HOW TO INVENT

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CHEMICAL PUBLISHING
NEW YORK

Published 1977 by
THE MACMILLAN PRESS LTD
London and Basingstoke

First American edition, 1979
Chemical Publishing Co., Inc.
155 W. 19 St., New York, N.Y. 10011
ISBN 0-820-60382-1

PRINTED IN THE UNITED STATES OF AMERICA

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PREFACE

Society needs good inventions more than ever before as the world's resources become scarce while one-third of the world's rapidly increasing population is undernourished. Inventing means applying a principle which is essentially different from those so far used on a particular problem and which is not derivable by a unique logical process.

The word 'invention' is essentially linked to the word 'new'. Patent literature is full of the words 'novel' and 'novelty', for newness is the essential ingredient to any valid patent. Even within the legal framework of Patent Law the idea of *newness* extends to a broader field than merely new pieces of hardware, for patents can be granted for new processes. Where inventiveness and the legal interpretation of it are different is that you cannot patent ideas (lest they never be fulfilled in practice) nor applications of a known idea.

In the broader definition of invention, however, it can be said to consist of a *new idea about anything* and therefore a comedian invents new jokes, a clown invents a new funny walk, a detective-fiction writer invents a new plot, and so on. But in this book we shall largely follow the legal definition and confine our objectives to new and useful pieces of hardware.

The primary objective of this book is to give people who have a spark of creativity in them the possibility of using this spark to invent practical useful objects. It is our experience that far more people have the potentiality of inventing than ever learn how to develop and use this power and, indeed, that much of our present educational system works against such development because it tends to make the student feel that he cannot achieve anything that has not been done much better before. We believe that this is a very harmful situation and we try to show the reader how to pinpoint some of the many small and large problems of extremely positive human value which are available (chapter 3) and how he or she can set about solving the ones they feel are really important.

One cannot teach creativeness, but the surprisingly large number of people who have it can learn how to direct it to the effective solution of the problems they have chosen.

We show how, in order to be able to invent, it is necessary to train the three 'brains': (i) the emotional brain (chapters 3 and 4) to give the necessary strength of purpose, determination and persistence, (ii) the intellectual brain (chapters 5 and 6) to ensure that one's inventions obey the laws of science and to be able to use analogical thinking, and (iii) the physical brain (chapter 7) to ensure that the inventions can be turned into real operating hardware. In chapter 10 we assemble some of the techniques we have found helpful in arriving at the inventive moment.

Teachers who are trying to encourage and develop inventiveness in their students may find chapters 2 and 8 helpful. People who want to find how to produce inventive solutions to problems that are around them are advised to look at chapters 4, 5 and 6 and to think about problems outlined in chapter 8. Chapter 4 gives our views on the actual technique of reaching the inventive moment. Readers who are interested in the idea and philosophy of invention may find chapters 1 and 2 interesting. We hope that the practising engineer and applied scientist may find chapters 7 and 9 of value in converting ideas into working reality.

We do not deal with economics in detail because we have concluded that premature entry of economic factors into the technological statement of the problem can be entirely inhibiting to the creative step of invention. Indeed, it can be demonstrated that most of the really big steps forward, such as tonnage steelmaking and the steam turbine, would have certainly been judged hopelessly uneconomic if a committee had been assessing them at any stage before the subsidiary inventions and prototype development had overcome the economic obstacles. They were so judged by all the experts in contemporary technology and this is why we encourage the would-be inventor to judge for himself or herself and not to be put off by the experts.

London, 1976

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1 WHAT IS 'INVENTION' AND CAN IT BE TAUGHT?

M. W. Thring

YOU CAN BE AN INVENTOR

It is a common fallacy to believe that only one person in several thousand is capable of invention. On the contrary most people at some stages in their life perform genuinely inventive acts; what is rare is for these inventive acts to lead to a new device, process or product which is commercially viable. Whenever we solve a small problem which has no obvious logical solution, by finding an unexpected solution, we are inventing.

We can call 'invention' the conception of an idea which is later put into hardware to solve a practical human problem or satisfy a human need in a way which is not an obvious extension of known methods; there is always a quantum jump in ideas. It is not a greater number, size or the use of a stronger material, but it involves a different basic design principle. It is this quantum jump to a new principle which could not have been derived from the existing method by any logical process which constitutes the creative act of invention. The fact that someone else has invented a similar solution before does not stop it being an invention if the inventor was unaware of this and arrived at it by his own independent mental process.

Housewives commonly think of new and more labour-saving ways of arranging their kitchens, interesting new ways of planning their households; gardens are full of inventive acts; for all creative artists invention is a key part of their work just as much as professional technique; the office worker can invent a better way of filing material for ready access; most home workshops are full of original inventions to make the tools and materials accessible and the particular type of work convenient within the limitations of the space available. Even in administration and human relations inventions can solve what appear to be insoluble problems. When we have judged children's invention competitions we have been immensely impressed by the scope and range of the original ideas invented, often in fields where we have ourselves worked and we say, 'Why didn't I think of that myself?', a criterion applicable to all the best inventions.

One cannot of course take people at random, or even people chosen from first class honours graduates or those with the highest I.Q., and teach them to be good inventors. The basic quality of being capable of really original ideas is of course part of a person's make-up and cannot be imparted if it is not there at all. But this quality is more common than one would guess if one judged by the proportion of people who achieve original results in our present society. One can draw a useful analogy with success in athletics of all kinds. The marathon runner must be a wiry man and the Olympic shot putter a massive man, but it does not follow that because a man is born with big bones and the ability to grow big muscles he will necessarily win the shot putt. He must be highly trained, physically balanced, exercise to develop particular muscles and acquire bulk. He must have coaches – and while *they* need not be big shot putters themselves, it helps a lot when it comes to the final stages if at least one of his handlers has had competitive experience. More than any of these, he must have a firm belief that he can win and an unshakable determination to do so.

We have come to the conclusion that the ability to do well in university science or engineering exams is totally uncorrelated with the ability to have original inventive ideas. We believe that people who get first class honours degrees in their finals are neither more likely nor less likely than university failures to produce such ideas. It is true that the examination-weak students are more likely to put forward ideas which are contrary to the known laws of Nature (for example, perpetual motion machines) whereas the well-drilled student will reject such ideas without mentioning them to anyone else, but the latter also tends to be inhibited from original thought by excessive addiction to analysis and excessive respect for the authorities in his subject.

A very good illustration of the fact that the ability to invent practical devices is latent in people who have not used it is provided by the work of physicists in Britain in World War II. Until the war most of them lived in the classical world of physics expressed in Rutherford's words 'It will take all the fun out of it if anybody finds a use for it.' However, when the war forced them to invent solutions to wartime problems they came up with radar, degaussing, infra-red detection and played a major part in the production of the atom bomb.

There is little doubt that the natural ability to have ideas which are genuinely original to the person concerned is quite widespread, indeed probably most people of normal intelligence have it. By 'genuinely original' is meant that the inventor has never seen or heard of this solution to this problem – often it has of course been previously invented by other people in the same or closely similar form but this was not known or if it had been, it was not the source of the idea in the inventor's mind. Why then do people so rarely make more than comparatively trivial localised use of this ability?

EDUCATION AND INVENTION

The answer to the foregoing question lies largely in three major defects of the education systems of all developed countries. These defects occur practically to the same degree in all countries with a formal universal education system, regardless of historical antecedents and political creed.

Education should be the complete development of a full man for a full life. A properly educated person would be one whose three faculties – called in poetic language, head, heart and hands – were trained and self-developed to their fullest possible capacity. In scientific language, these faculties are referred to as intellect, emotions (or feelings) and physical skills or techniques. Most education systems follow a scheme based upon ideas put forward by Plato; in these systems those people who can achieve above average intellectual achievement have a concentrated intellectual training and look down upon the manual craft skills for which their education finds little time. In Britain the onset of examinations drives out all free creative manual activities as the unfortunate child enters his or her teens.

The defect of the education system with regard to physical skills is therefore that it tends to despise them as only fit for non-intellectual beings, so that we can hear people who pride themselves on their scholarship saying, without any shame, 'I cannot knock a nail in.' We shall see in chapter 7 that the knowledge of reality which can only be obtained by skilled working with the hands is as essential to effective invention as the scientific experiment in the laboratory is to the development of science. We express this in the phrase 'Thinking with the hands'. It follows that if effective inventiveness is going to be experienced by everyone with the latent capacity for it, then everyone should learn at least one artistic or craft skill as well as they are able, as part of their normal education. Not only would this open up to them the possibility of making their ideas effective in the real world but it would also enrich their whole lives by enabling them to enjoy the pleasure of skilled creative work with the hands – certainly one of, if not the most fulfilling of all activities.

Even intellectual education suffers from one common defect, for students of the humanities (in spite of their claims to teach and encourage originality) as well as mathematics and the sciences. There is a tendency for teaching to consist of transmitting facts, dogma, opinions, ideas, theories and theorems to the student who then has to regurgitate them in half-digested form in examinations. It is rare for a really good teacher to teach the student to think for himself and work out his own ideas, opinions and conclusions or for science to be taught in such a way that the student is led to make his own discoveries, conclusions or hypotheses. Yet this is what the word *educare* means: 'to draw out' from the student. This has two serious harmful effects. First, the student rarely has the feeling that the acquisition of knowledge is an exciting process; the second is, from our present point of view, even more destructive. The student fails to acquire any belief that he himself is capable of original thought. As we shall see it is this self-confidence which is the first requirement in an inventor. This could only be put right by keeping an hour or two a week free from the examination cramming process and using it for open-ended problems for which every student is expected to come up with a different solution and for free ranging discussions and arguments in which students invent their own problems.

One can illustrate the discouragement faced by someone who has an original idea by some examples. Suppose I put forward a new idea that people could propel themselves several times as fast as they can walk and expend less energy by balancing on a two-wheeled device worked by pedals. I should be told 'We are not acrobats' if the bicycle was not familiar to us. Then I might suggest that we could go even faster without using our muscles at all, by using a machine in which thousands of explosions a minute did the work. Again I would be greeted by a chorus of horror at the dangers and impracticability of such a machine.

In chapter 8 we suggest ways in which originality can be encouraged and developed in the young inventor and in chapter 9 how an original idea can be turned into practical hardware.

The education of the emotions is by far the most difficult problem in education and one from which our present system has opted out completely. It is true that by studying great works of art or literature or the lives of great scientists or inventors or by working with a really good teacher a certain training of the emotional brain may rub off accidentally. But it is the emotions that provide our motivation – the driving force that we need to compel us to make efforts against our natural inertia and laziness. Indeed, in the Eastern analogy for man's three 'brains', the body is called the cart, the intellect the driver and the emotions the horse that pulls the cart. Educating the emotions would be equivalent to giving the driver reins so that he could control the horse's movement. Anything really worth doing, like inventing something of real value of humanity, is like pulling the cart out of a bog and up a steep hill – it requires all the effort the horse can make, the most determined control of its direction by the driver and the utmost self-confidence that such a task can be achieved.

The task of educating the emotions is naturally the most difficult part of a proper education of the whole man, and it is our failure to give young people an adequate ability to motivate their lives in a worthwhile direction that is one cause of the ever-increasing problems of the affluent society. Among these problems one can quote pollution, unemployment, unfulfilling work, the plight of the less developed countries, squandering of the earth's limited resources without regard for the needs of future generations and the arms race. All these lead to a steady deterioration of the quality of life of the individual so that a proper education in motivation must start with a clear explanation of the fallacy of confusing the standard of living, which is a cake of limited size in a crowded world, and quality of life, which has the characteristic that if one person enjoys more of it, then so does everyone around him or her. Such understanding of the basic difference between these two criteria of success in life can lead to the would-be inventor developing a determination to invent machines that increase the quality of life of the individual and do not add to the ever-increasing problems of the affluent society. In chapter 3 we shall try to identify the fields in which the inventor who sees this distinction clearly can have the greatest probability of making a real contribution to the quality of life of the citizen of an overcrowded world.

It is a basic hypothesis of this book that creativity in general and invention in particular come under a law which is neither causal nor casual. We assume in fact that human beings live at different moments of their lives under three different laws.

(1) *The law of accident* – randomness, casual events resulting from the interaction of quite different sequence lines of events with one's own sequence line. The extreme example is a brick falling on one's head as one walks along a street. Physics accepted this law in the first quarter of the century when quantum mechanics was developed to supplement the causal laws of classical physics. This law can be fed into a computer.

(2) *The law of causality* – the logical consequence of one's actions. If I eat too much food I get fat; if I drink too much alcohol I get drunk. This is the law on which computers operate, at least when there are no malfunctions. In the human mind it is the logical pursuit of a line of thought, so objective that all people who do it properly arrive at the same conclusion. All the laws of classical physics come under this heading.

(3) *The law of free will* – the process by which a human being makes a free choice or decision which could not have been predicted because it is neither a logical consequence of its antecedents nor an accidental random process. Careful introspection will convince anyone that at least in small things he does have a real freedom of choice, although he very rarely exercises it. Many words in the English language relate entirely to people acting under this third law, for example courage, self-discipline, self-control, decision, perseverance, effort, inner struggle. The only entry of this law into physics is the conception of Maxwell's Demon which could reverse the increase of entropy by opening and closing a little door to separate gas molecules into higher and lower temperature groups. This idea is very characteristic of the law of free will which does enable a creative person to create order out of chaos. It is not of course realisable because human consciousness, which is necessary for free will, cannot exist on a sufficiently small scale.

As soon as one accepts the possibility of a human being living occasionally under the law of free will, the whole human situation is changed, because one can make small decisions which gradually change oneself to the point where one can have the power to make greater decisions. Just as an artist prepares himself to paint the kind of creative pictures he wants to paint, so the would-be inventor can prepare himself to invent the kind of things he wants to invent; this book is concerned largely with developing the methods of such self-preparation.

The pure scientist can occasionally achieve one of the truly creative acts of

(1) producing a new hypothesis which leads to a deeper understanding of a body of scientific observation or (2) perceiving that an unexpected observation is not due to the cussedness of nature trying to spoil his experiment but to an important, hitherto undiscovered phenomenon. The true artist strives for creative acts in all his work but achieves it only occasionally. The engineer strives for the truly inventive idea which creates a new order in the solution of a practical human need.

WHAT IS INVENTION?

Arthur Koestler in various books, but especially in *The Act of Creation*,[1] has analysed truly creative ideas by the expression 'bisociation', which he defines as the solution of a problem in one matrix of associated ideas by bringing in an idea from an entirely unconnected matrix. Inventing a new process or product is certainly a truly creative act just as is the invention of a new hypothesis that makes sense of a group of scientific observations, and Koestler's analysis certainly applies to the act of invention. The example of Archimedes jumping out of his bath and shouting '*Eureka*' because he had thought of a way of measuring the volume of the king's crown, and so deciding whether it had the density of copper or of gold, is a well-known story of an invention to solve a practical problem by applying to it a hitherto unconnected scientific observation. Many, if not all, true inventions correspond exactly to bisociation in the sense that they correspond to solving an apparently insoluble practical problem by bringing in an idea which is well known in some quite other connection, but which could not be reached by a direct logical process or a systematic search of a predetermined field of knowledge such as a computer can be instructed to perform.

A closely similar idea has been expressed by Edward de Bono in the concept of 'lateral thinking' which implies a thought process which proceeds sideways from the normal branched chain of logical possibility. This he illustrates very nicely with the action of a girl forced to choose a pebble from a bag which is supposed to contain 3 black and 3 white pebbles, when she finds out that they are all in fact black. She picks one out and drops it, to disappear in the gravel; she then claims it was white and the villain is forced to agree or his deception will be exposed.[2]

In our view both these descriptions apply only to the intellectual aspect of invention, whereas a true invention involves the complete working together of the three 'brains' of the inventor. A real invention in the sense the word is used in this book is the conception that can lead to a device (for example, mechanical, electrical, electronic) which can be constructed and worked to serve a human need of some kind in a way which is clearly better than before. Two other essential parts of an invention are therefore (1) the strong feeling of desire to produce such a better solution to a human need and (2) the understanding of the way things work in space and time through the hands and eyes without which no realisable idea can be born (see figure 1.1).

That the emotional 'brain' is essential to the achievement of a successful

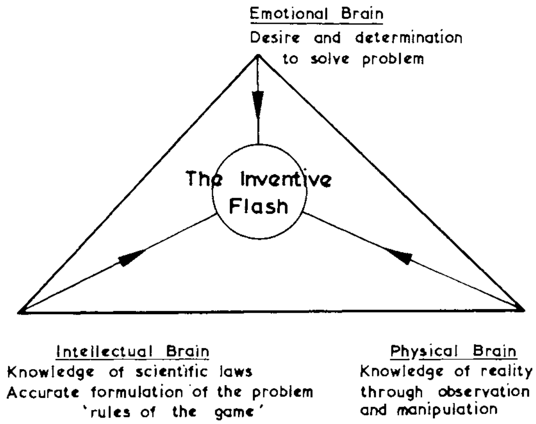

Figure 1.1 The act of invention; the three brains work

invention is clear to everyone who has invented anything, however slight. An inventor must start with the absolute certainty of belief that he can succeed, in spite of the fact that everyone else will tell him that he is bound to fail when so many better men have tried and failed. He must also have the absolute emotional certainty that the solution of the problem is important enough to enable him to produce the necessary emotional power. He must suggest not merely one really creative solution, but often a whole series of original ideas, since the majority will have to be rejected because they prove either to be completely unworkable or to produce undesirable side effects which nullify their value. Again an idea may seem to be unworkable but a further emotional effort may result in an associated invention which overcomes the objection to the first. The would-be inventor must necessarily pass through black periods when even to himself the problem seems insoluble, or when a cherished idea has on further consideration proved to be worthless. Success is achieved only if one has the emotional strength necessary to continue the struggle to find a solution even when it seems hopeless. Not even the greatest inventors achieved their successes without such difficulties, and knowledge of this fact can be a great comfort to the young man determined to find an inventive solution to a problem.

This essential emotional content of invention means that the preparatory step is not only to work out what is the exact problem you want to solve but also to make up your mind that it is really worth solving. It is no longer sufficient to feel that one can make a personal fortune by an original invention for two reasons. First, the kind of invention that can lead to a personal fortune is, to say the least, thousands of times more difficult to achieve than it was in the nineteenth century. Then, the rapid expansion of the tools, machines and materials of the Industrial Revolution was constantly opening up new possibilities and the first inventor to exploit one of them had a fair chance of personal affluence. Now, even the rapidly developing subjects like

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