MATERIALS FOR PRODUCT DEVELOPMENT 1953

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The Role of Engineering Materials in Today's Business

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THROUGHOUT history, we have marked various eras through which civilization passed by designating them as "ages." Our history books are filled with references to the various ages—stone, bronze, iron—and now we are searching about for a materials designation that will distinguish the present. It will be difficult to find an accurate and all-inclusive name, I'm afraid, because so many materials have become so essential to our current economy that it would be inaccurate to give the accolade to any one. In addition, there are so many new materials coming along that hold out promising futures that one would be foolhardy to predict the top role for any one of them. In addition to zirconium, titanium, and other new metals, cast irons and steels are now being improved to the point where they can almost be considered new materials. Plastics, ceramics, and engineering glasses are being called upon to serve where metal fails. So who can say what material is going to have the top spot? It is more logical to assume that all will be important in our future.

In the early days of industry as we now think of it, the choice of a material for any product was usually dictated by circumstances. In other words, the material nearest at hand was the one that was used. Trail-blazers in the field now known as materials engineering were required to take what was available in the way of materials and adapt it as best they could to the product they were responsible for.

Today the selection of an engineering material for any product, whether it be a toy train or a jet engine, has become such a complex problem that a person responsible for making an ultimate choice must not only possess a sound engineering background in all manner of materials, but also be highly imaginative. For today, it is not enough that a product be made to an engineering specification so that it will function efficiently; it must also have good sales appeal.

Two Illustrations

Illustrative of that latter thought is the fact that so many products being made and sold today are being promoted as being made of specific materials, or the public is made aware that the outstanding features of the products are possible only because the manufacturer relied upon certain specific materials.

Anyone watching the progress of electronic equipment cannot fail to be aware of new components known as transistors. Transistors are being considered for items ranging from hearing aids to such complex electronic equipment as television sets and computing machines. Transistors, to describe them briefly, are simply little chunks of certain materials which have extraordinary electrical properties.

Dictating machines once were heavy and bulky. Now, because competition has dictated improvements, dictating machines are so light and compact that they can be carried about in an ordinary briefcase. In addition to being lighter in weight, more compact and more attractive, the machines are more efficient. The intelligent use of new materials has made all these improvements possible.

These two illustrations help to show that under today's conditions a materials engineer must know what a material can and cannot do, and, equally important, must know whether that particular material can be used to advantage in providing a product with additional sales appeal. In some products the sales appeal will be largely visual; but in many others, the sales appeal will be based on greater value to the user.

Effect of Costs

There is one other important area in which the choice of materials can be important. Today labor costs are high and appear to be going higher. At the same time, there is a certain amount of consumer resistance to high prices. Thus, it will be necessary for manufacturers to reduce costs in any way they can. One of the most logical places for them to look is in their materials departments. There are only a few materials today that have such unique properties that they alone can be used for certain applications. Usually there are two, three, four, or even more materials that can be considered for any one product or part. It becomes necessary that the materials men find the best material at the lowest cost. Today that often involves making a complete break from tradition and discarding an old familiar material and going on to something new.

In summary, it might be said that we are just beginning to approach the frontiers in engineering materials and as each frontier is approached, a new one appears on the horizon. Where it once took a couple of generations to discover, perfect, and understand a new material, we are now forced to achieve the same results in a few years. Thus it would seem that the future of engineering materials is going to be interesting, exciting, and above all—fast moving.

Materials and the Future

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I HAVE the feeling of being present, this morning, at a really significant occasion. This conference presents solid testimony that we in the United States are now at last recognizing and taking hold of the most important, and hitherto the most neglected, problem in the worlds jointly occupied by industry and engineering, politics and government. We are becoming conscious that not only our prosperity but our existence depend upon our ability to dig stuff out of the earth—or the sea or the air—at satisfactory rates and costs. This cannot be a static situation; the rate has got to keep on going up and the costs have got to keep on coming down. If these two things do not happen, our economic reaction slows or stops.

Present Consumption of Materials

First of all, what *is* the materials problem? Basically, I think it can be considered that it has just one fundamental, rooted in mathematics. It is that our consumption of everything is rising along an exponential curve, and that our reserves, whatever else they may be doing, are certainly not doing *that*. So we are off balance—rather badly so. Today, we as a nation consume two and a half *billion* tons of materials of all sorts every year. That is some 18,000 pounds per capita, counting every man, woman and child of our population. But our consumption is growing so fast that we will be using up four billion tons by 1975 and around seven and a half billion by the end of the century. When you study rates and figures like this sufficiently long, you get a nervous inclination to find an engineering handbook and look up the mass of the earth—and then make a projection to the point in time when we will have consumed the last spoonful of the planet on which we are standing. I am all for interplanetary travel, but I do want to have the feeling of being able to return some place familiar at night after a hard day on one of Saturn's Rings—and these consumption figures make me a little apprehensive. Like New York, Venus is a nice place to visit, but I wouldn't want to live there. And at the rate we're going, I might have to.

For example, in 1950 we took from the earth two and a half times more coal, three times more copper, 26 times more natural gas *and* 30 times more crude oil than we took in 1900. The quantity of most metals and mineral fuels we have used up in the U. S. since the first world war exceeds the total used throughout the entire world in all history preceding 1914.

Now this is colossal. Project the figures further, and you reach the conclusion that all the copper so far discovered in history would last for only 25 years at the consumption rates that seem likely for 1975. All the lead ever discovered would last only 18 years, and so on. In short, handing over the U. S. mineral deposits, intact and pristine as they were when Columbus discovered America, to our children in 1975 would scarcely help them solve their materials problem at all.

At this point I can hear some sceptics rustling in the audience. They would like to point out that various wise committees and commissions have caused us to run out of oil *statistically* five or six times since 1920—and they want to know what it is we are still running our cars on, and what lubricates the nation's bearings. Someone will also be eager to point out that more oil was discovered last year than was consumed. All right—it was. And the gentlemen who caused the statistical exhaustion of our crude petroleum in the 1920's can make their own excuses.

I think it is silly to cling either to the grim side of the materials problem or to the glib side. It is more sensible for us to look at as many indicators as we can and then draw our conclusions from *all* the data, not just the kind that pleases us most. Although great oil discoveries are still being made, the *cost* of discovery is rising. More dry holes are drilled. No one can blink the fact that a barrel of oil removed from the earth is a barrel gone forever, and that iron ore does not regenerate after it is dug out of the Mesabi range.

For some reason we have never, in this country, liked to think about raw materials as a problem. Whereas the poverty or unproductiveness of other continents has made them obsessed with gleaning, we in the U. S. have been so rich that we have tended to throw away everything. We have lit cigars with million dollar bills. We have said "Keep the change" to thousands of wasteful practices. Basically we are more interested in sawmills than seedlings, and we put more engineering thought into factories to cut up metals than into mines to dig them out. We think about raw materials last, not first. And now at last we must change.

I am very conscious that I am speaking to an audience of engineers. You are the keepers and operators of this thing called *technology* which so impresses the man in the street, and whose miracles are invoked so often. American technology over the last quarter century has responded to the demands of the American people with a series of amazing achievements. But so far as the materials problem is concerned, technology may have caused more problems than it has solved. That is, of course, because technology has had two opposite effects on materials: It has greatly increased the efficiency of their use, but it has also greatly increased the total drain on the resources from which they come.

Evidence of the first effect lies in the increasing quantities of useful energy we have been able, over the years, to extract from a pound of coal, in savings of steel and copper used in an electrical generator per unit of output, or in the transformation of previously wasted natural gas into fuels and hundreds of chemicals. The second effect reaches everywhere; whereas the mineral fluorspar, for one example, was once in modest use as a flux in steelmaking, it must today also bear combined and increasing demands as a source material for refrigerants, new types of plastics, propellant gases, oil refining reagents, the production of aluminum, and the fluoridation of water supplies. The first effect is conscious and calculated; the second is neither, and has thus never yet been subject to control.

There is no question that some wonderful transformations and substitutions, at which today we can only guess, lie ahead of us. A plentiful supply of sufficiently cheap energy could end many of our materials problems for good and all. But the wonders of science are not at issue in the materials problem. What is at issue are the hard facts of economics: How can you do what you want to do, cheap enough?

The Next 25 Years

I had the privilege of being a member of the President's Materials Policy Commission—the Paley Commission—during the 18 months that it studied the materials problem, and tried to formulate a national policy to fit it. I should like to spend just a moment discussing the data with which we started our task, and the sort of assumptions we made to carry us on. First, we were under the necessity of defining the "long-range" outlook—for it was that that the White House had asked us to investigate. Just how long *is* a long-range outlook? We defined it as a look 25 years ahead. If you want to know why we picked 25 years, I can easily tell you: because it is a quarter of a century, and thus fits more or less neatly into the decimal system. It was not so short as to get our Commission mixed up in thinking about rearmament and defense emergencies, which we were not supposed to do—and it was not so long as to encourage foolish star-gazing, or so we hoped. In picking this span as "long-range" we were widely criticized on two grounds: one, that our period was too short; the other, that it was too long. Both these criticisms, it must be admitted, are well taken.

Having committed ourselves here, we took a deep breath and went further. It seems safe to assume that consumption will vary with population, working force, and productivity. Estimates of U. S. population by 1975 run all the way from 180 million to 220 million; we assumed, for reasons I cannot go into here, that the U. S. would have a population of 193 million people by 1975, contrasted with 151 million in 1950. Our working force has always stood (except in wartime emergencies) very close to 56 per cent of the population over 14 years old, and we stuck with that figure to give us our estimate of a working force of 82 million a quarter of a century hence, against 62 million today. In line with the trends of the last quarter century we assumed that our work-week would be 15 per cent shorter in 1975 than now, but that we would have a rise of about 2.5 per cent in production per man-hour. This is a little higher than the 2.1 per cent that represents the historical past rate, because we thought it reasonable to expect steadier levels of employment in the future than we have had in the past, in line with our avowed national objective of making major depressions a relic of the past. We may know soon more facts about the wisdom of that assumption.

From all these, we then drew the major assumption on which our entire report was based. It may be wrong, but nobody can call it radical: It is that the rate of growth of our economy in the next 25 years will be neither more or less than what it has averaged during the last 100 years. All booms, busts, and wars included, this works out to be about 3 per cent per year compounded. Three per cent compounded results in a doubling every 25 years, so that, if our Gross National Product in 1950 was $283 billion, the GNP in 1975 would, in consequence, be in the vicinity of $566 billion of the same dollars.

Fortunately, this doubling of the GNP between now and 1975 does *not* mean a doubling of the materials input to sustain it—thanks in large part to advances in technology. Taking these into consideration gave us the figure that an over-all increase in the total materials stream of between 50 and 60 per cent would be enough to achieve a doubling of the GNP by 1975 or thereabouts. Even that is big enough.

Having reached this point, we went on to project the general magnitude of demand in the decade 1970-80 for various major materials. It is important to remember that the figures projected are not in any sense prophecies. The figures are estimates of what materials demands *might* be if relative prices of these materials remained the same as in early 1950—which we very well know they won't. Moreover, such projections can make no allowance for unforeseeable new uses, sharp substitutions, or dramatic technological improvements. A revolutionary advance in the utilization of atomic or solar energy will, of course, knock our projections for future demand of mineral fuels into a cocked hat, and that is just as it should be.

There is room for wide differences of judgment in this difficult area of demand projections, but there need not be any misunderstandings. For one point of overriding importance stands out. Whether you conclude that the demand for a particular material will rise 50 per cent, or 150 or 200 per cent, the central point is that future demand *can be expected to rise considerably*. There may always be a depression, but economic history records many more underestimates of the future than overestimates. Therefore we are bold enough to say—greatly increased demands are inevitable in the long-range future, despite unexpected dips and sags, and we had better accept this as a basic fact and guide ourselves accordingly. The alternative is stagnation.

You most certainly will want to ask: What about war? What sort of assumptions about war did we make in trying to set up the long-range demand outlook? The answer is that we assumed a continuation of international tension for most of our quarter century. This seems rather bleak, but we could do no other. If cold war should erupt into hot war, the patterns of demand and supply would obviously alter in swift and drastic ways. Yet the great uncertainty as between war and peace *might* have less effect upon the materials problem than you would at first suppose. For if complete peace, prosperity and confidence should descend upon us tomorrow, the materials problem would not vanish and might not necessarily become less severe; if all the nations of the world were to achieve the same standard of living as our own, the resulting world need for materials would increase to six times today's massive consumption. It won't, but it could—and it is potentials with which we are dealing.

Despite all uncertainties, I think these projections have a considerable value. They are conservative. In many cases, they assume slower growth in the future