LOGIC IN ENGINEERING

BY

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A letter in the *Journal* (Vol. 9, No. 1, of January, 1956) expresses regret that the science of logic is seldom taught to engineers as an essential fundamental : without it the engineer is likely to lose his way and, properly applied, it can make all the difference between failure and success in engineering matters. Much depends on how ' logic ' is defined : no one would say that engineering is not a logical process, but the science of logic as usually defined and as formally taught deals solely with ideas, whereas engineering is a practical art, dealing always—in the end—with material things.

It may well be that in the analytical stages of any engineering development logic takes a large part. The gist of this work is often applied mathematics, and mathematics may perhaps be said to be applied logic, though not quite : solutions to equations are often just as empirical as many engineering processes, needing experienced craftsmanship rather than science. Much of engineering is more of an art than a science ; the difference may not always be clear, but with a science it may be sufficient to understand it, and be able to explain and expound it. With an art, on the other hand, it is always necessary to *do* something, to execute it in material reality, and to produce, not ideas expressed in words, symbols, or figures, but the material things themselves. While any art must have a kind of logic of its own, its dependence on the science of logic, as usually taught, seems small. In a science, in so far as it can take the form of ideas expressed in words or symbols, formal logic may play a very large part—almost the whole. We are exercising a medium in which logic may be supreme, but the weakness of the idea that formal logic is an essential fundamental of engineering appears on approaching the material stage, where words have little, if any, meaning, or value. The essence of the thing can only be expressed by the thing itself or by proper engineering drawings (not pictures) of it.

It would be of great interest to know the views of the great engineers of the past as to the part which logic played in their achievements. It would not, I think, be a very large one. Logic can build up a vast, and apparently safe, structure on a few assumptions or premises. The engineer can rarely afford to do this. As the structure—or rather the design of it—grows, he must ask himself, at every step, ' Are my foundations good enough to support all this ? Is this superstructure justified ? ' When dealing only with ideas one can assume the premises as sound and argue from them, and in the end if the solution appears absurd it can be discarded, and no harm done. Not so the engineering product, whether it be a bridge or a dam, or a new gas turbine. It is perhaps characteristic of formal logic that it relies on its initial assumptions and lacks the elasticity of a ' feed back ' system whereby the conclusion, as it is being developed, may modify the premises, and so change the whole situation. Whether the work of men such as Brunel, the Stephensons, father and son, or Whitworth, would have been any better if they had had more training in formal logic seems very doubtful.

In many engineering problems there are two divisions : deciding what is to be done, and doing it. Although a good deal of the latter may be necessary before a decision can be made, the decision is usually a philosophical, or logical question ; the doing of it more of a creative or mechanical one. The first is an

administrative and the second an executive problem. The engineer must remember that his problems can rarely be so classed, or rather that the two aspects can rarely be so separated. He must deal with both parts, and the doing of it, or perhaps showing how it can be done, may need qualities and abilities equal to those needed for the first part, the decision as to what is to be done.

An essential difference between an art and a science has been given in that science is based on laws, formulated as a result of observation and measurement, and sufficiently well established to be considered certain in their application so that, by following these laws, certainty in results can be expected. The experimental work of science lies in establishing these laws, and here logic can play a large part if due regard is paid to the limitations of observation and deduction. Usually, in an art, such as engineering can be considered to be (the various relevant sciences serve, as it were, as handmaids to the art) the laws—except as covers some of the auxiliary sciences—are not fully known. The artist, or engineer, though perhaps guided by formal sciences (including logic) must work largely in the region of the unknown, guided by his own judgment, which may be innate or may be the result of accumulated experience.

The scientist may work in a similar way, but unless the sequence of thought is apparent and clear he may condemn the results of the engineer's judgment as not scientific, but merely empirical. The engineer, though seeing the steps of reason by which the scientist approaches his conclusion, may throw them all on one side and adopt another, to which his instinct leads him. The science and the art of engineering are partners, working in double harness, and it is sometimes rather an uneasy partnership. At their best, however, they merge, and the art at its highest development becomes a science in exactly the same way as the science—at its best—becomes an art. Just as science, properly applied, can lead to the development of a technology, so technology applied in the relevant directions, can provide the material and physical basis of a science. All these are essentially logical processes, but the value to an engineer of training in the science of logic, as it is expounded in the literature of the subject, appears very doubtful.