rockets was conceived in 1909; the general theory was put in satisfactory form in 1912; and the use of these substances mentioned in Smithsonian Miscellaneous Collections, Vol. 71, No. 2, for 1919. Oberth, on the other hand, claims in his book to have made his first finished plan of a rocket to use wet gun-cotton in 1909, and to have drawn up his first plan of an hydrogen-oxygen rocket in 1912.

Further, as to the use of liquid propellants and continuous combustion, these were suggested by me, *by publication*, in 1914, and were *tested experimentally* in 1921, the development carried on under my direction since that time having been confined entirely to rockets of this type.

It may be mentioned here that a request was received from Herr Oberth, dated May 3, 1922, stating that he had been working for some years on the problem of passing over the atmosphere of the earth, and requesting me to send any books I might have on the subject. Compliance was made by sending a copy of the above Smithsonian publication; and a copy of Herr Oberth's monograph, which incidentally deals with theory rather than with experiments performed, was received on July 19, 1923.

As to the idea of a passenger-carrying rocket, and the reaching of planetary distances, it is only fair to say that, while I have considered these matters with much care, and have gone so far as to make laboratory tests to check my conclusions, I am now, and always have been, only too well aware of the conservatism of the average person regarding new applications of physics. Thus, because it has been my desire to make actual progress and to conduct actual experiments, I have endeavoured, so far as possible, to focus attention on the problems that lie immediately ahead, the first of which is an exploration of the earth's atmosphere, and have restricted the discussion of certain sensational, but nevertheless interesting and realisable, matters to confidential reports.

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Five- (and Six)-Point Support: "Right as a Trivet."

As practical problems are usually a function of several variables, individual opinions are determined by the order of importance attached to the variables. The more numerous the conditions, the truer becomes the old expression, "Quot homines tot sententiae."

If in this question of fits we place pure mathematical and geometrical principles first, we have one point of view. As there are others which I think largely determine the workshop attitude and possibly the "Enfield Tradition," I should like to refer to some of them very briefly; to do so fully is not possible in a letter.

Let us consider the example from Thomson and Tait quoted by Sir George Greenhill in his letter in NATURE of September 27. It is stated therein that "the rifle may be replaced any number of times in precisely the same position." If much accuracy is demanded, that statement is not correct, because the materials at the points of support, where the forces of impact may be considerable, swage or wear away and quickly so when the parts are handled as they must be in the workshop.

In designing our apparatus we must consider the physical properties of the materials as well as the geometrical principles involved. The materials determine the areas over which the loads must be distributed and, if they cannot be approximately points, what value are we to attach to the principles of geometrical fits?

To demonstrate the practical application of these principles Thomson and Tait selected a bad example; as in the case of a rifle the convex abutments cannot be placed in their more proper geometrical position within the bore. Suppose a cylinder mounted in the manner described has longitudinal freedom and is constrained transversely: the slightest bend of the cylinder under its own weight, or by the action of the sun on one side of it, may destroy the longitudinal freedom, as the circular section of the fixed abutments must then accommodate an elliptic section of the piece.

The geometrical principle is based on the assumption that *all* the parts involved are absolutely rigid. We practical men, whose business it is to understand the limitations of materials, dare make no such assumption. In the workshop most of us are thoroughly familiar with geometrical principles. We were taught them in the universities and colleges. If we do not slavishly adopt them, it is generally with good reasons.

There has been within the past few years a good deal of adverse criticism of the practical trial-and-error type of man in industry, the articles having usually for their text "The Neglect of Science by Industry." If the writers of these articles were better informed, I feel sure they would find the converse text "The Neglect of Industry by Science" a more appropriate one.

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October 7.

Fine Structures in Non-Hydrogenic Atoms.[1]

FOR some months we have been studying the data on fine structures of the lines of non-hydrogenic atoms. These fine structures arise, in every case so far studied, from transitions between the components of complex spectral levels. Save for a few isolated examples, it can be readily proved that fine structures are not due to isotopy. (See Scientific Paper No. 490 of the Bureau of Standards.)

It is necessary in certain cases to introduce a *fine quantum number f*, the values of which characterise the different components of a complex level. In some elements, a selection principle for this quantum number makes its presence felt, and the separations of the components are in integral ratios. So far, attempts to establish intensity rules have failed, but this part of the work is not finished.

Nagaoka, Sugiura, and Mishima (*Jap. Jour. of Physics*, 2, 121, 1923) have published measurements of mercury fine structures which are precise to almost 10^{-4} A. These data have enabled us to analyse successfully the complicated fine structures of nearly all the mercury lines they studied.

The phenomena of fine structures are so diverse that we cannot hope to have a unified physical explanation for them. In isolated cases, such as the 4_4 terms of Al^+ studied by Paschen, they may be due to relativity. In other cases, the components of a complex level behave like a tiny multiplet, and the structure may depend on magnetism for its origin. In other cases, magnetic fields do not affect the fine structures, and we must look to unknown dynamical peculiarities of the individual element for an explanation.

A paper covering the whole field will soon be published.

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Bureau of Standards,
Washington, D.C., U.S.A,
August 23.

[1] Published by permission of the Director, Bureau of Standards, of the U.S. Department of Commerce.