THE TRAINING OF ENGINEERING DESIGNERS

BY

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In a recent lecture, reprinted in THE ENGINEER *of May* 22, 1953, *Professor Ewen M'Ewen suggested that engineering undergraduates should undertake real design work as part of their training. The following are some notes of such a scheme in being at the Royal Naval Engineering College. The article is reproduced from* THE ENGINEER *of June* 26, 1953.

The training of engineer officers of the Marine Engineering Specialization at the Royal Naval Engineering College, Plymouth, consists of a two-year ' Basic Engineering ' course roughly equivalent to a degree course, followed by a year at sea and then by a year's ' post-graduate ' course. All officers are considered sufficiently trained for maintenance work in the marine engineering field after the period spent at sea and a short ' consolidation ' course. The ' post-graduate ' course in marine engineering which follows is thus intended, *inter alia*, to give young officers an insight into the problems of design, such as will enable them to co-operate with industry in ensuring the progress of naval engineering equipment. These courses were planned in close consultation with the universities and industry : they place full weight on the need to educate and develop reasoning power as well as to instil a knowledge of the applied sciences and of the technical material necessary to naval marine engineers. Even so, at an early stage during the first such course to be undertaken, the need for some practical design work became apparent. A series of pilot experiments was accordingly decided upon.

At the time the main reasons for this undertaking were to give experience in the application and integration of the applied sciences, mechanical drawing and workshop practice in a real case ; to bring home the extent to which design consists of a skilful but arbitrary disposition of carefully selected materials, having regard to production techniques, rather than a series of stress calculations, and to give students an insight into the practical snags likely to be encountered in the manufacturing stage (e.g. holes inaccessible to the drill, distortion of a bore by external welded attachments).

Method

The method of carrying out this ' design and make ' task evolved by experience of three attempts is described in the paragraphs that follow.

The class is divided into teams, each ideally of five officers. Each member of the team is given a specific duty, the remainder working under him in the exercise of his particular function, as follows :—

(*a*) Managing director—responsible for all correspondence, contracts and other dealings with the staff of the College.

(*b*) Chief designer.

(*c*) Chief draughtsman.

(*d*) Works manager.

(*e*) Cost accountant.

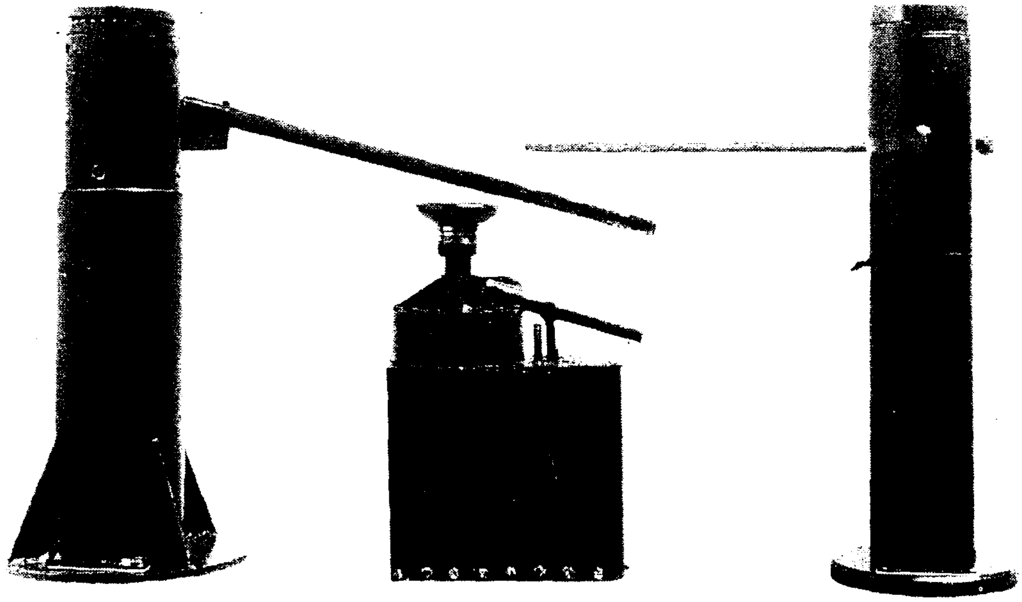

FIG. 1—THREE DESIGNS OF JACKS

Left—' Nifty Lift ' Design. Centre—' Incognita ' Design. Right—' Up-u-Jack ' Design.

The task, which is the same for all teams of a particular class which compete against each other, is required to be designed on the basis of 100 ' off.' Each ' company ' assumes a title of its own devising (this often involves almost as much thought as the design itself) and, dealing with the College staff by correspondence under an appropriate letter-head, first submits its design to the staff officer in charge of machine design instruction. Subsequently working drawings are prepared and submitted to the appropriate staff officer and, when these are passed, materials and standard items (ball bearings, for example) are ordered from the officer in charge of workshops.

Experience has shown the necessity of permitting pattern work and certain other work requiring special skills or techniques to be ' ordered out.' In such cases a proper form of contract has to be prepared and a 25 per cent surcharge on the work carried out (by workshop instructors) has to be ' paid.'

Work in the shops then proceeds. Job cards are kept for each item and the cost estimated. In general, manufacturing costs are charged in full, on a standard 4*s.* per hour basis, whilst the cost of modification and other ' development ' work as well as design and drawing work is spread over the 100 items.

The completed jobs are then submitted to appropriate tests.

Finally, at a meeting presided over by the Commanding Officer, the designs submitted are examined in detail, marks are awarded for soundness of design, performance, assessed reliability, lightness, low cost, efficiency, original features, etc., and the winning design is selected.

A total of eighty-eight hours of ' time-table ' time is provided for this work but, even with teams of five, this is inadequate. The remainder of the time required, amounting to perhaps fifty to sixty hours each, has to be put in by the student officers concerned at their own convenience.

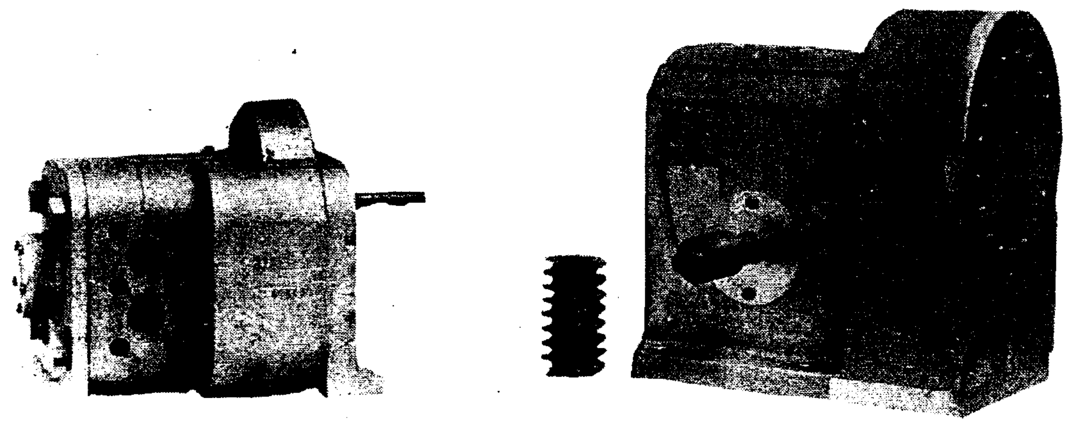

FIG. 2—TWO DESIGNS OF 2 H.P. PNEUMATIC MOTORS

Left—'Whirlwind' Design. Right—'Power Puff' Design.

The hob shown was designed and made by the 'Power Puff' team for cutting the worm wheel used in the reduction gear.

Examples

The first task set was not, naturally, an ambitious one. It consisted of a jack, working load 5 tons, capable of an 8 inch lift, the head to be capable of rotation under load. The three designs produced are shown in FIG. 1. Detailed comments on them would be out of place, but it may be mentioned that, although stayed, the spectacle of the $7\frac{1}{2}$-ton test load swaying gently on the somewhat flimsy 'Incognita' design, at full lift, was truly alarming! The authors thereof are unlikely to neglect the effect of eccentric loads or potential 'strut' failure in the future; nevertheless, they incorporated ideas that, with better design, might have won the day.

The second task was to produce a pneumatic motor capable, when operated off the shop air main, of producing 2 h.p. at 500 r.p.m. High 'static' torque was specified and tests at continuous full output for a minimum of ten minutes had to be achieved. The class was a small one and only two designs were undertaken. Both, one a vane type and the other a Pelton wheel (blades machined from the solid), were successful and to adjudge the winning design was a difficult task. It is worthy of note that both would have been equally successful if the design task had been to produce an air-raid siren! The two motors are shown in FIG. 2.

The third and, to date, both the latest and the most difficult task completed was to produce an air compressor capable, when driven by a given motor, of pumping a large air reservoir up to 60 lb per square inch in a set time. The time, with motor and reservoir details, was chosen so as to require a good volumetric and overall efficiency. Three designs were produced and are illustrated in FIG. 3; they comprise a conventional reciprocating and two vane types. The 'Umbalair' designers became involved in an attempt to reduce centrifugal rubbing loads, and thus wear, by the use of non-radial vanes, which produced unexpected complications, and they failed to achieve the test. The 'Eezi-Squeezi' design, a most 'fluent' one with 'pressurized lubrication,' 'fully floating' liner and other selling points which were heavily stressed when the design was placed before the judging committee, failed the test by a small margin due to 'lack of time for development.' The conventional design won the day, mainly by virtue of its successful test performance.

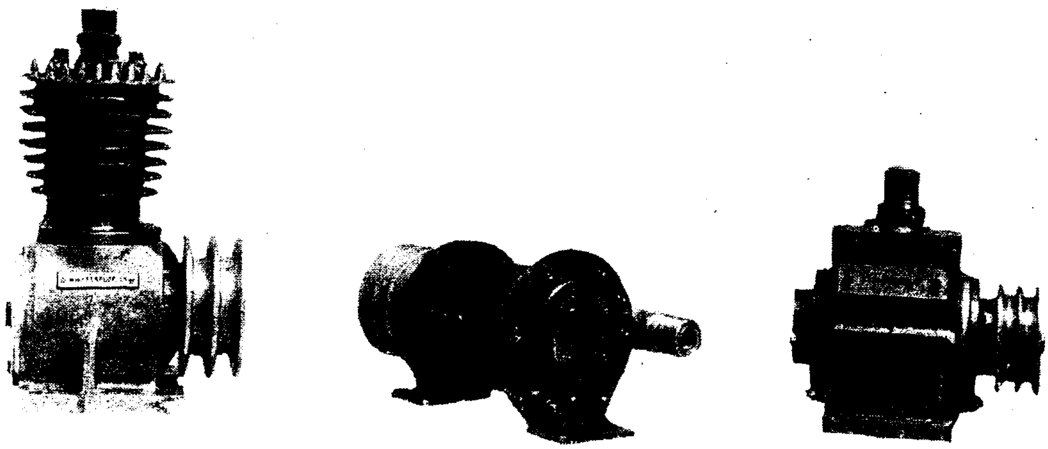

FIG. 3—AIR COMPRESSOR DESIGNS

Left—' Whiffenpuff ' Design. Centre—' Umbalair ' Design. Right—' Eezi-Squeezi ' Design.

Comments and Future Intentions

The enthusiasm and interest aroused by these ' design-and-make ' projects among the student officers has been remarkable and very gratifying. At the same time there seems little doubt of their value to the professional training of the young men concerned. It is felt that not only has the aim of the experiments been largely achieved, but also that the time that must be allotted is not excessive. The additional load on the teaching staff, observing that too much guidance is undesirable, has not been found to be a serious factor. It is hoped, in the future, to be able to include similar design projects in the courses given to specialists in other fields.