 kpc, somewhat smaller than that of Centaurus *A* but still large compared with the average source. Also the 11·3 cm brightness temperatures of the outer components of both sources are low, 10° K for 13–*33* and 3° K for Centaurus *A*, whereas that of the central sources is high, being of the order of 100° K for both objects.

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The linear polarization of the radio emission from 13–*33* was measured at wave-lengths 11·3, 21·3, 29·6 and 31·2 cm as a part of a programme in which the polarization of 150 sources was investigated. The percentage polarization and the position angle found at each wave-length are given in Table 1. The 11·3 cm polarization data for each of the three components could be obtained with the narrow beam at this wave-length. As the 21·3 cm beam-width is 14·0′, the flux and polarization data for the closely spaced components (*a*) and (*b*) which are separated by 10·8′ were obtained by making observations at the

Table 1. 11·3, 21·3, 29·6 AND 31·2 CM DATA FOR THE RADIO SOURCE 13–*33*

		Component (*a*)	Component (*b*)	Component (*c*)
Right ascension (1950)		$13^h 32^m 58^s$	$13^h 33^m 44^s$	$13^h 34^m 47^s$
Declination (1950)		−33°37·9′	−33°43·0′	−33°54·2′
11·3 cm	Observed angular width in R.A.	8·7′ ± 0·1′	7·4′ ± 0·1′	8·6′ ± 0·1′
	Observed angular width in Dec.	8·5′ ± 0·1′	7·6′ ± 0·1′	9·6′ ± 0·1′
	Peak intensity	2·7 f.u.	2·8 f.u.	2·0 f.u.
	Integrated intensity	3·7 f.u.	2·9 f.u.	3·0 f.u.
	Per cent polarization	7·3 ± 1·0%	20·8 ± 1·0%	24·0 ± 1·5%
	Position angle of polarization	92·5° ± 3°	103° ± 2°	94° ± 2°
21·3 cm	Intensity	5·9 f.u.	4·8 f.u.	4·2 f.u.
	Per cent polarization	3·7 ± 1%	12·2 ± 1%	19·9 ± 1%
	Position angle of polarization	39° ± 4°	49·5° ± 2°	31·3° ± 2°
29·6 cm*	Per cent polarization		9·4 ± 1·5%	
	Position angle of polarization		129° ± 3°	
31·2 cm*	Per cent polarization		7·0 ± 1·0%	
	Position angle of polarization		125 ± 3°	

* Includes contributions from components (*a*) and (*c*).