

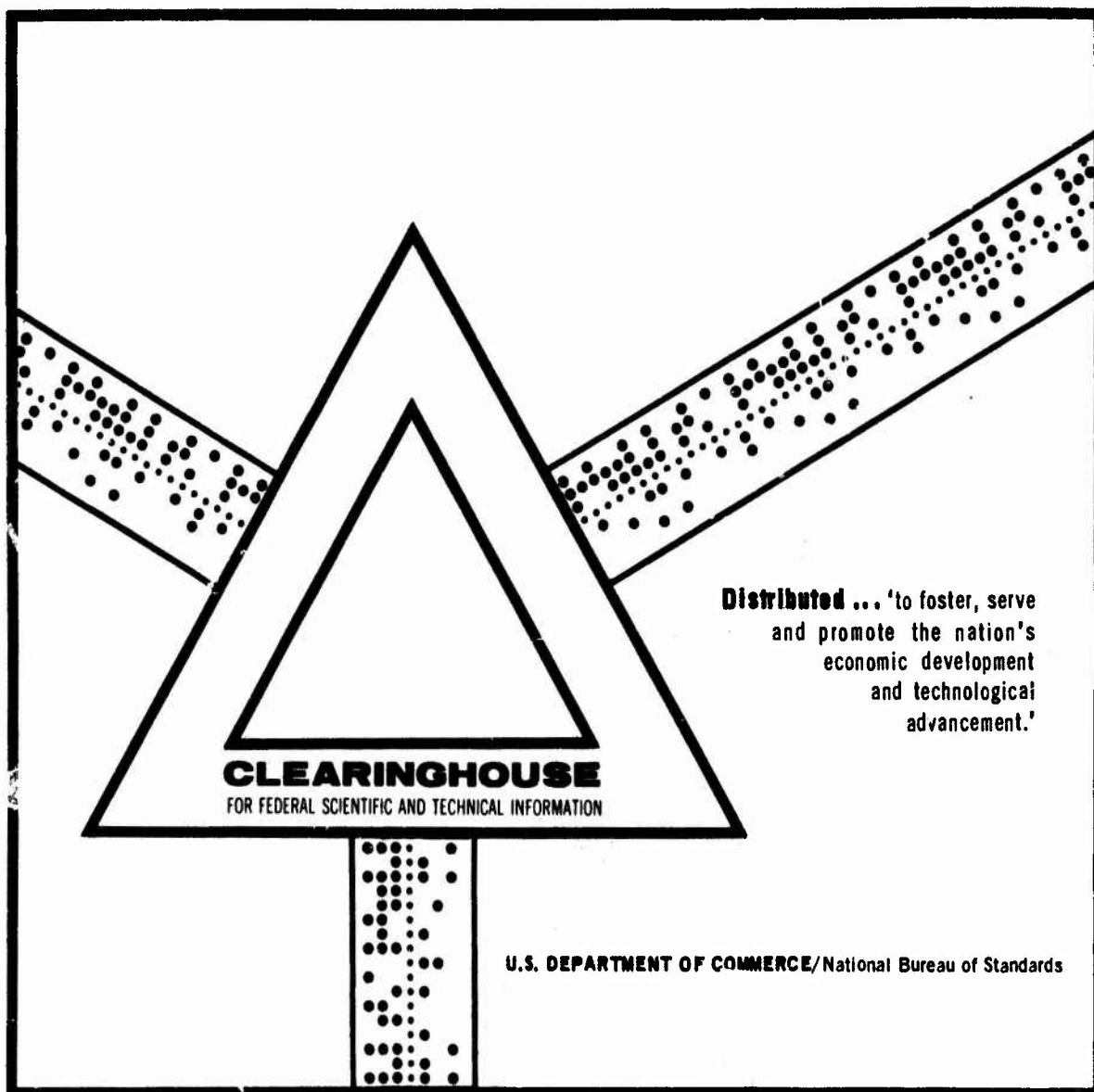
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THE FUNCTION OF SPECIFICATIONS

James H. Flanagan

Army Natick Laboratories
Natick, Massachusetts

July 1969



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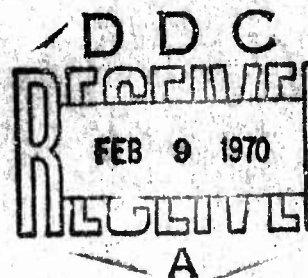
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TECHNICAL REPORT
70-14-080

THE FUNCTION OF SPECIFICATIONS

by



James H. Flanagan

July 1969

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760



Office of the Scientific Director

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TECHNICAL REPORT

70-14-OSD

THE FUNCTION OF SPECIFICATIONS

by

James H. Flanagan

July 1969

Office of the Scientific Director
U. S. ARMY NATICK LABORATORIES
Natick, Massachusetts

FOREWORD

This report was presented at the DOD Specifications Seminar at Fort Lee, Virginia on 15 July 1969. The interpretation of the information and the proposals made resulted from individual study. As such, they do not necessarily represent a conclusive position of the Natick Laboratories. The report is published in an effort to stimulate much needed research in a technical field which has a very long history of practice and little evidence of analytical study. Acknowledgement is made to the active support and encouragement given by Mr. John J. Riordan, Director for Technical Data, Standardization Policy and Quality Assurance (Office Assistant Secretary of Defense (I&L)) to all who work to build the missing foundations.

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ABSTRACT

A Government specification has as its primary function in our technological economy, promotion of rational competition for the purpose of securing economic procurement. As a control mechanism, a proper specification requires feedback -- it should operate as a cybernetic machine -- and it must be designed and constructed by men skilled in all of the several technological communication and control techniques in use today. Optimum designs and designers are still to be created.

THE FUNCTION OF SPECIFICATIONS

Introduction

Three different sets of men process ideas in our technological economy. They may be classified according to their decision-making techniques as scientists, engineers, and artists. Each of these sets obtains, transforms, and communicates intelligence in ways quite indistinguishable within each set, but readily distinguishable when the sets are compared. Within a set, processing takes on a form peculiar to the set ¹ but regardless of the form, it occurs because the set members think and communicate in the same language. Between sets, there can be zones of silence.

The artist was the progenitor of the other two. Oddly enough, evidence available ² indicates that scientists fissioned first and very early in recorded history. Engineers evolved in rather more recent times, and that evolutionary process is now changing the engineer and his work at a faster rate than at any time in the past. In the vulgate sense, the artist persists to this date as, for example, the sculptor of stone and the composer of concertos; he will always serve thusly in a role valuable to mankind. In a philosophical sense, the artist exists, for example, as the chef, brewmaster, tailor, or as one of many tinkering inventors; a need for these men remains, but the numbers required are fast dwindling. The chef who once created for hundreds now satisfies the needs of millions. The tailor who designs and constructs and the inventor who doddles and tinkers are still with us and producing, but with each passing day, our technological economy becomes less and less dependent on their work. By many examples, it could be shown how analysis of the artist's effort by scientists and engineers, together with application of the factory system, has cut both the need for artists and at the same time increased by many fold, the number of people who benefit from their genius. No one predicts a reversal of this trend.

The early scientists were primarily thinkers in the abstract; however, they were also conscious of the value of real structures and mechanisms. What little of the technological glory of Greece that is available today exists, unfortunately, only in the form of crude attempts at perspective sketches and much of the rationale is lost. Early in the Renaissance, a small group of artists, popularly exemplified by da Vinci, began to make use of the sketches and achievements of the Greeks. Thus started the long-troubled but always fascinating history of the engineer: the set that has still not stabilized, the set which is still seeking its full identity.

For the purpose of this report, the term engineer is applied to all who in our technological economy rationally process product configuration ideas. The three sets, while usually distinguished one from the other by their characteristic decision-making processes, will here be analyzed by another distinguishing characteristic - the method by which they record, transmit, and execute their achievements.

Achievement Records

The artist may prepare a recipe wherein he records a result and cannot himself defend this product by rationalization. The cookbook, the high-fashion sketch, the automotive stylist's high-key, exaggerated perspective, all are recipes which can be copied, often used, but never easily extended by analysis of elements of rational thought. An intriguing example of a recipe is given by Klemm ^{3/} which he attributes to Theophilus, a Medieval German Benedictine, probably circa 1,000 A.D.

Another kind of tempering of iron instruments is also made in this manner by which glass is cut and also the softer stones. Take a three-year old buck goat and tie him up within doors for three days without food. On the fourth day give him fern to eat and nothing else. When he shall have eaten this for two days, on the night following enclose him in a cask perforated at the bottom under which holes place another sound vessel in which thou wilt collect his urine. Having in this manner for two or three nights sufficiently collected this, turn out the buck and temper thine instruments in this urine. Iron instruments are also tempered in the urine of a young red-haired boy harder than in simple water. (p. 67)

It makes one wonder how the first alchemist got himself and the goat into that awful situation. Today, one millennium later, a metallurgist could dissect this recipe and explain the "why" and thus rationalize a new "how"; but since other sources of acid, carbon, and water are more easily obtained, he had directed his attention away from the inefficient goat and turned, rather, to the chemical processing plant.

The scientist prepares a report, a report which now is being questioned as an effective means of communication. This is not because it can't be understood, analyzed, and critiqued for rationality, but simply because the number being produced exceeds the capabilities of scientists to make even a small portion of them a part of their readily available experience. A scientist has always thrived on his own publications, but today he chokes when he tries to ingest all that is recorded and

available from a morass of sources. Early scientists did not have that problem. Even as late as the fifteen hundreds, Francis Bacon, as stated by Bowen, ⁴ "... (had) a vision of a new Atlantis where scientists might share experimentation in colleges and work shops..." She adds:

... all this has become so much a part of modern life that we can scarcely fix our minds on it. We are used to such ideas, we forget the courage and the vision needed to propose them in Bacon's day. We forget that to challenge the accepted epistemology -- let alone to challenge God's cosmology and the mysteries of His universe -- was to query the established social and religious order. For this impudence, Bacon's Italian contemporaries Galileo, Campanella, Giordano Bruno, were imprisoned as heretics and one of them was burned at the stake. (p. 7)

The engineer prepares relatively little in the way of written record as compared to the scientist. More like the artist, the engineer is driven by an interest in things rather than ideas and thus builds and leaves units of reality or at least drawings of what he thinks could be reality. Both Gille ² and Klemm ³ note this as an early characteristic of engineers and some may agree that things have not changed much over the years. Figures 1 through 3 are taken from Gille. Figure 1 is an extreme case of a medieval engineer's attention to configuration and gives little evidence of even a thought as to how it could be made. Figures 2 and 3 are similar, but progressively less extreme. Some engineers and artists are still prone to think in terms of the "what" aspect of a job and dismiss the "how" rather than bore themselves with details.

The basic record prepared by engineers is the drawing. Of course, research and analysis reports are written and text books are cascaded, but the drawing has persisted as the pervasive record of the practice of engineering. It has persisted because it is a reasonably effective way of communicating the "what" and some of the "how"; but it is almost totally silent on the "why."

A complete record of technological work really requires all three things:

- a. The report of the scientist.
- b. The drawing of the engineer.
- c. The recipe of the artist.

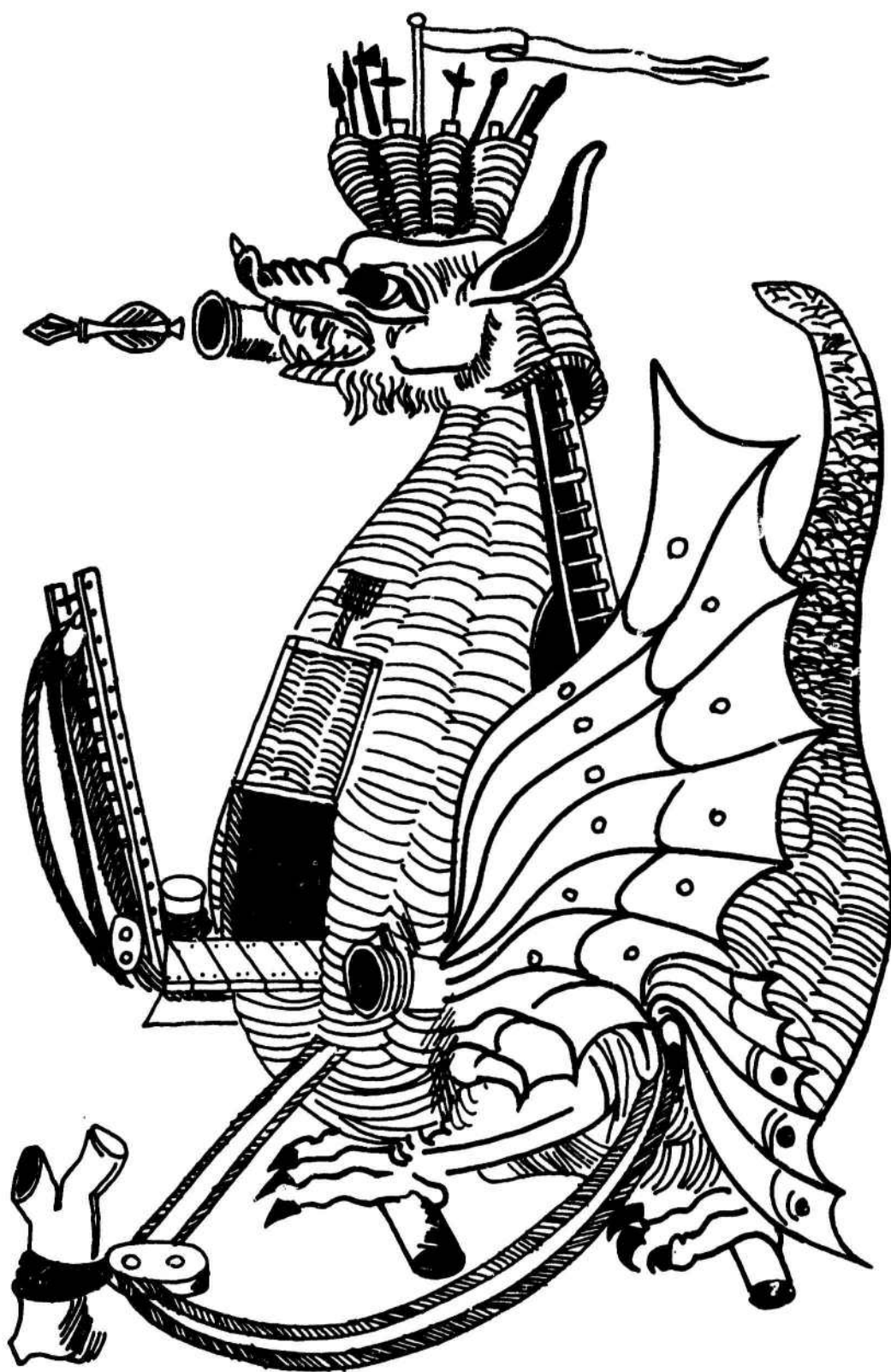


Figure 1. Valturio: espringal

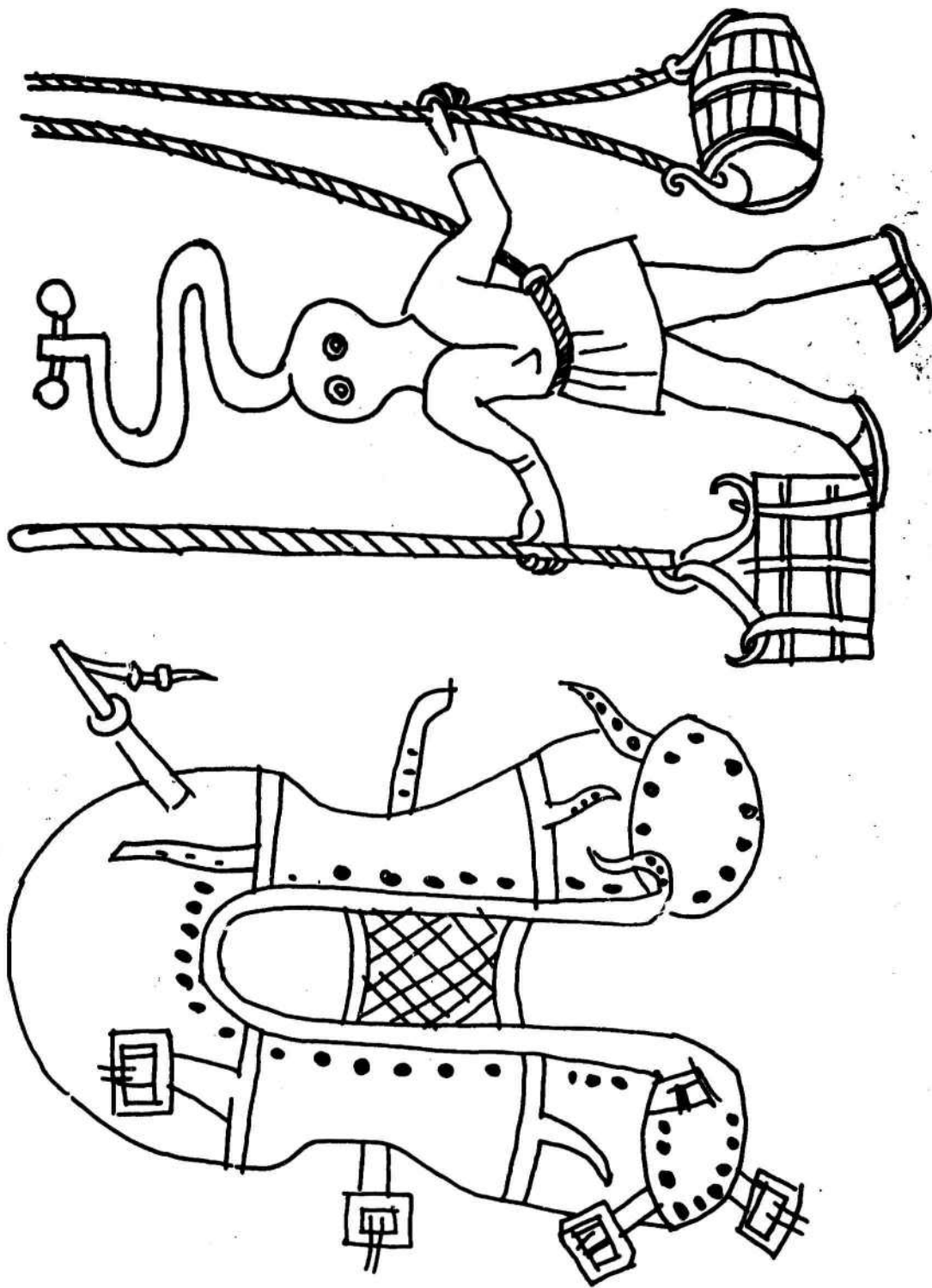


Figure 2. Hussite MS: diving suit

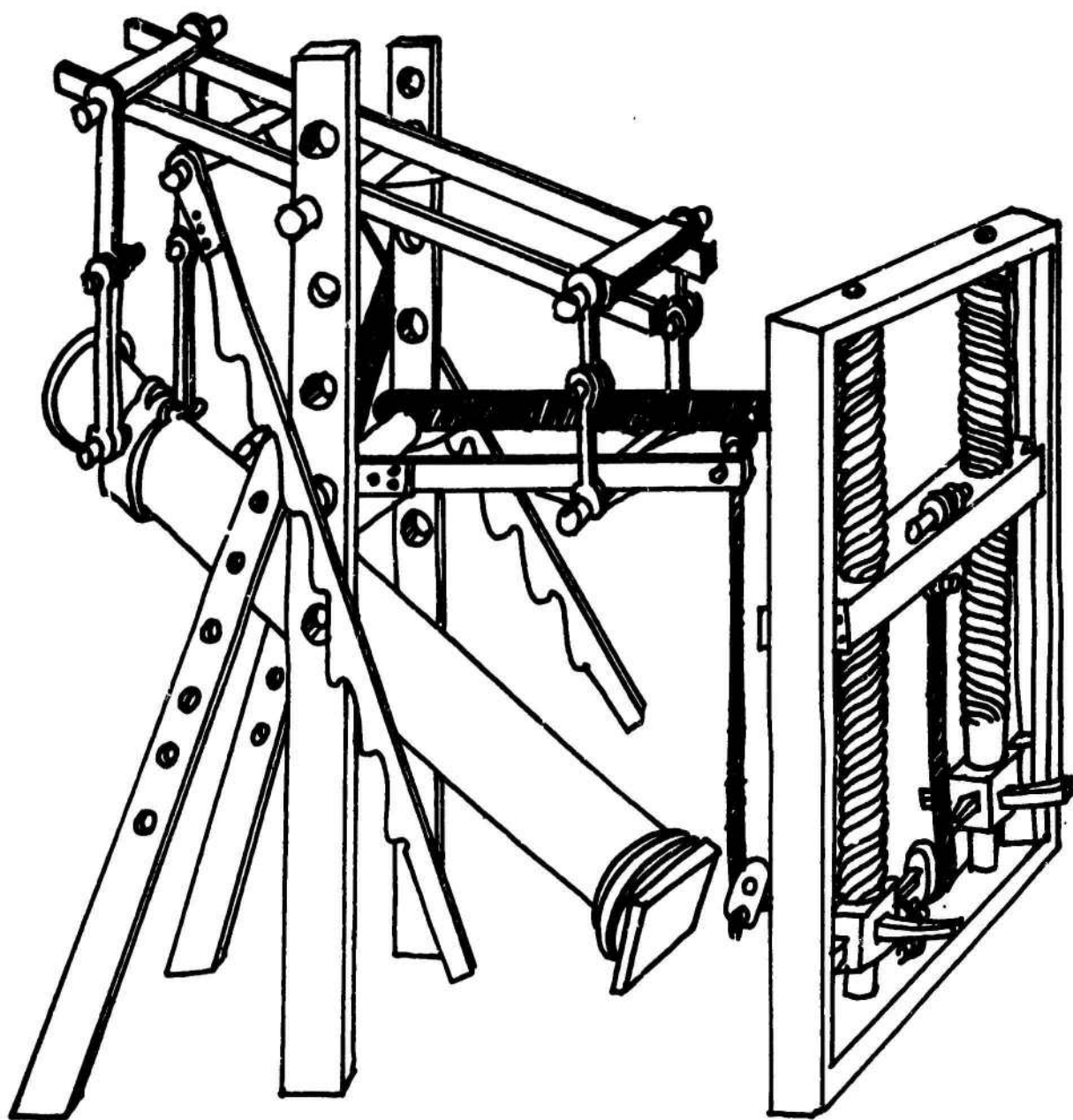


Figure 3. Francesco di Giorgio: Column raising machine

These three, when taken together, constitute a total record of technological achievement. When they are available, the process of product creation, evaluation, and evolution toward perfection can move at a rate set primarily by factors external to technology. These three types of record in combination, constitute the ultimate item description; these three records are the end products of the three sets of men who are distinguishable because their thinking and recording processes are different.

Achievement Communication

Each of the three sets also differ in their communication characteristics. While this subject has too many facets to be fully discussed here, a few generalizations are in order. Scientists read, write, and argue freely within their set. Engineers are more prone to observe, listen, and introvertly analyze and decide with little recourse to debate within the set. Artists are similar to engineers, but usually do not make a habit of idea analysis.

The transfer of records is the passive role of communication; there is more to it than that. In a technological economy, controlled action based on the communication, must occur if it is to have economic value. In this, the active role of communications, the three sets again differ.

Within the scientist set, there are few if any directed actions. Self-motivation drives most members of the set to compete, and action is almost an unavoidable result of the passive communication. This set has often been pictured as being self-contained and not interested in causing action to occur outside of their sphere. Most anyone is able to examine their communications, but too few outside of the set can do anything with what they find.

Engineers are also self-motivated and to a degree, cloistered. They must, however, direct actions outside of their sphere because they are not consumers of their own product. They have, therefore, closely allied themselves with technicians and some of the trades. If the communication link is short, as in the case of a small shop where the designer can walk to and talk to shop people, communication need not be a problem. It is a problem whenever the sphere of direct influence of the engineer is small relative to the mass he is trying to move.

The artist is so often his own craftsman, that the active mode of communication is seldom a problem. Action at a distance, therefore, is not necessary, and for the purpose of this report, no further discussion is essential.

The three sets have thus far been presented as discrete sub-sets of our technological economy. For brevity, let us assume that a requirement for production is generated by an operationally oriented sub-set of the economy, and it is expected that that input will cause a production sub-set to go into action. Is it necessary for the requirement sub-set to know which of the three sets - scientist, engineer or artist - he needs to process and transform his requirement, or just what should he do? What he should do is to cause all three to act in concert to produce a technical communication which will control the production sub-set. That control is a specification.

The Function of Specifications

There are many definitions and explanations of the word specification. One brief explanation is given on the subject card of a library catalogue as: "Here are entered works on the particular qualities prescribed for a product to meet specific requirements." As you all recognize, that leaves much unsaid. Rather than to repeat the more complete statement which is given in DOD Directive 4120.3, let us consider the following excerpt from a book by Senator Paul H. Douglas.² Senator Douglas gave the Godkin Lectures at Harvard in 1951 on the subject of "Ethics in Government." His words are interpreted as an apt description of the function and economic need for specifications in government procurement.

In a free market, prices are fixed impersonally by the forces of supply and demand, and, therefore, adjustments in quantities produced, and hence in unit prices, are made according to the schedules of costs and profits. There is little room for corruption or undue favoritism here. In contrast, when the government makes the decisions about prices, quantities produced, and what firms may enter an industry, the door is opened wide for the exercise of favoritism and corruption. These matters are life or death to the businessman or industrialist. A hostile government may put him out of business, while a friendly administration may give him great profits. Wherever government controls a business, it becomes inevitable that the business should try to control the government. (p. 32)

A government specification is, therefore, the crucial technical statement which has as its sole function, enablement of free market operations while maintaining an economic position for both the government as a buyer and the governed as a seller. Its function is control.

The term economic position means that in the most general sense the exchange between the buyer and the seller has taken place with acceptably balanced and limited advantages accruing to each of the parties, both at the instant of the sale and for the useful life of the item. Whenever either party disrupts this balance by intent or through ignorance, a problem arises which demands solution. Certainly, a specification does describe the particular qualities prescribed for a product, but this alone does not enable the buyer or the seller to maintain an economic position. The buyer and seller must be parties to the attribute requirements and they must be parties to the assessment requirements because, taken together, these two requirements are essential to their economic positions. These are what must be controlled.

Under the laws of this country, it is required that the Federal Government as a buyer give each seller an equal or at least rationalized similar opportunity to compete for the sale. All too often, however, the concept of competition is applied only to the seller. It is only in the last decade or so that active recognition has been given to the fact that the Federal Government as a buyer is not one but many, and that competition among these buyers can wreck havoc on the economic position of each. When properly drafted and used, a specification will minimize competition among the buyers. No reference to central procurement and the advantages that are claimed for large volume buying over small is intended, but rather, reference is made to the fact that with limited personnel skills, the Federal Government should prepare and use one effective specification to replace the many -- the many that are similar but which individually may be technically weak, and thus not able to support the government's economic position.

Specifications also function to stabilize competition among sellers. The shrewdness of an effective specification must here be adjusted not in proportion to the number of sellers, but rather inversely to degrees of freedom the buyer can exercise in choosing from among the sellers. For example, when an individual goes to the market place, he does not carry a specification. Surely he has an idea of what his requirements are, but at the market place he can adjust these requirements as he reviews the items offered. When he rejects a seller, no explanation is necessary; he has full and effective control over his choice. He has many degrees of freedom. When a corporate buyer enters the market, he may be almost as free as the individual, but more likely he will have to prove to management that he has achieved an economic position for the company; he has several degrees of freedom and, therefore, a specification of an intermediate level of astuteness is all that is necessary. When government buyers enter the market, they will not be able to maintain their economic position unless they carry very astute specifications to the contract

signing; they generally have very restricted degrees of freedom. Anything less than an astute specification will most certainly permit the economic position of either the buyer or seller to be irrationally unbalanced.

From the point of view of this report, it should be clear that the primary function of a specification is control. For the buyer, it controls competition through standardization. For the seller, it puts competition on a comprehensible and controlled basis by restricting selling competition to price and delivery terms. When specifications are properly drawn, there are no possibilities for performance or quality or any similar encapsulating terms to be available for negotiation or arbitration.

Specification Problems

The number of specification problems which could be identified is far too great to include in this paper. What may be considered to be the crux of the situation is well put by Struglia in his book on Standards and Specifications Information Sources: ^{6/}

Forty years ago the National Bureau of Standards undertook to publish the first edition of the National Directory of Commodity Specifications. It was a classified, annotated list of all commodity standards and specifications issued by over 300 associations, societies and government agencies. This monumental task was discontinued in 1947 when a supplement to the 1300 page, third edition was issued.

In the intervening years, there have been sporadic mutterings about the possibility of a revival of this publication under different auspices, but at least 350 organizations are now too busy grinding out commodity standards and specifications to give much thought to the need for recording in orderly fashion what everyone is doing. (p. 23)

Accepting that the Department of Defense has made good strides in inventorying and displaying its specification documents through the Defense Logistics Services Center operation in Battle Creek, Michigan, an engineer who works with specifications is still faced with the problem of trying to unravel and make progress through a morass of national and commercial statements of unknown and often unproven quality.

Is it no wonder, therefore, that the ultimate specification is yet to be written? Is it no wonder that even with so many specifications in our national inventory, the catalogue of the Engineering Library at the Massachusetts Institute of Technology contains less than five entries of books and reports about the concept and function of specifications? Not one of more than six books about the history of our technological economy contained the word specification in the index. Is this because there is no need to understand and perfect this control element, or is it, rather, because it is a highly complex interdisciplinary problem for which we have no fourth set of skills trained and ready to work? There is desperate need to create and give status to the fourth set.

Proposed Solution

At this moment we cannot determine and direct the solution to this crucial national problem. The problem, however, can be subdivided into special cases and improvements made to these elements.

First, it should be noted that in spite of continuous turmoil, this country has accepted Congressional standards for weights, measures, and money which are used daily. If these standards did not exist, many, many more specifications would have to be attached to each contract between a buyer and a seller. Why has this country lagged in the application of the concept of enforced standards to other aspects of our technological economy? Some standards for grade have been established in agriculture. Some standards for safety have been promulgated for drugs, food, and transportation. Most of the standards which have been established relate to health and safety, but none have been found outside the agricultural area which relate to utility, and utility is an important consideration in securing economic position. The French and the British, for example, have made headway in establishing and enforcing this type. It is now time for the Department of Defense to greatly increase its activity in the work of the United States of America Standards Institute (USASI), together with the Department of Commerce, for its own self protection as a significant buyer within the Federal Government.

The Department of Defense has lagged in aiding the development of enforceable standards because it has given too much status and attention to research and development and has not given recognition to the value of standards even to the extent of exploring the economic value that such actions could have. The DOD annually spends billions of dollars in supply procurement. Each year these procurements use an inventory of technical documents which is given management scrutiny as to quantity, currency, and maintenance costs, but relatively little

analysis is made of technical quality and its potential effect on procurement costs. Technical men are encouraged to join the R&D programs and lately even more status is being given to those who system analyze these programs for cost effectiveness; but not much is done to launch a programmed technical attack which would apply these analysis techniques to perfect technical controls in supply procurement.

One sub-element or sub-system problem which could be attacked beginning today, would be to separate the DOD inventory of standardization documents into two groups. The first would be a stable group which when made technically sound would require little maintenance attention. The second would be transitory and could be given the squeaky hinge treatment.

The real payoff is waiting to be discovered in the stable, intransitory group. Here the development of enforceable standards as building units for combination and recombination into specifications as required for each procurement, can be established. Once established, many of these units would also find application in the transitory inventory and even there, would enable rapid and economic procurements to be accomplished. The primary technical effort required is extension and purification of the USASI standards which are needed by the Department of Defense to replace many of the vast conglomerate of documents now inventoried. This must be done before the next step can be taken -- to create a scheme for the assembly of supporting documents to automatically control the technical aspects of supply procurement.

In the near future, it will be possible to design specifications to perform as cybernetic machines. Servomechanisms and some electronic amplifiers are elementary examples of cybernetic machines. These machines exercise control, but also because of programmed logic, respond to the effect of the control in a corrective manner. In recent years, application of cybernetics to management problems has been discussed, notably by Beer. ^{1/} The important point here is that arbitrary control without feedback to perfect it, is self-limiting in value. An example will clarify the point. A traffic intersection with a volume of vehicular traffic far below intersection saturation, may be routinely controlled by either signal lights, a traffic officer, or by each individual driver. The least time on the average to move a vehicle through the intersection occurs when each driver exercises his own control decision based on the feedback he gets from seeing and listening to the intersection situation. The next best is when the control and feedback is given to one man, the traffic officer; and the worst is the traffic signal which gives orders and is not at all influenced by their effect. The rank order of effectiveness of these three controls

almost completely reverses when the intersection becomes uniformly saturated. Under this situation, too many decisions are being rendered by individual drivers at too fast a rate for them to rationally respond to feedback. The traffic officer can attach no unique significance to any of the feedback and will either act like a clock control or preferably vacate his post to the automatic signal -- that is until the first accident occurs. The accident sound and image is the type of unique feedback which can be used by the officer to restore balance to the traffic flow through the intersection. This solution to the intersection problem is, however, critically dependent on the availability of sufficient numbers of qualified traffic officers. When the demand exceeds the supply, alternate solutions must be found. In cases like this, one can either eliminate the intersection, a solution that has contributed to the building of limited access highways with overpasses; or design a cybernetic machine, a technique that is being explored in some cities using computers and television.

As an analogy to supply procurement, the traffic intersection example should not be taken too literally; however, the basic principles are applicable. For small, low saturation procurements between a buyer and a seller, each with restricted and common interests, the individuals can rapidly make decisions based on feedback. When these same individuals attempt to control a near saturation situation such as one in which many different buyers or inputs interact with many different suppliers or outputs, feedback to humans cannot be efficiently used to control. Just as in the traffic intersection problem, the solution lies in designing the specification/contract system to be self-correcting, control devices or cybernetic machines. Much study, research, and experiment will be required to design and perfect this machine, a paper machine-for-teaching-itself. Just as research and development have so remarkably contributed to the design of physical machines of ever increasing sophistication, it is to be expected that research and development when conducted on the specification or communication machine, should yield a solution different from building an overpass or eliminating procurement.

Summary

What has been proposed is that the primary function of specifications is to promote controlled competition, that the value of competition is to maintain an economic position for both the buyer and the seller, that the real problem with specifications today is that there are far too many and that there is an insufficient number of technically qualified personnel to properly service the inventory. Two actions are recommended. The first amounts to reducing the number of transitory specifications and stabilizing these by consolidation and replacement with standards. The ultimate objective of this action would be to

enable procurement support to be provided by a cybernetic machine. The second proposal relates to increasing the number of qualified personnel available for work on standards and specifications by improving the technological status of the work. This will be a very difficult task and it should be begun in the universities. Even today, changes in engineering curricula are occurring and have moved far from the classic courses toward ones which now at the graduate level include many of the new engineering analysis and management techniques. However, to date, the primary emphasis at universities has been on research and application of these techniques to R&D programs and organizations, with limited application to production and marketing and essentially none to communication between a buyer and a seller. If the universities undertake graduate teaching and research programs relating to the preparation and use of standards and specifications as cybernetic machines, we would find an immediate improvement in the technological status of this very critical work. If that were done, it would then be possible to take the necessary steps with the Civil Service Commission and the employing agencies to insure that the grades and opportunities of qualified personnel in the standardization program are at a level comparable with those who are associated with research and development. Until this is done, there will be very little incentive for major changes in the number of personnel eager to work in standardization. There has been much attention paid within the Department of Defense to teaching programs relating to standardization. Unfortunately, many of these have not been conducted in the atmosphere of inquiry, but rather more usually in the atmosphere of training by the rule book. Until sufficient university participation takes place, it is necessary for schools such as the Army Logistics Management Center to undertake the building of appropriate teaching and research curricula for the purpose of enabling select men who have backgrounds in science, engineering, and the arts to fission forward as members of the new technological set -- the fourth set.

NOTES

(The following excerpts from the reference sources are added for background information purposes.)

- 1/ Allen, Thomas J.
Pages 1, 2

"Information processing is now and always has been the basis of scientific activity. As physical systems consume and transform energy, so does the system of science consume, transform, produce and exchange information. Technology, too, is an ardent consumer of information, but as in most physical systems consuming energy, technology produces transformed information primarily as a byproduct. The principal output in this system of technology is, of course, physical hardware. Even though it is a byproduct, information does not occupy a position of sufficient importance for it to have become to some degree a commodity of exchange within the system. Information processing in science is thus different in nature from information processing in technology. . . . Information in science retains its verbal form throughout the process. As a result, it is readily contained and stored in a written form. In the case of technology, the information is used to direct and mold the energetic inputs which become the final product and accepting the extent to which transformed information is produced as a byproduct it loses its form and becomes coded in the structure of physical output. True enough, this structure can very often be decoded as is done for example in the analysis by U.S. aircraft experts of the technological information contained in captured Soviet Mig fighters or in the analysis by commercial R&D laboratories of competing firms' products. But coded in this way, it is much less accessible and is certainly much more difficult to physically exchange. Decoding from physical structure is then resorted to only when for some reason as the unwillingness on the part of one party to the exchange, the byproduct information is unavailable. But even when it is readily available, the fact that this information is a byproduct of the technological process introduces certain factors which not only distinguish the technological situation from the scientific, but also in many ways impedes the flow of technological information."

2/ Gille, Bertram
Page 15

If there is any field in which continuity of effort appears to be the rule in which this continuity is characterized as strongly by the transmission of knowledge as by inventions and imagination whose sole basis is a long progression of thought, that field is the technical one. While certain scientific ideas have been lost and rediscovered and certain sources of artistic inspiration have been forgotten and recreated, tools and manufacturing processes with some exceptions have remained constantly available. From one generation to another as from one man to another there are only imperceptible differences.

Page 24

The notebook of Villard de Honnecourt is typical of those engineers' notebooks such as we shall find from the fifteenth century onwards. That is to say a simple collection of drawings and notes for work in progress the methods of representing them (his machine sketches) are the same as those used in the Greek manuscripts of the eleventh century. In this respect, up to about 1270, the date of Villard's notebook, there was no change.

Page 38

The teaching of Mathematics was marginally introduced into the universities, Oxford first and then Paris. A little before 1366 the candidates for Bachelor Degrees had to swear that they had followed at least 100 mathematics lessons, this formula being, however, interpreted in a very restricted sense thus the efforts of certain scholars from the the thirteenth century onwards taken up and developed by the University of Oxford tended to make of Mathematics and through Mathematics, all techniques, a branch of knowledge analogous to all those which had been traditionally taught.

Page 198

The textile industry made slower progress (than machine design) despite Leonardo's (da Vinci) work. The loom said to be by Jean le Calabrais which made it possible for the silk industry to produce figured materials made its appearance in France under Louis XI at the end of the fifteenth century. It is what is called a button loom which can be used only for small-scale designs and is worked by one operator. A certain Anton Muller

2/ Gille, Bertram
Page 198 (continued)

appears to have seen in Danzig in 1529 a machine for weaving four or five textiles at a time. Invention of this machine appears to have caused such unrest in the working population that the magistrates of the city demanded that it should be suppressed and the inventor drowned. Doubtless this is a legend but it denotes a curious reaction which was subsequently to grow. The great printing riots in France in the middle of the sixteenth century were no doubt caused by technical modifications of the printing presses which in fact led to a reduction in the number of workers. Lee's stocking loom at the end of the sixteenth century represents the first successful attempt at mechanization in the textile industry.

3/ Klemm, Friedrich
Page 283

(Klemm discusses Henry Maudslay circa eighteen hundred. Scott James Nasmyth, a pupil of Maudslay is quoted as saying) He (Maudslay) proceeded to dilate upon the importance of the uniformity of screws. Some may call it an improvement, but it might almost be called a revolution in mechanical engineering which Mr. Maudslay introduced. Before his time no system had been followed in proportioning the number of threads of screws to their diameter. Every bolt and nut was thus a specialty in itself and neither possessed nor admitted of any community with its neighbors. To such an extent had this practice been carried that all bolts and their corresponding nuts had to be specially marked as belonging to each other. Any intermixture that occurred between them led to endless trouble and expense as well as inefficiency and confusion--especially when parts of complex machines had to be taken to pieces for repairs.

8/ Terry, W. M., Jr.
Page 72

In introducing the procedures for proper engineering communications we have to recognize first that we are dealing with what are called the four primary types of engineering personnel: engineers in training, experienced technical engineers, supervisory or middle management engineers, and top management engineers. Different companies may call them by different names but the four classifications definitely exist. It should also be mentioned that in the engineering area there are secondary personnel involved: technicians,

- 8/ Terry, W. M., Jr.
Page 72 (continued)

layout designers, draftsmen and clerical help. However, outside general company information and training material, all technical communications flow to this secondary group directly from primary engineering personnel.

In order to further simplify our discussion, we shall make the assumption that if we have good communications between the primary types involved, there will follow a correct flow of information to the secondary group. In other words, it is the responsibility of the engineer to prepare and formulate the information used by this group.

- 9/ Hindle, Brooke
Pages 48 through 49

The greatest achievement to come out of arms production of course was interchangeable parts or the 'American system of manufacturing' . . . indeed it appears probably that the bare concept of the interchangeability was less important than its workable fulfillment and its extension. This owed much to (Eli) Whitney but also to other private manufacturers who introduced it almost coincidentally and to the government armories.

- 10/ Haefele, John W.
Page 248

The immediate concern of a human being in society is to find a useful niche in which his service as a valuable instrument of social design earns social recognition and reward. Be he a laborer, a bookkeeper, a baseball player or an executive, he does something worth paying for. In general, society is interested in each individual's being a valuable instrument and not much more. If the instrument is not one of the few required to be creative then the road to creativity is hard.

- 11/ Inglis, N. P.
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The final embodiment of the advice given by the metallurgist to the engineer in the consultations they have together on the selection of a particular metal or alloy for a given duty is the specification document on which subsequent purchase is based. Whilst many organizations prepare their own specifications, in this country the British Standard Institution is the responsible part for the preparation and issue of standard specifications. BSI has,

however, received much criticism, mainly for its slowness in the preparation and issue of such specifications. Such delays often lead the larger purchasing organizations to prepare their own specifications which naturally differ from the BSI specification when it appears simply because of the whims, fancies or self-interest of the two different sets of drafters. Whilst faults can be found in the organization and structure of BSI it must be remembered that (a) BSI leans over backwards to try and satisfy all minorities, and (b) BSI is essentially a secretariat for industry in this matter. Much blame can be laid on the drafting companies since each individual member believes in the value of standardization only provided the standard is based on his selection and what he wants. The result is usually a compromise between conflicting views, a compromise which usually takes a very long time to hammer out, moreover there is a multitude of such committees and since BSI is organized on an industry basis, quite unnecessary differences often occur between the composition and properties of the alloy specified for a particular engineering part in one industry as compared with the same engineering part used in another industry. All this plus the private specifications of many large purchasing organizations inevitably result in a ridiculously large number of specified alloys. This means that in many metal-producing and metal-fabricating plants, the economic value of mass production and automation cannot be realized. It can be appreciated that if a metal producer is given an order based on a specification which is different to the standard to which he normally works it is reasonable and logical that he should increase his charges simply because it is a different specification, even if it involves no especial additional technical difficulties. He must put a reliable staff of men specially on the job to make sure that the differences are observed. If there are differences in the points of inspection and testing, this might necessitate changes in the normal pattern of rolling and heat treatment. It may even necessitate scrap from this order having to be segregated from normal scrap.

In a lecture given to one of the courses in the Institution of Metallurgists two years ago, Dr. Edeleanu pointed out that industry is inclined to leave the matter of standards and specifications to what he termed 'the second eleven'. If it is thought that attention to these matters is rather lowering and that there are more important and higher things to which attention should be devoted, then this attitude should be modified in the light of the remarks by Lord Hinton in his presidential address to one of the Institutions. Lord Hinton pointed out that in a series of very senior positions he had

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filled in four important industries he had devoted considerable and personal attention to the subject of standards and specifications with highly beneficial results in each industry.

One of the most important steps which can be taken to simplify and improve the technological selection of materials is for engineers, metallurgists, suppliers, and users to reduce drastically the number of steels and alloys now being specified. When the number of standard steels and alloys has been drastically reduced and specifications agreed for them, their cost and delivery should be considerably reduced. Of course, there will always be a need and a demand for 'specials', i.e., compositions outside the standard range. These must command a very special price until the demands for them are such that they can become a standard. The present system whereby a metal producer whose plant is laid out and whose organization is planned for making a very limited number of standards - both in composition and size - is asked to produce a multitude of alloys is wasteful and one of the causes of the lengthy delivery periods which are extremely costly.

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A Government specification has as its primary function in our technological economy, promotion of rational competition for the purpose of securing economic procurement. As a control mechanism, a proper specification requires feedback -- it should operate as a cybernetic machine -- and it must be designed and constructed by men skilled in all of the several technological communication and control techniques in use today. Optimum designs and designers are still to be created.			

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