CORRESPONDENCE

SIR,

Engineering Fundamentals

When I was a student, fifty years ago or more, text books of applied mechanics listed and classified the elements of mechanism, the so-called ' Mechanical Powers ' of still earlier text books. The number of these elements varied with the ideas of the author : there were the lever—three different systems according to the relative positions of the power, the weight, and the fulcrum. There was the inclined plane, the wedge, the endless screw, or worm and wheel, and almost innumerable systems of pulleys, the Chinese windlass (differential pulley block), spur gearing, and probably others as well. All these had the property of transmitting work or energy, the force applied, or available, varying inversely as the speed or distance moved of its point of application.

All these apparently different ' mechanical powers ' can be whittled down and shown as applications of a very few basic principles. The wedge, the inclined plane, and the screw or worm are obviously the same. The fact that the lever and pulley systems are also the same is not so clear, but in any pulley and cord system the pulleys can be replaced, for small movements, by equal-armed levers. The pulley is merely a continuous lever, just as the screw is merely a continuous wedge, or inclined plane. The wheel and axle are merely pulleys—or levers—and the roller, as used to eliminate friction, is merely a lever again. All spur gears, including epicyclic and other differential gears can, like pulley systems, be replaced, for small motions, by lever systems.

Further consideration of these so-called ' fundamentals ' shows that they are nothing of the kind. With the exception of the wedge and the lever, which can be defined as ratio gears for linear and rotary motion respectively (the screw being a combination of both), they are elementary mechanical devices believed, in the earlier days of natural philosophy, to be different in some way, like the various kinds of electricity, static, galvanic, voltaic, and faradic, of the earlier years of application. The real fundamentals are principles, such as are defined by Newton's or Faraday's laws, which can be extended to deal with any particular application, for example, the force, mass, weight and acceleration business, about which some confusion seems to exist.

One of the worst pitfalls is to try to define and relate force, weight, mass and acceleration to the satisfaction of another. The reason for the confusion is probably that each of us thinks of the problem in his own way. Both may have identical principles in view and, faced with a problem, would arrive at the same conclusion, but the terms of thought are different. An interesting and illuminating exercise in this field is to take two clocks, one with a pendulum and one with a spring balance escapement, to the moon and consider what different sorts of time they would keep, and why. They could be checked by a quartz crystal timer, independent of gravity, mass, etc.

The ready made formulae like : $p = m \times f$, or $T = \pi\sqrt{L/g}$ which can so easily be learned by heart, may lead one astray if proper attention is not firmly held on the real inner meaning of the symbols used. Unless this is done, and there is some qualifying condition implied, they may not represent any fundamental truths at all. Similar considerations to the above probably apply to thermodynamic problems and, even more so, to those involving atomic energy, about which fields I would not presume to write. It was said by some philosopher that in important matters there are no easy short cuts. I think that this probably applies more to these fundamental questions than to anything else. One must understand the general nature of a problem to be able to apply the simple formulae with confidence, except under restricted conditions.

There was a concluding paragraph in Lieutenant-Commander Bowers' 'Review of Fundamentals' (Vol. 8, No. 4) that I was so surprised to see in an engineering journal that I must run the risk of quoting it in full, and asking my readers to read it *slowly* :—

'It may be noted that the mechanics and thermodynamics of a problem are finished when the problem is stated in symbols and the symbols have been connected by experimental laws. The solution, if any, is then implicit in the resulting equations and by applying the arts of the mathematician, metallurgist, economist and administrator it can be extracted and put to good effect.'

The engineer has evidently no part in this work.

If only this were true ! If only these theoretical matters would serve as they stand, expressed on paper, and that we did not have to go through the severe discipline and hard work of turning the ideas into apporpriate useful iron-mongery! To the marine engineer in particular a solution of a problem in terms of equation is of no use whatever, except in so far as these may serve as a preliminary step to the creation of the appropriate hardware. In this, perhaps the most fundamental and important part of all, the five contributors mentioned in the paragraph quoted can play little, if any, effective part : they are dependent on the creative work of others. It is here that the engineer comes in, in a role which is difficult to define briefly on paper, but unless it is well done, all else fails.

(*Sgd.*) H. CLAUSEN.

SIR,

Seized Nuts

Many readers, both officers and artificers, must have cursed nuts on steam systems which have seized solid and had to be chipped off or split to remove them.

They may be interested in the results of a small-scale experiment made in H.M.S. *Bulwark*.

The threads of bolts in a few selected flanges were treated with various compounds ; others were left untreated as control specimens.

On dismantling a year later, all the treated specimens could be unscrewed easily. The untreated specimens were significantly harder to unscrew ; many had to be driven off by hammer and chisel, and one was seized solid and had to be removed by splitting it.

Three compounds were used : two proprietary graphite lubricants supplied by Admiralty for test, and Detel DMU paint. There was little to choose between their effectiveness.

No doubt there are many other compounds equally suitable, but Detel DMU is already available in the *Rate Book*, pattern No. 4300A.

B.R. 1988, Clause 0432 is relevant.

(*Sgd.*) J. SIDGWICK,
Commander, R.N.

Comment by E.-in-C.

The mechanism by which Detel DMU achieves such performance is not understood. The DMU is a paint, heavily loaded with metallic zinc dust, and it can function in one of two ways :—

(*a*) By providing a very easily sheared separating layer between the two mating surfaces, or

(*b*) By providing a barrier of entirely different characteristics between two similar oxide films which, without such a barrier, would tend to weld together.

If other ships experiment with Detel DMU, E.-in-C. would welcome reports on their experience.

In using Detel DMU, particular care should be exercised to wipe off any surplus paint which might drip on the pipes, especially if of carbon or chrome molybdenum steel.

SIR,

Work Study

Your Correspondent in the *Journal of Naval Engineering* (Vol. 10, No. 3), writing over the nom-de-plume of ' K ', well succeeds in his expressed intention to display a profound ignorance of Work Study.

The article by Lieutenant-Commander Dibsdall in the same issue may serve to enlighten him regarding the methods used, but a few words in general terms on this thorny subject may also be acceptable. Surely the first thing to realize is that Work Study is not an invention, not an improved administrative procedure, but simply a technique to be learnt and applied. Because of this, there is no reason for ' K ' to fear a paper avalanche from Bath. Work Study bears a similar relationship to ' simply getting on with the job ', as a mechanical drawing does to a freehand perspective sketch. The latter is more common-sense, but the former more useful.

By the application of Work Study it is possible for administrative authorities to obtain a realistic estimate of the man-power and time required for any job, so that complements can be more accurately laid down. Moreover, the need for adjustment to complement can be clearly and simply established by ships and shore establishments. This should lead to a decrease in the amount of late work necessary and even ' K ' may find himself more often in his bunk during the middle watch.

Finally, it must not be thought that Work Study, is solely or even chiefly, applicable to repair work. Indeed, it pays best when used to co-ordinate a repetitive, multiple activity such as the serving and sighting of a large weapon, or the launching of aircraft from a catapult. Work Study is particularly valuable if built into the construction and lay-out of plant, and the sooner we apply this valuable technique to the construction of ships, their weapons and their machinery, the sooner will we be able to cancel and forget Admiralty Fleet Order 2074/57.

(*Sgd.*) H. J. S. BANKS,
Commander, R.N.

SIR,

Work Study

Work Study is surely a process of elimination of wasted effort. A Work Study specialist applied the technique to his wife's preparation of breakfast. Before work study she took twenty minutes. Now he does it in twelve minutes.

' HUGH MOORE '

SIR,

False Gods

In reply to the invitation of Captain Wheeldon to comment on his article in Vol. 10, No. 3 of the *Journal*, I think the first essential is to make quite clear what is meant by ' repair by replacement '. It was certainly never intended to mean the replacement of a defunct unit by a spare demanded from Eaglescliffe.

The scheme of repair by replacement is applied to the Fleet in two conceptions, one for large ships and one for small, but the aim, to reduce the time that machinery is out of action for maintenance and repair, is common to both.

Let us first consider the scheme as applied to large ships. Space, weight and expense penalties will be incurred by carrying about two tons of additional spare gear in the shape of sub-assemblies for turbo-driven pumps, generators, boiler mountings, distilling plant, etc. The advantages, however, will include increased availability of machinery and a more even load on the workshop staff. For example, during the internal cleaning of a pair of boilers in *Eagle*, which normally takes five days, all air cocks can be replaced by refitted spares using relatively unskilled personnel. If these air cocks are to be refitted *in situ*, with the labour likely to be available the time would greatly exceed five days.

With small ships the scheme must work in a different way. In very small ships (I.M.S.s and M.T.B.s), no replacement units can be carried and in some cases no personnel capable of undertaking anything other than running maintenance and greasing, are borne. These ships must, therefore, be maintained by repair by replacement, the necessary spare units being carried in the depot or depot ship. In destroyers and frigates, small quantities of sub-assemblies can be carried and the balance necessary to support a repair by replacement scheme can be held in the depot ship. Many will no doubt be thinking ' Ah, here's this expensive and vulnerable stores carrier '. Don't let us fool ourselves ; modern destroyers and frigates must have depot ships. It can easily be shown that, to obtain a reasonable operational availability, they must depend on outside support for more than 50 per cent of their maintenance effort and, if the Fleet is to operate in Task Groups, regular rendezvous with depot ships will be necessary for replenishment and maintenance periods. Why not, then, carry a comparatively modest quantity of spare sub-assemblies and cash in on the extra operational availability ? The depot ships have plenty of time and effort to recondition worn units removed from ships.

It will be noticed that Eaglescliffe does not come into this operational scheme and urgent demands for replacement parts would certainly be far less than those made under the old ' repair while you wait ' scheme.

I maintain that the above concepts of repair by replacement are comparatively new and have no officially sponsored precedent in the Fleet which can be said to be the reason for its existence now. Its success in the ' air ' world has shown us how it could benefit the Fleet, particularly small craft.

With regard to the suggestion that we should accept lower powers to achieve greater availability, surely this is retrogressive. Higher powers per unit weight (a ' must ' in war) should certainly be our aim, but let us direct the designer's skill to the maintainer's problem which has tended to be pushed into the background in recent years. Most cases of poor performance of machinery in modern ships arise because we are unable to repair by replacement and must, therefore, resort to tinkering *in situ* with machinery made to very fine limits.

Captain Wheeldon does well to place an arm round the idol—it's worth cultivating !

(*Sgd.*) M. GRIFFIN,
Commander, R.N.