ing a time $t$ deduced from the observed rise of $i_d$. We assume that this barrier layer is a film of cuprous oxide. From the specific heat and the specific mass of cuprous oxide, and from the area of the barrier layer, we get its thickness $h$.

In this way we find a value for $h$ of $(2\cdot0–4\cdot1) \times 10^{-4}$ cm. (Westinghouse copper oxide rectifiers); that is, rather less than the Waibel value of 1936.

An extensive research on the dependence of $h$ upon several physical variables is now in progress.

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## Tensor Forces and the Neutron–Proton Interaction

IN a recent article, "On the Neutron–Proton Force"[1], Blatt has advanced cogent evidence for an "effective triplet range" of between $1\cdot30$ and $1\cdot55 \times 10^{-13}$ cm., that is, for a triplet range which would correspond to a square-well-width of between $1\cdot5$ and $1\cdot7 \times 10^{-13}$ cm. In view of the new importance given to investigations using well-widths of these magnitudes, the preliminary results of some calculations on the binding energy, quadrupole moment and magnetic moment of the deuteron may be of interest.

The work closely follows the classical calculations of Rarita and Schwinger[2], except that the ordinary and tensor force ranges are not assumed to be equal, and neither is restricted to $2\cdot8 \times 10^{-13}$ cm.; and that the labour of solution has been lightened by use of a differential analyser.

A paper by Guindon has just appeared[3] in which results of similar work for central force ranges of $2\cdot5–3 \times 10^{-13}$ cm. are given. His notation will be adhered to in this note. Four parameters are involved, namely, range of central force ($r_0$), range of tensor force ($\varepsilon r_0$), depth of (square) central well ($J$), depth of (square) tensor well ($\gamma J$). Thus, for any chosen value of $r_0$ we may expect to be able to satisfy three independent conditions. In Table 1 the values of $r_0$, $J$ and $\gamma J$ are such that, for each $r_0$, the correct binding energy $E$ and quadrupole moment $Q$, and a value of 4 per cent for the $D$-state probability, are obtained for the deuteron.

Table 1

| $r_0$ ($\times 10^{-13}$ cm.) | $\varepsilon r_0$ ($\times 10^{-13}$ cm.) | $J$ (MeV.) | $\gamma J$ (MeV.) | Conditions satisfied |
|---|---|---|---|---|
| 1·6 | 3·08 | 39·3 | 10·04 | $E = 2\cdot185$ MeV. |
| 1·8 | 3·04 | 31·8 | 9·52 | $Q = 2\cdot73 \times 10^{-27}$ cm.$^2$ |
| 2·0 | 3·00 | 25·9 | 9·46 | 4 per cent $D$ state |
| 2·2 | 2·94 | 20·2 | 9·85 | |

Work is still in progress, but it is estimated that the error in the above values is well under 5 per cent, and the final results, which will be given later, should be at least accurate to 1 per cent. The value of 4 per cent for the $D$-state probability is deduced from the experimental values[4] of the magnetic moments of the neutron, proton and deuteron using the non-relativistic theory given in ref. 2. The validity of this theory is particularly dubious when the ranges are as small as those considered here[5]. Tables similar to Table 1 are available for $D$ probabilities of 2–5 per cent.

Approximate sets of values have been found for $r_0 = 1\cdot2 \times 10^{-13}$ cm. to $r_0 = 2\cdot8 \times 10^{-13}$ cm., but with less accuracy than those given in Table 1. The values obtained at $r_0 = 2\cdot8 \times 10^{-13}$ cm. may be of interest for comparison with the (accurate) values given by Rarita and Schwinger.

Table 2

| | $r_0$ ($\times 10^{-13}$ cm.) | $\varepsilon r_0$ ($\times 10^{-13}$ cm.) | $J$ (MeV.) | $\gamma J$ (MeV.) | Conditions satisfied |
|---|---|---|---|---|---|
| Rarita and Schwinger | 2·8 | 2·8 | 13·89 | 10·76 | $E = 2\cdot17$ MeV.; $Q = 2\cdot73 \times 10^{-27}$ cm.$^2$. 3·9 per cent $D$-state |
| Differential analyser | 2·8 | 2·77 | 13·6 | 10·6 | $E = 2\cdot185$ MeV.; $Q = 2\cdot73 \times 10^{-27}$ cm.$^2$. 4 per cent $D$-state |

In presenting these preliminary results, I should like to express my thanks, first to Dr. N. Kemmer, under whose helpful direction this work has been done, and also to Dr. M. V. Wilkes and Mr. B. Noble of the Mathematical Laboratory, Cambridge, the former for his generous provision of facilities in the Laboratory, and the latter for extensive and expert help and advice in putting the problem on the differential analyser.

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[1] *Phys. Rev.*, **74**, 92 (1948).
[2] *Phys. Rev.*, **59**, 436 (1941).
[3] *Phys. Rev.*, **74**, 145 (1948).
[4] Arnold and Roberts, *Phys. Rev.*, **71**, 878 (1947).
[5] *Phys. Rev.*, **72** (Sachs, 91; Primakoff, 118; Breit and Bloch, 135) (1947).

## Study of the Rheological Properties of Rapidly Thickening Colloidal Systems by Means of the Stormer Viscometer

IT has been shown recently by Lindsley and Fischer[1] that by simplifying the design of the Stormer rotational viscometer and by varying the effective length of the inner cylinder to eliminate end-effect, viscosity may be expressed in terms of the relevant dimensions of the instrument, the weights used and the observed rate of revolution. Further, for Newtonian liquids the viscosity is proportional to both the actuating weight and the time for an arbitrary number of revolutions.

Independent studies in this laboratory have shown that the equation $\eta = KWt$ also gives a good estimate of viscosity when applied to the commercial Stormer viscometer[2] (with vanes and baffle) over the following ranges of variables: viscosity $\eta$ from 2 to at least 75 p., actuating weight $W$ from 100 to 500 gm., time $t$ for 100 revolutions greater than 18 sec. The instrumental constant $K$ was determined statistically for our instrument as $2\cdot93 \times 10^{-4}$. Liquids of known viscosity (glycerol solutions of various concentrations and mineral oils) were used in the investigation. For values of $\eta$ between $1\cdot5$ cp. and 2 p., and of $W$ between 10 gm. and 100 gm., where influences such as kinetic energy are more pronounced, an additional term is required in the