AIRCRAFT AND GUIDED MISSILE PRODUCTION FOR WAR

19 January 1955

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INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington, D. C.

Mr. William B. Bergen, Vice President of Operations of The Glenn L. Martin Company, was born at Floral Park, Long Island, New York, 29 March 1915. He is a graduate of the Massachusetts Institute of Technology and began his business career in 1937 when he joined The Glenn L. Martin Company. In 1939 he was appointed as chief, vibrations engineer and later assumed the duties of chief, flight test engineer. In 1945 he was appointed chief, pilotless aircraft to initiate and direct the Martin guided missile program. Under his direction, this section was enlarged to a Special Weapons Department charged with development and design of guided missiles, fire control, electronic and electro-mechanical systems. He became chief engineer in 1949 and was elected vice president in 1951. Mr. Bergen is the author of numerous technical papers and winner of the Lawrence Sperry Award in 1943 for "Theoretical and Experimental Investigations of the Dynamic Leads on Airplanes." In April 1953 Mr. Bergen was appointed Vice President of Operations coordinating all company functional activities for the various projects.

AIRCRAFT AND GUIDED MISSILE PRODUCTION FOR WAR

19 January 1955

GENERAL NIBLO: To each of you a good morning. Today is Glenn L. Martin Day at the Industrial College. Our speaker this morning is Mr. William B. Bergen, Vice President in Charge of Operations for The Glenn L. Martin Company. He will discuss "Aircraft and Guided Missile Production for War."

Bill, it is a pleasure to welcome you back to the Industrial College and to present you to our class of 1955.

MR. BERGEN: Thank you, General Niblo, gentlemen: You fellows are very kind and we certainly appreciate your courtesy, but I want you to understand that you don't fool me a bit. Two years ago, I was asked to give a talk on guided missiles. The only guided missile we had flying at that time was in all sorts of difficulties--falling apart in the air; couldn't get near a target. So we were chosen as experts in guided missiles because we couldn't make them work. We have them working now.

Today I am billed as an expert on war production planning. I want to make it clearly understood before we get started that I don't know a thing about war production planning. However, I don't feel too badly about this, because you fellows haven't told me what kind of war you are planning; you haven't told me when it is going to take place.

No, I don't know what kind of war to talk about, but I have a hunch we are planning for a war in what we are doing today and every day. I certainly don't subscribe too much to the theory that you can carry on a peacetime activity in an outfit such as ours, and then be able to convert to war production as soon as the gong sounds. Rather, I subscribe to the theory that the next time the gong sounds the boys in the dusty room are not going to have enough time to get off their desks and find out what is going on in the world.

A topic of interest to you, I know, and something we can talk about among friends is aircraft production. We have learned what not to do inside an aircraft factory by doing so many things wrong in the past. By the same process of trial and error we also have learned how to organize best for peace and war.

I have broken this production talk down into three or four phases. As I said last year and still believe--the strongest bulwark for war or peacetime production is the kind of people we have. I am talking about teamwork, the nebulous ideal that everybody writes books about, but nobody seems to be able to carry out too well.

The next phase of my talk covers planning. How do we go about planning for these eventualities? And then, perhaps, I will touch on the three main elements that make up a production program, at least as far as the Martin Company is concerned. We divide what takes place in the engineering area primarily into tooling and manufacturing. Finally, although these aren't earth-shaking, I want to discuss some of the interesting trends that we take. The trend may start in a very innocuous sort of way, and you don't realize its significance until it is well along. I think I touched on one of these trends last year, and it has certainly blossomed out during the past 12 months--new fabrication techniques.

Another problem, almost taking as much time as production itself, is timing and acceptance. I believe it warrants inclusion in this talk, and finally, I want to cover something terrifically important--plain old packaging.

I would like to go back now and talk about our first topic; let us call it management. First of all, I think we are a little unique in the business world in that our sole customer is the military. And really what we have to sell and what we have to do as a service, and especially the contribution that justifies our profit and our reason for being is the ability to be close to the forefronts of new advancements--as close as you can possibly get in any kind of an organized society.

I think you'll agree that in our industry, particularly as it serves the military exclusively, we have more of a competitive situation than you will find anywhere else. We can't sell a new airplane by changing a fender line or putting new tail lights on the back end of it.

We don't always consider this, but underneath all this competition is a life and death struggle with the fellow we never even see, the fellow in Russia. As a result of this keen competition, our preponderence of technical people has to be high.

Being an engineer, I used to think the engineer was the lifeblood of industry. Everyone else was there to help him. I have come to

realize that people with other special technical skills, one example--such as machine tooling, are just as important as engineers. There are not many of these people about. Moreover, you can't train them overnight. So it is important that when we talk about war mobilization that we have a nucleus of these technical people who are capable of expanding into much larger organizations than we have now.

So far as products are concerned--getting back to the technical nature of the business--a lot of us are liable to say, "Well, gee, things are getting so complex, they are getting hopeless." I don't think this complexity talk holds too much water. But what we are doing today is putting a lot of things together that we never had to put together before.

In the airplane today the airframe is a smaller percentage of the overall effort than it used to be. Also, we find, surprisingly, that the airplane itself works much better than the "junk" we put into it. I say "junk" facetiously. Nevertheless, what makes the weapon is the equipment that goes into it, not the visible frame that flies around. True, the airframe design is what appeals to everybody. So we emphasize it.

The philosophy in the Martin Company, and this is becoming more and more true, is that we like to think we are now working closely enough with you people so that we know your fundamental requirement. And, if we understand the requirement as you tell it to us, we are in a much better position to fulfill it than we would be if you kept us in the dark, giving us only part of the specifications from time to time.

Here's a term that is very badly abused. We call ourselves a "weapons systems contractor." This means that we determine precisely the subcontracting components that will go into an aircraft. It doesn't follow that we intend to compete with the subcontractors in building any of these components, however.

In order to perform this contractor service, and we believe this is our mission in life, we have tried to organize our whole company on a basis that would help us carry it out. You can organize on the basis of doing business with the Air Force, doing business with the Navy, and doing business with the Army. We haven't done that. We have organized our company on the basis of technical skills.

Chart 1, page 5.--This is our fundamental organization. As you can see, we have a number one boy, and then directly under him we have all the vice presidents representing what we call the technical skills which go to make up our organization.

The first one is sales and service. You may lift your eyebrows at sales and service being called a technical skill. I can assure you that it is one. It is one of the mediums by which we have communications with you people to learn what your requirements are, make sure that we understand them, and make sure that we can get the feed back properly.

The second one, quality control, is responsible for final certification of an aircraft. Certification, in this instance, means the highest standards have been met.

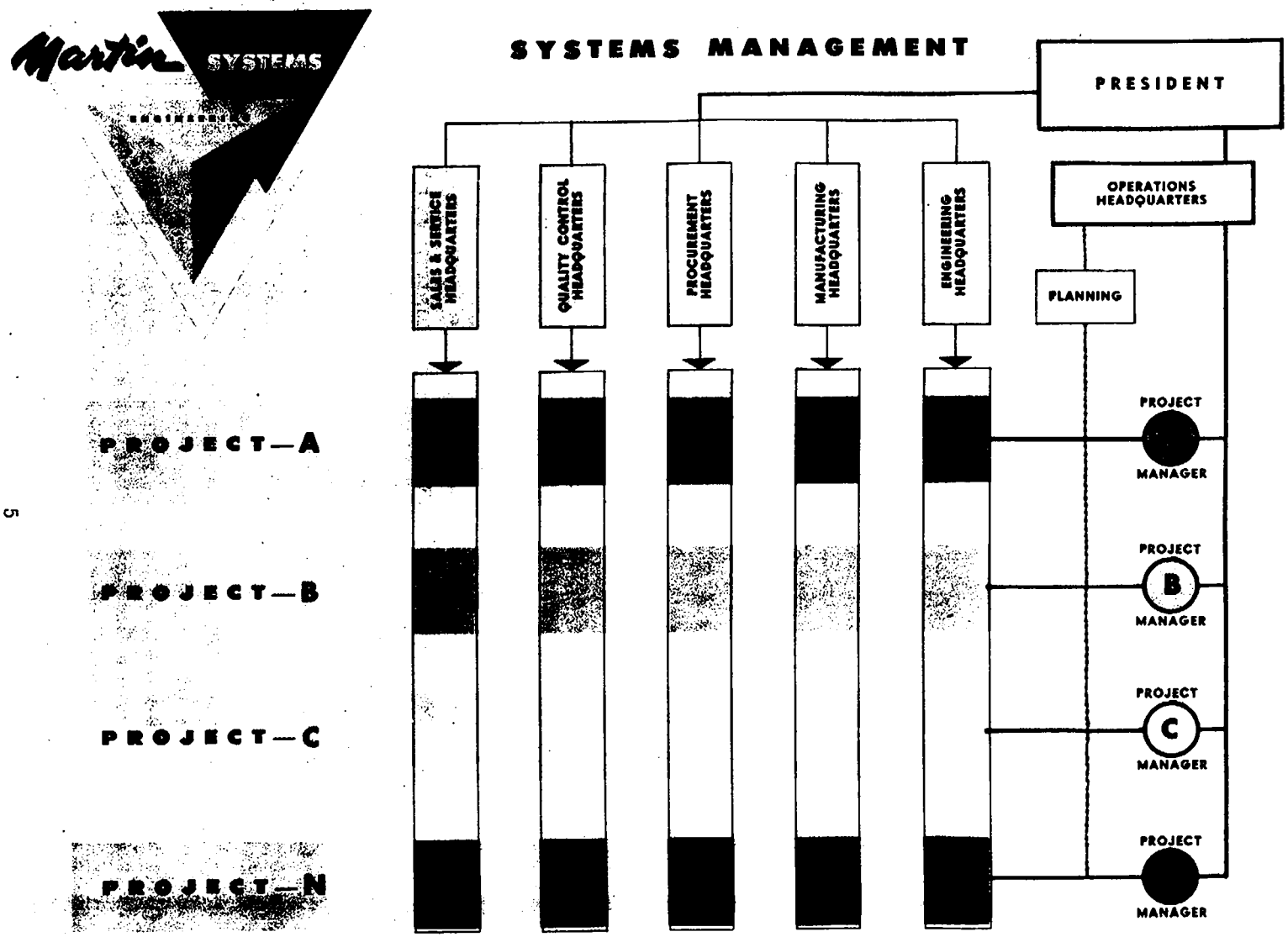
Procurement.--This might interest you. Normally, you will find procurement as a service under manufacturing. We have actually found that, because of the importance of the equipment that goes into our weapons these days, procurement very often is the deciding element in whether we meet our schedules or not. Not only that, but our analyses of subcontractors--in trying to pick out the sheep from the goats--is an extremely important part of our business. So we have dignified procurement by setting it up under a vice president.

The Manufacturing Division, of course, is fairly obvious, as is the Engineering Division. But just to give you some idea of their importance--right now we employ 18,000 people in Baltimore, 2,500 are engineers. The bulk of the others--15,000 or 16,000 are under Manufacturing; and the rest, relatively few in number, fall under the first three groups, "sales and service," "quality control," and "procurement."

So if you are interested in what we are doing in the Engineering Division, what our philosophies are, what our methods are, what our equipment is, it is quite easy just to follow Engineering down through the various projects, and you will find it completely unified. Everyone in Engineering, for example, wears a badge which says "Engineering" on it.

However, for several reasons, it would be very nice if we could produce, say, one model of an aircraft and just come along with an improvement on it every year, or once in awhile take a drastic design

CHART 1


Martin SYSTEMS
SYSTEMS MANAGEMENT
PRESIDENT
OPERATIONS HEADQUARTERS
PLANNING
SALES & SERVICE HEADQUARTERS
QUALITY CONTROL HEADQUARTERS
PROCUREMENT HEADQUARTERS
MANUFACTURING HEADQUARTERS
ENGINEERING HEADQUARTERS
PROJECT—A
PROJECT—B
PROJECT—C
PROJECT—N
PROJECT MANAGER
PROJECT B MANAGER
PROJECT C MANAGER
PROJECT MANAGER

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step. But, as I will show you a little later, we run into the problem of peaks and valleys. Not only that, but since we are running close to this technical forefront I mentioned, we don't know whether the development we are working on today is going to be any good tomorrow. It can become obsolete overnight. Nor can we afford to gather the technical people or staffs we need and have them support one or two projects. That's why we have gone into a multiplicity of projects in the Martin Company. I believe we are unique in having all our different projects and contracts with the three military services under one roof.

This may come as a surprise to you, but we have found that the three military services have different personalities. So we have tried to set up what we call a "product control" within a "functional control."

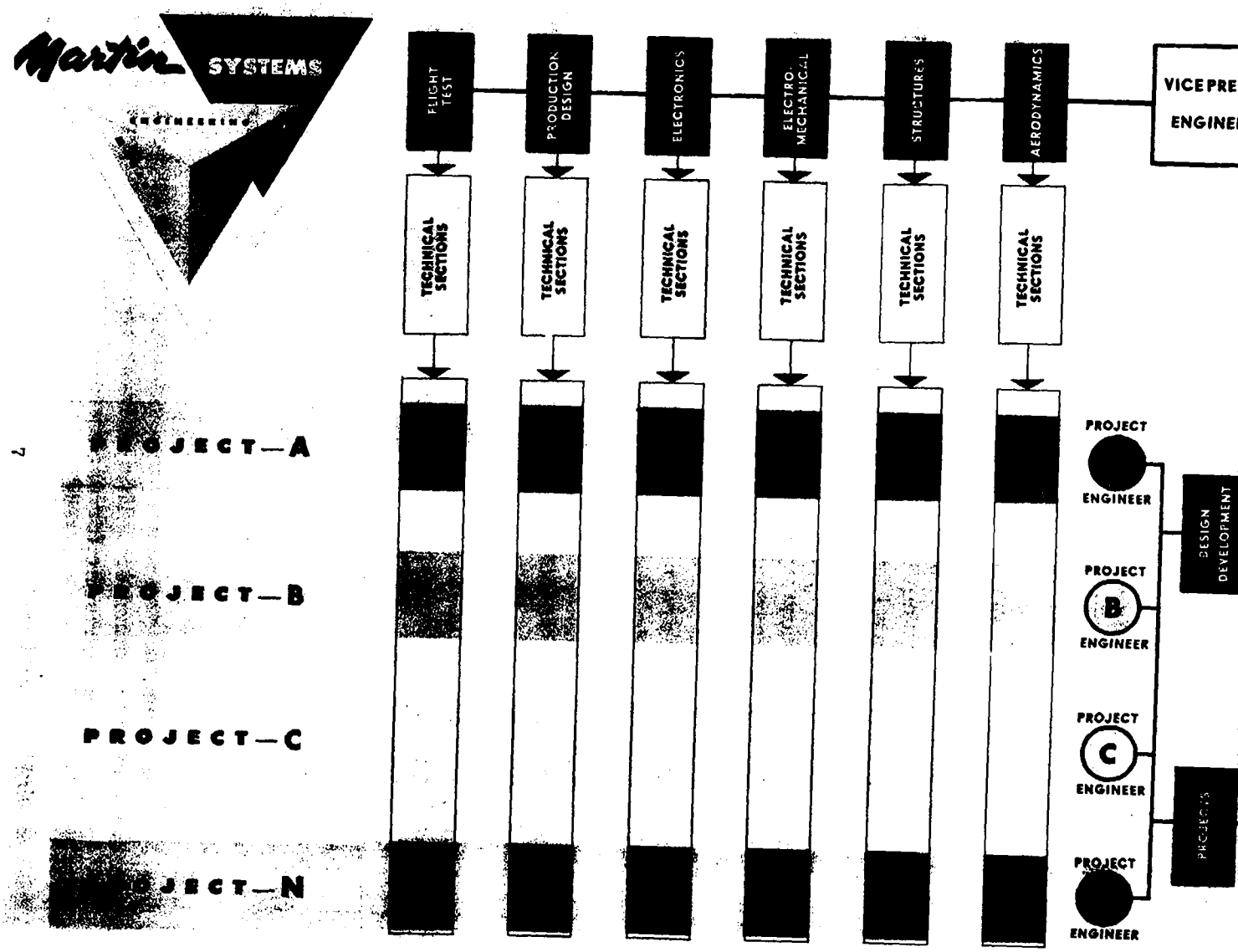
We have also found that each product we manufacture has a rather different personality. For example, by just looking at a small air-to-air missile which maybe weighs 200 or 300 pounds, you can tell it is obviously different from a 160,000 pound seaplane.

Consider Project A the Matador TM-61 missile, for example. We have set up under the Operations Division an operations manager who is responsible for the complete administration--whether it fails or is a success--of this particular project. This has been done before. But you know what happens when you set up such a fellow. Unless he has an extremely good and dominating personality, nobody pays too much attention to him anyway, and they run around behind his back and make sure no one gets hurt in the Engineering Department. Also, we have his counterpart in Engineering. We have a project engineer. So all engineers assigned to Project A, no matter what their specialty is, report to the Project A engineer, who in turn is responsible to the operations manager. This holds true for the other projects, also.

Chart 2, page 7.--This shows the engineering organization, which in turn is divided according to the functional skills that we think go to make up an aircraft engineering. We happen to call them aerodynamics skills, electronics skills, design, and flight testing. Here within Engineering we now have set up a Project Department. This is complicated because we also have a Design Development Department which does planning for new design. The Project Department handles those design projects which are pretty much under way.

Consider Project A the Matador again. At the extreme right is the project engineer for the Aerodynamics Department. We have a

CHART 2


Martin SYSTEMS
ENGINEERING
FLIGHT TEST
PRODUCTION DESIGN
ELECTRONICS
ELECTRO-MECHANICAL
STRUCTURES
AERODYNAMICS
VICE PRE
ENGINE
TECHNICAL SECTIONS
PROJECT—A
PROJECT—B
PROJECT—C
JECT—N
PROJECT
ENGINEER
B
C
DESIGN DEVELOPMENT

group of aerodynamicists working on this project who report to the aerodynamics project representative, who in turn reports to the project engineer. This holds true across the chart for each engineering department.

The interesting commentary on this is that many people say it won't work because no man can report to two bosses. With this, we do not agree. Let us take a simple analogy.

For those who are fortunate enough--or unfortunate enough, depending on how you look at it--to be married, if you will examine your souls, you will admit that there are a lot of jobs you do before you go to work that are directed by your better half. When you go to work, if you drive the way I do, and if you happen to see a little boy in a blue suit, you soon recognize that you are not controlling your speed; he is. Moreover, when you get to work, the ugly ogre of a boss has considerable to do with how you conduct yourself during the day. What I'm saying is you can report to several bosses, but it's important to know to whom you are responsible for what. If you recognize that you are responsible to your wife for getting the maid from the station in the morning, and you are responsible to the cop for not going over 50 miles an hour, it is pretty easy, and you don't get confused.

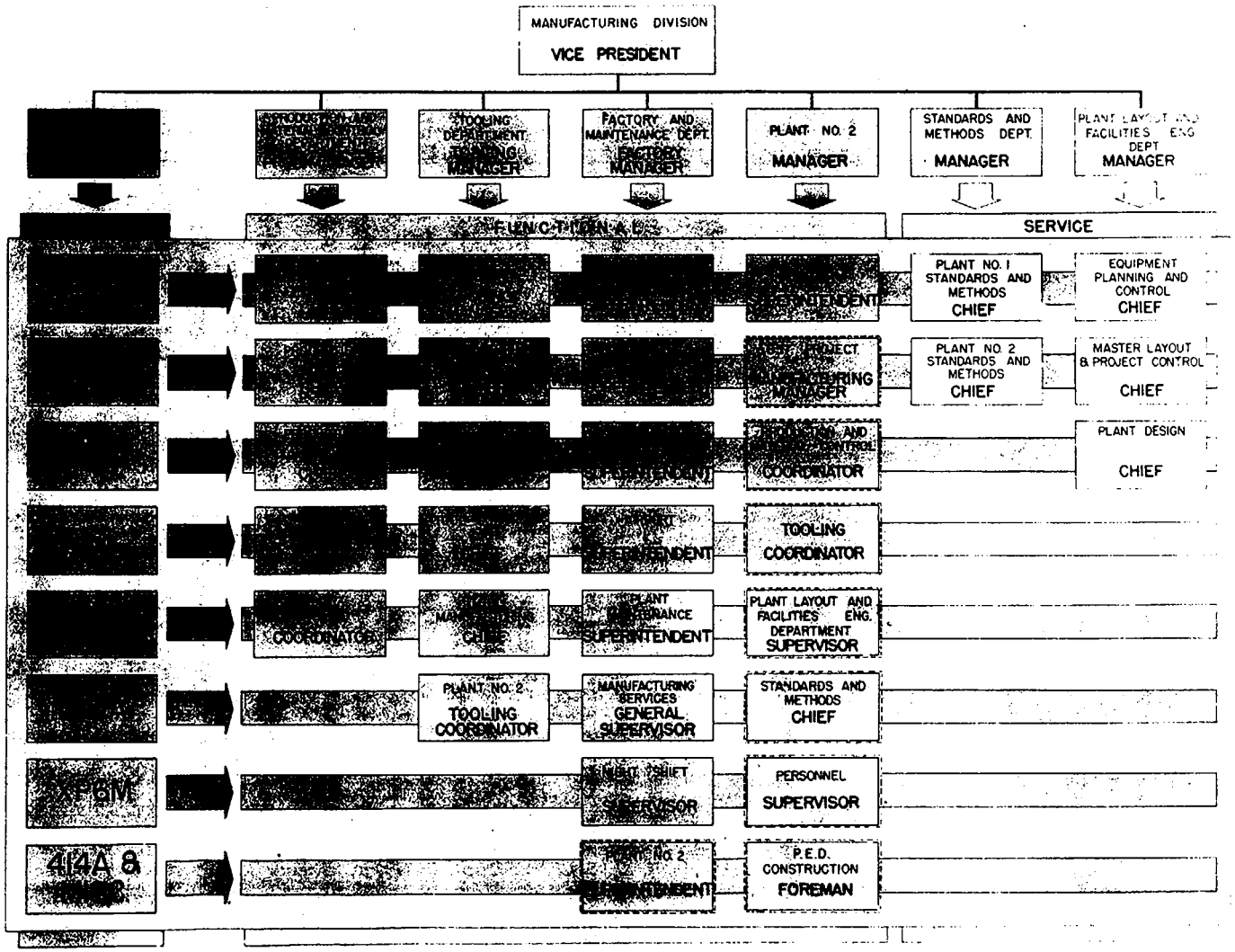
This dual responsibility at Martin works the same way. The aerodynamicists on Project A, for instance, are responsible to their project engineer in so far as their technical skills on the project are concerned, and to the manager of the Aerodynamics Department for their overall specialist skills. We have had this system in operation now for a little over two years and it works well.

Chart 3, page 9.--I had this chart made up differently from the first two to show that we aren't in a rut. Here is Manufacturing. We have said the functional, technical skills required in manufacturing are the Production Department, tooling, and factory manager. We actually have another plant and this setup is the same in both plants.

Here, again, you see as an equivalent to the project engineer, a manufacturing manager. This, I think you will find very unique--a manufacturing manager for each project.

Perhaps you can argue with the way we have broken down some of these skills. This type of organization has a lot of administrative

CHART 3


MANUFACTURING DIVISION
VICE PRESIDENT
TOOLING DEPARTMENT
FACTORY AND MAINTENANCE DEPT.
FACTORY MANAGER
PLANT NO. 2
MANAGER
STANDARDS AND METHODS DEPT.
MANAGER
MANAGER
FUNCTIONAL
SERVICE
PLANT NO. 1 STANDARDS AND METHODS
CHIEF
EQUIPMENT PLANNING AND CONTROL
CHIEF
PLANT NO. 2 STANDARDS AND METHODS
CHIEF
MASTER LAYOUT & PROJECT CONTROL
CHIEF
PLANT DESIGN
CHIEF
COORDINATOR
TOOLING COORDINATOR
PLANT LAYOUT AND FACILITIES ENG. DEPARTMENT
SUPERVISOR
PLANT NO. 2
TOOLING COORDINATOR
MANUFACTURING SERVICES GENERAL SUPERVISOR
STANDARDS AND METHODS
CHIEF
PERSONNEL
SUPERVISOR
P.E.D. CONSTRUCTION
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advantages other than the technical organization advantages I just mentioned. One of these advantages actually applies to engineering more than to any other division. Everyone likes to be known as some sort of specialist. Organized in this way, all our people retain their specialist identity regardless of where their particular skills are being utilized. After all, the worst thing you can do is to confuse an electronics engineer with an aerodynamicist. Within this type of flexible organization, however, we can shift them from project to project--as we have to do--and they don't get upset because they remain an electronics engineer or whatever they may be.

Chart 4, page 11.--If we follow a breakdown of a particular project such as Project A, you will see we have the operations manager, then ranged below, the project engineer, the manufacturing manager and so on. The other divisions aren't shown but they are organized in the same way.

One of our biggest problems was convincing the financial people that they should be organized in this way. If you have ever had any conversation with your accountants, you will recognize that it was our final victory in getting them to realize that they are accountants on a project and not accountants for an IBM machine.

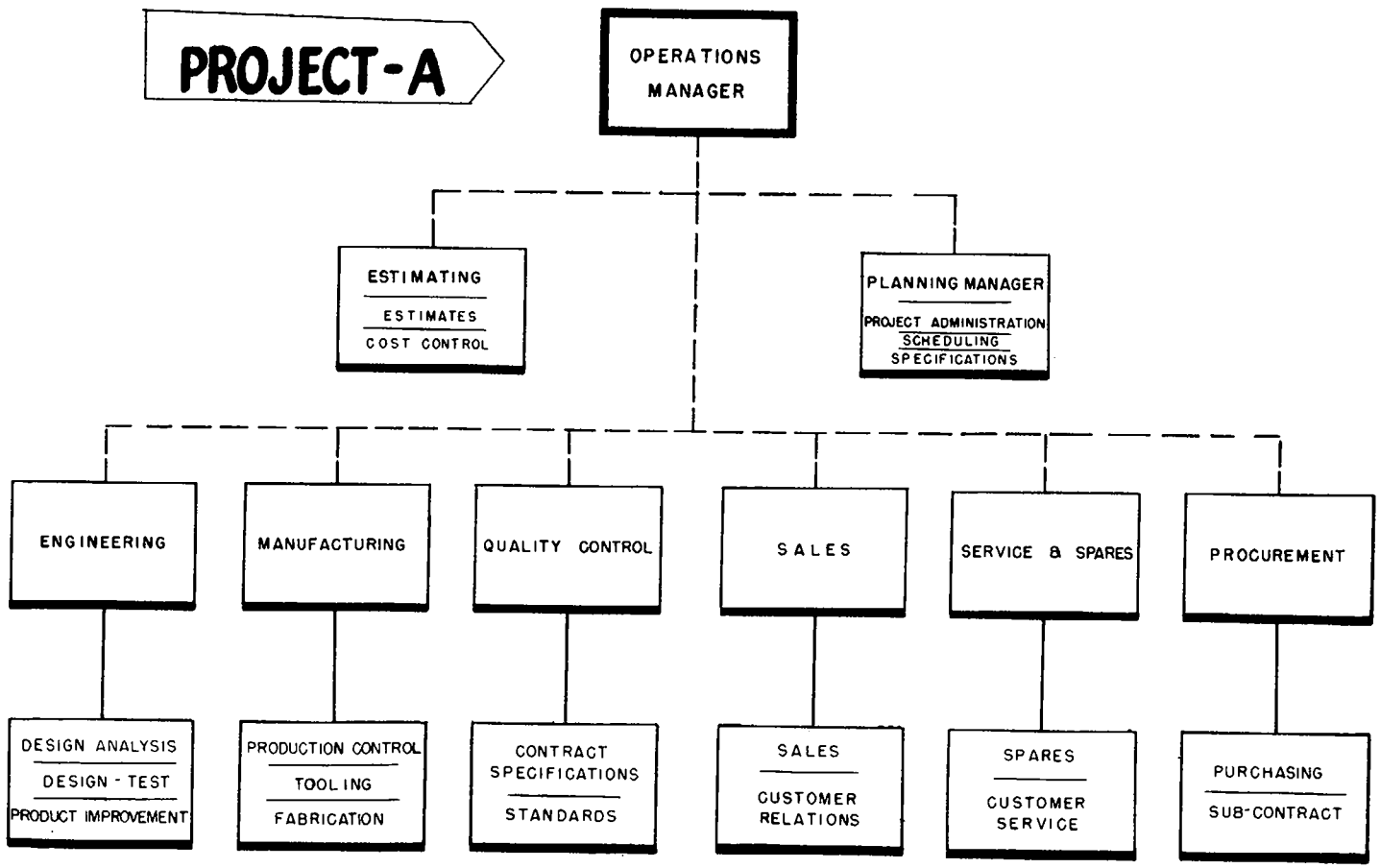
Speaking of functional control, the best type we have is contract control. Then following this sequence down from the contract is the most important part of the contract, which is known as specification, and stepping down further, we have scheduling and finally the budget. I don't say, "Finally, the budget," as though I don't think it is important, but actually in our business we find that it is necessary to make sure that the budget isn't the tail that wags the dog.

I have heard a great many dissertations about this question of budget and I have seen it get into the problem until you receive a very strange interpretation of it. For example, you give Engineering so much budget; you give Manufacturing so much budget; and some people begin to gage their promotion and salary-increase possibilities according to how they do on their budget.

Say the Engineering Department pulls a blooper. The Manufacturing Department people say, "If Engineering gets that much money for pulling a blooper, we want more budget." They have a good point. So you answer, "O.K., we will figure out some way to give you more

CHART 4

OPERATIONS - FUNCTIONAL CONTROL



budget" and they begin transferring charges all over the place and getting themselves all mixed up as a result. I maintain this doesn't have very much to do with building airplanes.

So you have to consider the budget in a very sophisticated way. What we have done is set up a planning manager who has charge of the administration of contracts and specifications, and also, an Estimator who has charge of estimates and cost control. We have put them in staff positions because we feel that real budget control is done by the project engineer, manufacturing manager, and people on their level of supervision. The planning manager and estimator coordinate the whole picture. We feel quite strongly that the very best planning department we can have is one which is not set up as a separate empire trying to act as an overseer but one which is completely decentralized by projects.

If we have an ideal situation then--which we never have--all we have to do is draw a circle around each project and say, "Fellows, go to it. You are the Martin Matador Company, so, just let us vice presidents go out and play golf and drink cocktails." It doesn't work out that way. We play very little golf. But this is the way we attempt to push responsibility down the line.

We have found that if this type of organization doesn't solve too many problems--you never solve a problem by an organization incidentally--it enables us to spot trouble areas an awful lot quicker than we ever did before. Having had years of batting around by you fellows, I think we became good at getting out of trouble once we were in it. The problem was finding out when we were in trouble. We darn near went bankrupt in 1949 and didn't know it until two months before the banks closed down on us. I don't think that would ever happen today.

Nor do I think this is the most important result. The really important effect is the filtering through of responsibility, down to the lowest supervision level capable of assuming it. In other words we are not a one-man company. We have very few geniuses and we are sort of proud of this.

Let us go on to some of the mundane parts of this program, such as planning. This is the bane of our existence. I am sure you are familiar with the implications of the next chart. Actually, it tells only half the story.

Chart 5, page 14.--This assumes that we have a "go ahead" on a new contract. It shows engineering, tooling, material, and so forth, and how we build up a curve. I think the Air Force calls it the "Craigie-Cook Plan." The Navy has another name for it. If everything goes well and we have no major problems after we get the contract, it takes perhaps four years to produce about 300 airplanes. This, I think, is very optimistic.

The other part of the story, which we don't show here because far be it from us to start a controversy with you fellows, covers the time from when we start working on the idea until the time we get a contract. This allows for all your design studies, computations, and reevaluations, and may run three or four years. This is not the exception. We are working on programs now that started off in a formalized study with five or six different contractors participating. After three years of work on this project, the purchasing agency is considering giving a contract to three of these contractors as soon as this requirement comes up. I think this is a rather serious problem with you people. I can tell you right now, you fellows are taking as long to evaluate design proposals that are submitted to you as it takes us to put the proposal together.

I don't want to argue with you today but these are the realities that affect lead time. Moreover, you can see our planning stretches out into a matter of years; not of months, which makes planning difficult, particularly as everything is subject to change.

Chart 6, page 15.--This shows a typical growth curve built up for the single project shown here. Because the manufacturing scale is so high, it doesn't look like we have many engineers working on it, but let me assure you that 500 engineers is a lot.

As an aside, let me say we do something else that is unique. We have pretty much set a 500-engineer ceiling on our normal type of project, whether missile or airplane. This is the number of engineers that can be efficiently administered. This figure is a maximum; it can be less. We are inclined more and more to base schedules on the use of 500 engineers per project and then see how our schedule works out. We have found that when we tried to do a bangup job on the theory that if 10 men can do it in 5 days, 5 men can do it in 2.5 days, it doesn't work out.

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CHART 5

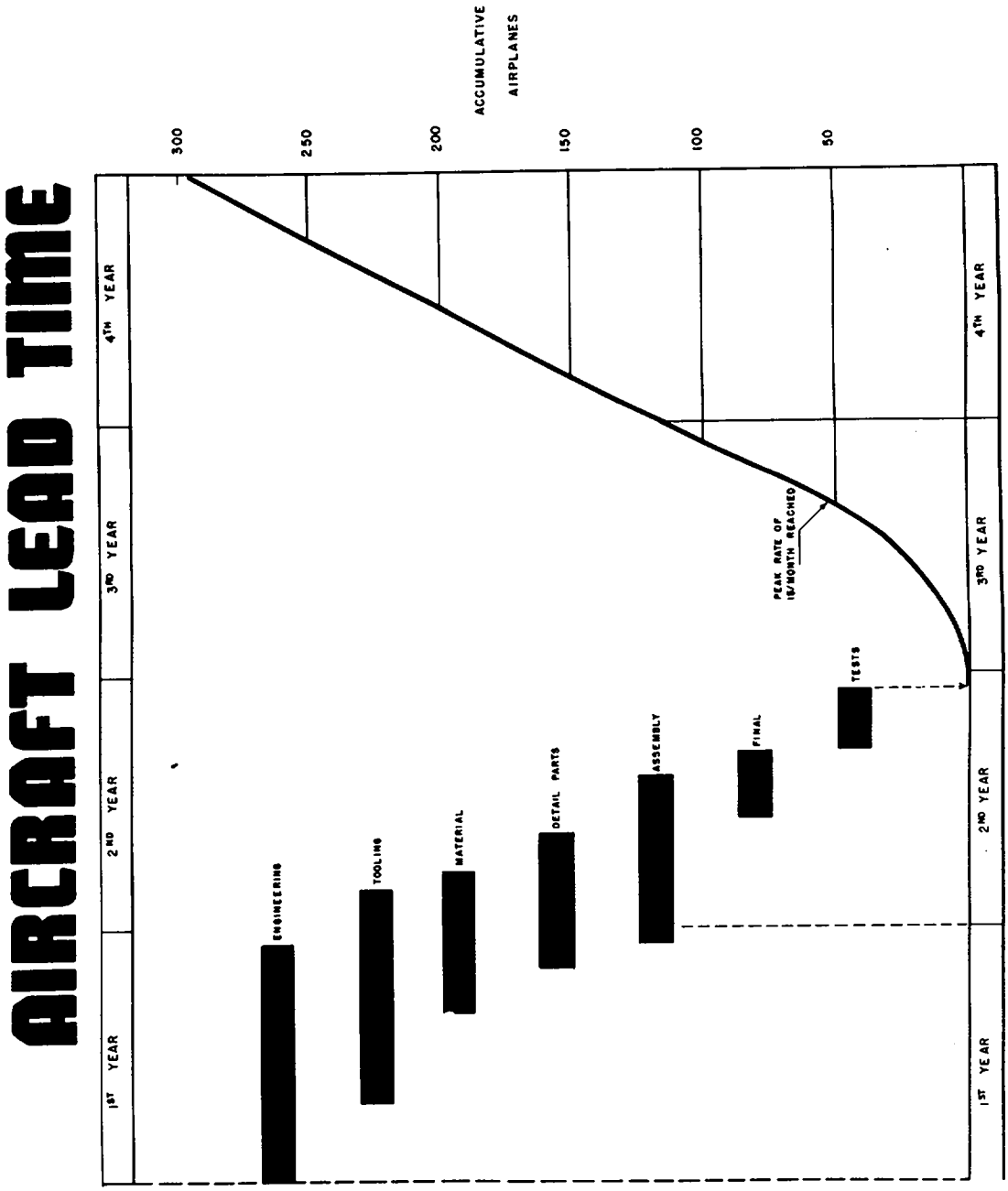
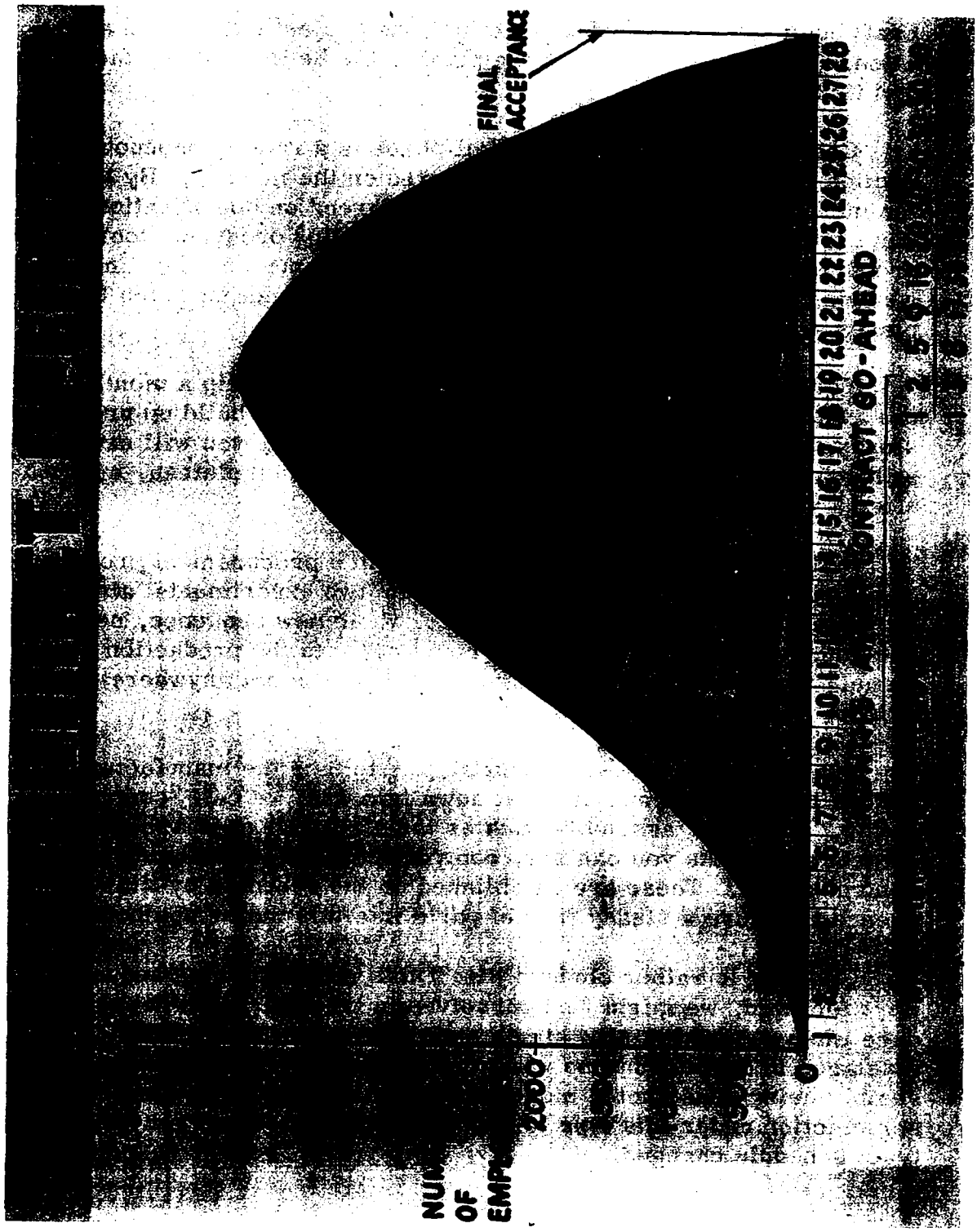

AIRCRAFT LEAD TIME
1ST YEAR
2ND YEAR
3RD YEAR
4TH YEAR
ENGINEERING
TOOLING
MATERIAL
DETAIL PARTS
ASSEMBLY
FINAL
TESTS
PEAK RATE OF 15/MONTH REACHED
ACCUMULATIVE AIRPLANES
300
250
200
150
100
50

CHART 6



The main reason I want to show you this curve is that obviously no company requiring technical skills such as we require in the aircraft business can afford to have just one project under such a situation. The busiest people in the plant would be those doing the hiring and firing.

Chart 7, page 17.--This detail phase is a rather innocuous production schedule. We like to get started on the mockup. By the time the mockup is finished, we should have agreed on specifications with our customer. Then we outline the engineering program, tooling, procurement of raw materials, equipment, manufacturing, and, finally, we come down to final assembly and to the sequence in which the airplanes are turned out.

You will notice we will turn out one airplane, skip a month, turn out another one, then two, three and so forth. We build up pretty slowly. Following this schedule across the chart, you will see we still haven't reached anywhere near our production plateau, even after a year.

Incidentally, as an aside, we prefer this procurement program to the old one when we would build one or two experimental airplanes, fly them awhile, and then go through a whole new sequence, new engineering, new tooling, and finally come out with the production airplane. Sometimes, the production airplane was not anywhere near as good as the experimental one.

Chart 8, page 18.--The next step is to take the manufacturing part of the schedule and break it down into what we call "control points." A major assembly such as the aft-fuselage is a master control point. As you can see, control point 803 is broken into subcontrol points. These are established on the schedule by time sequence to insure a steady flow of parts into this major component.

I think it is rather obvious that if this manufacturing sequence isn't followed, we might find ourselves in trouble. This happened once when we had set up a single contract for the wing. We had fuselages in quantity but no wings. Also, if you see one major assembly being constructed more rapidly than another, you can take some action under this type of production sequence and get the contract schedule changed.

CHART 7

TYPICAL AIRCRAFT PRODUCTION SCHEDULE

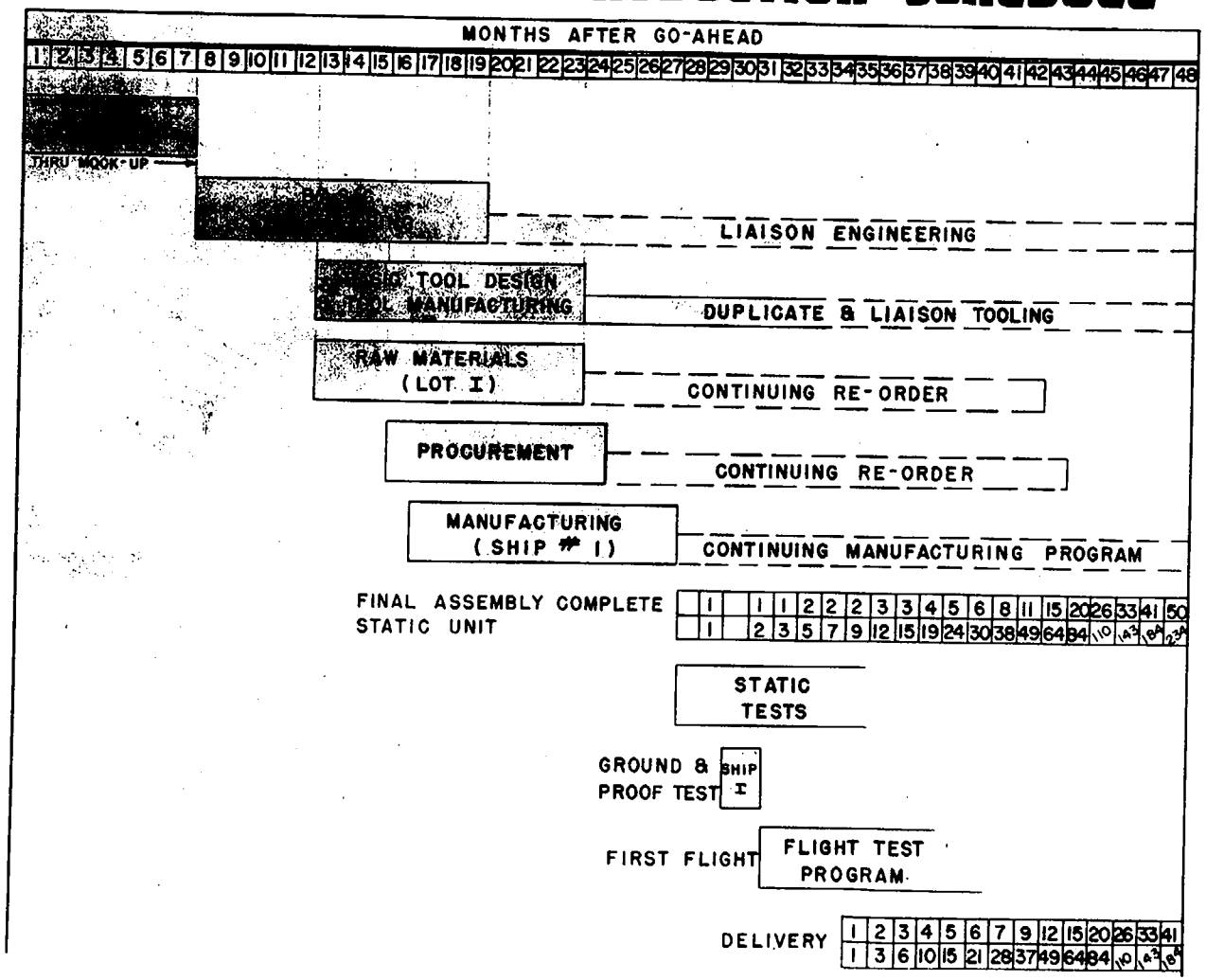


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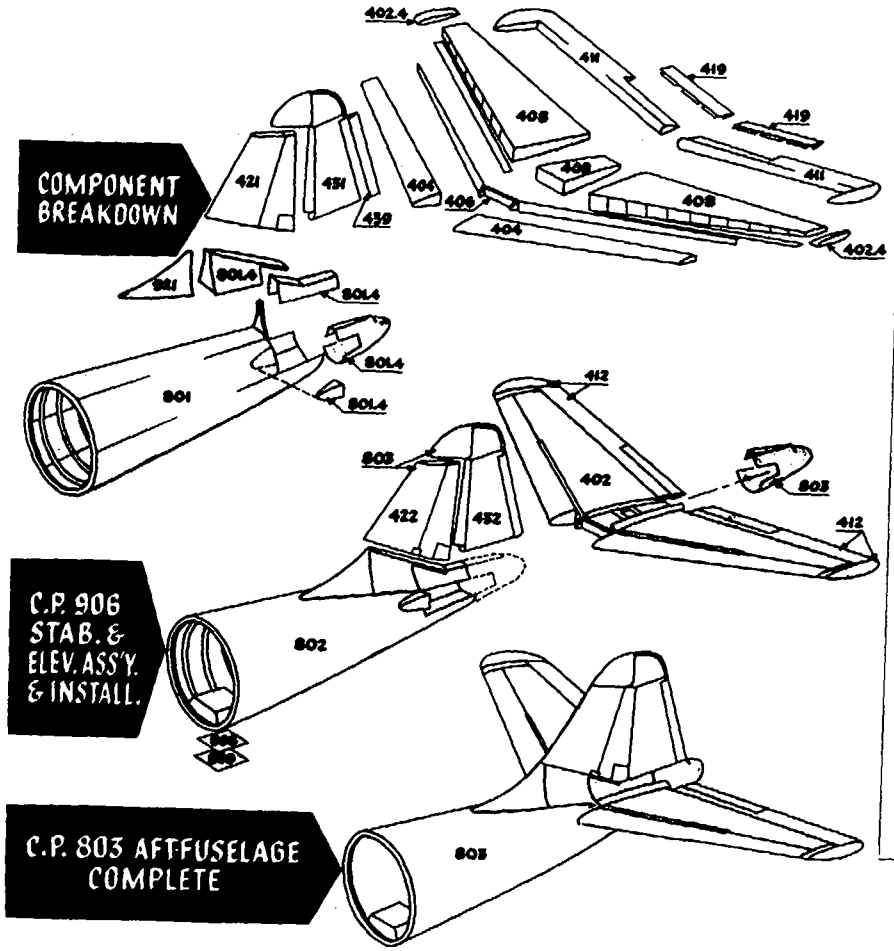
CHART 8

AFT-FUSELAGE-CONTROL POINT SEQUENCE



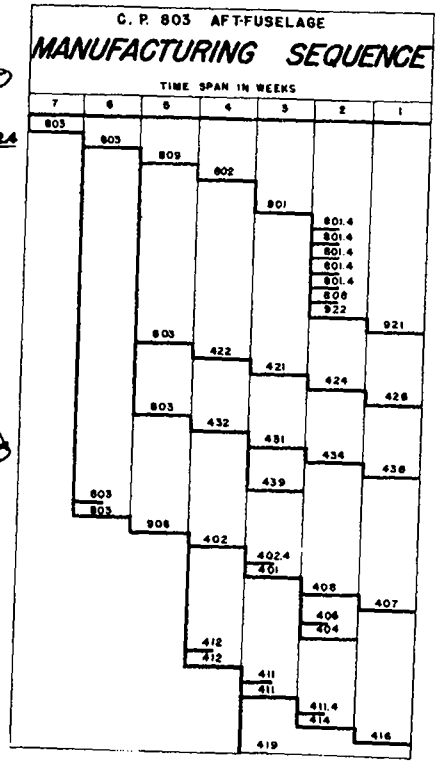


Chart 9, page 20.--I would like to emphasize the cost here. We apply the same type of control to cost as we do to the fabrication of parts. Supervising cost control is the operations manager; below him is the project estimator. Because we ran into so much trouble with budgets, we have outlawed the word and we use the expression, "allowable cost." The project estimator is responsible for letting each department know how much money it has for operating. Of course, the engineering representative has to pretty much agree with the estimator's allocation. If he doesn't, it is hashed out. There is no controversy about it by the time it reaches other levels within a department.

The estimator is the boy who keeps track of how much money he is spending. The important part of his job that requires genuine skill is not knowing how much money has been spent; it's estimating how much money must still be spent to complete a project. When you start out, everybody does fine. There is no financial problem until you get 95 percent of the job done. Then it's like pulling teeth.

The ground rule here is that each division sets up, controls, and polices its own internal cost control. For example, in manufacturing, the amount of allowable cost given to the foreman is less than the amount we have allocated for him. Within a department, allocation standards may be changed as often as once a week, but as long as their figure is less than what the operation manager has allowed them, it doesn't concern him. However, if they report they are exceeding their allowable cost, then it becomes cause for major concern.

Chart 10, page 21.--This is an airplane that has been interesting to us, not only as an aircraft, but because it is the first one affected by our product cost control from the time we got the contract until the time it was completed. Actually, it hasn't flown yet, but it is pretty well along. I am showing it to you because the General told me I could take five minutes for advertising. It is the Martin XP6M-1.

Chart 11, page 22.--This is the total cost control record--the only record that has been officially kept in the company--on this program. It is interesting because this is a rather large program and has absorbed, I believe, somewhere over 50 percent of the Navy's Bureau of Aeronautics Aircraft Research and Development. This meant that if we encountered any serious overruns, we would not only put ourselves in a bad position but we would jeopardize that bureau's funds.

CHART 9

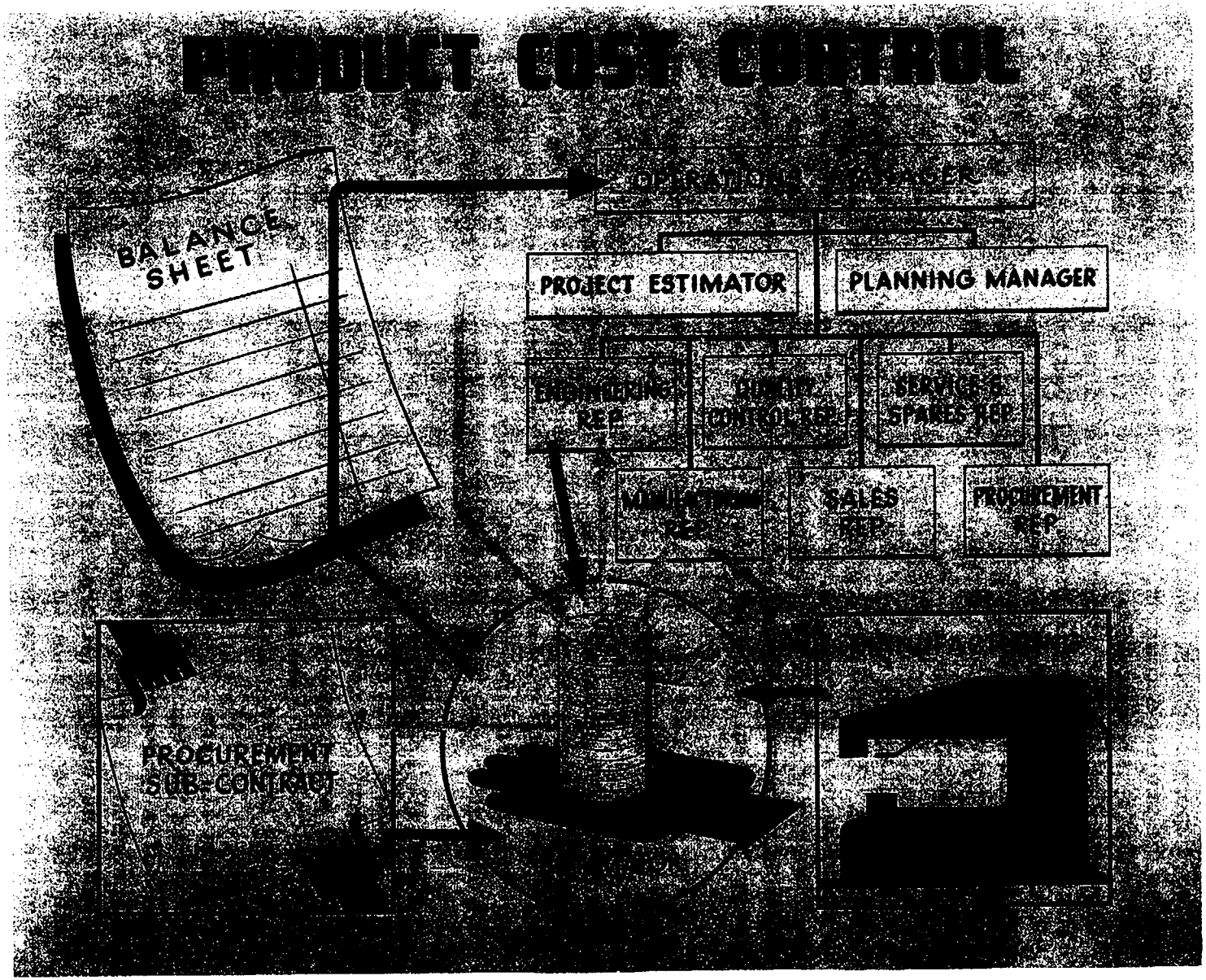

PRODUCT COST CONTROL
BALANCE SHEET
OPERATIONS MANAGER
PROJECT ESTIMATOR
PLANNING MANAGER
ENGINEERING REP.
BUDGET CONTROL REP.
SERVICE & SPARES REP.
MANUFACTURING REP.
SALES REP.
PROCUREMENT REP.
PROCUREMENT SUB-CONTRACT

CHART 10

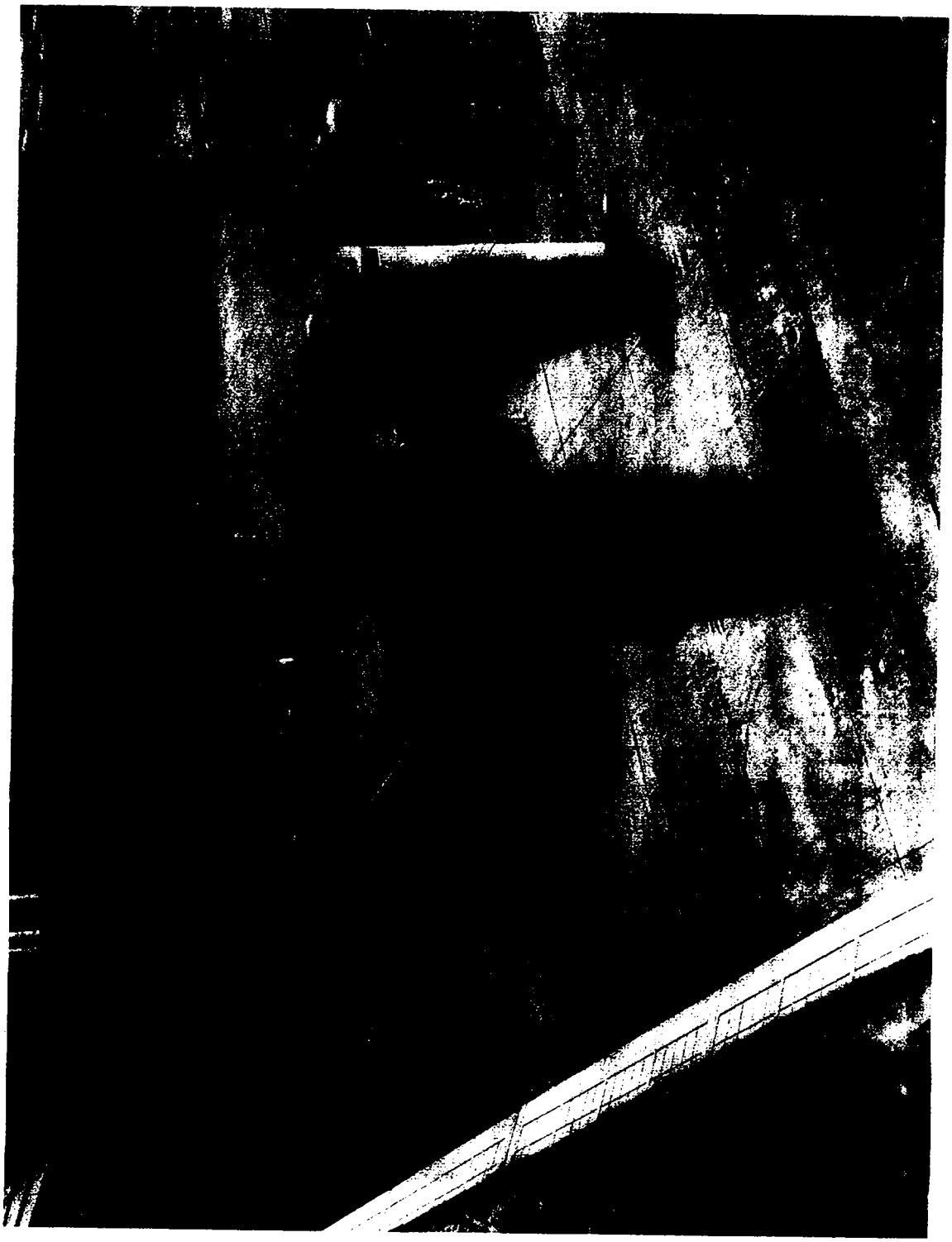
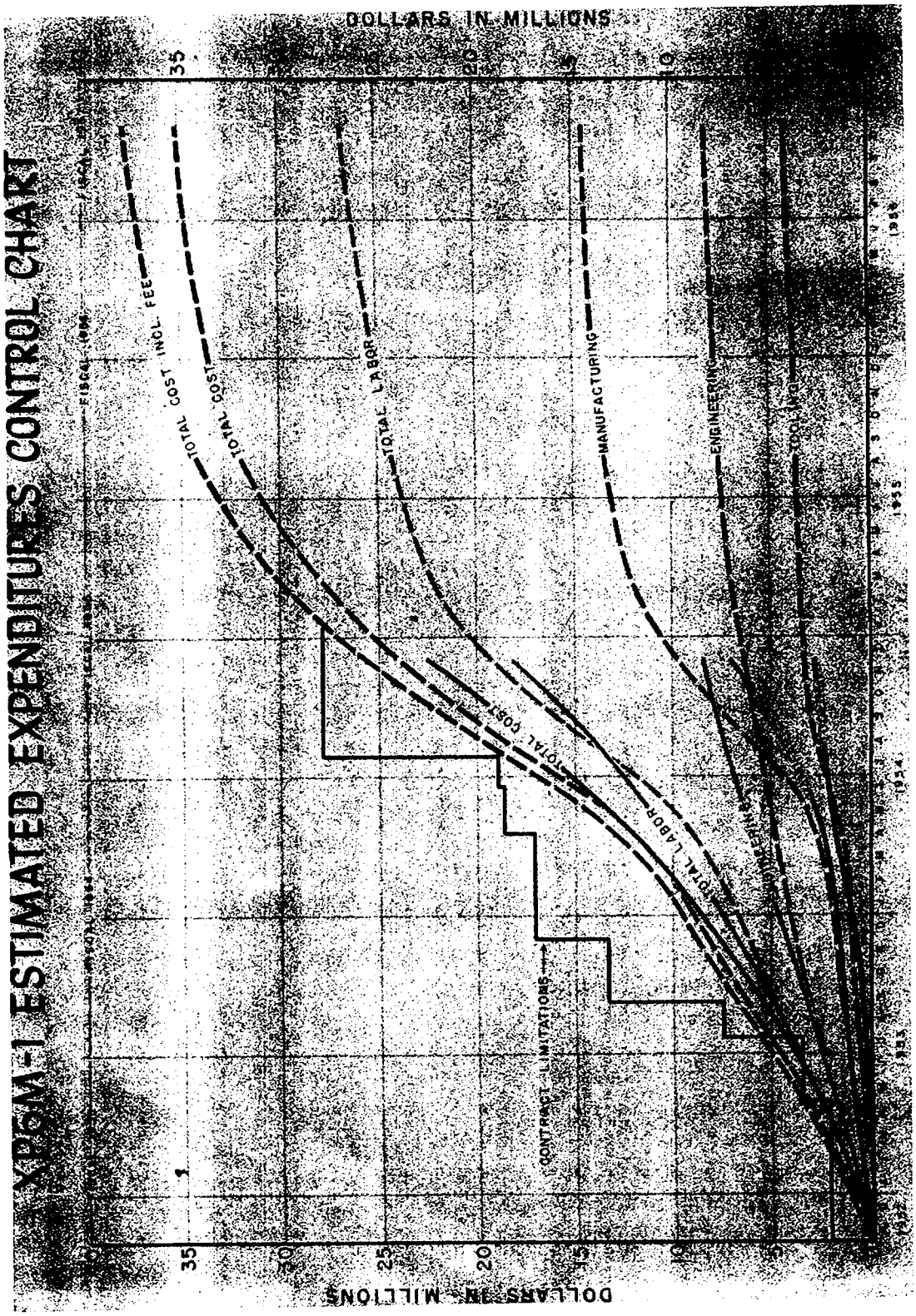


CHART 11


XP6M-1 ESTIMATED EXPENDITURES CONTROL CHART
DOLLARS IN MILLIONS
TOTAL COST INCL. FEE
TOTAL COST
TOTAL LABOR
MANUFACTURING
ENGINEERING
TOOLING
CONTRACT LIMITATIONS
35
30
25
20
15
10
5

Moreover, although this total job was supposed to cost in excess of 35 million dollars, the monies could only become available to us in increments, as you see them listed on the chart. This is the money authorized by the customer. We divided the allocated funds between engineering and manufacturing. Both total labor and total cost, which includes procurement, are shown. I trust you are all impressed by the small profit margin.

We kept a running account of what we did. You will notice in this case that engineering is considerably over its allowable cost. It was cause for some concern. However, manufacturing has run considerably under its budget and tooling has been even lower. The net result is that our actual total cost has been only a little under the total amount allocated to us.

Chart 12, page 24.--The next step is a detailed layout of how we go about building an aircraft. The Matador is interesting because it fits into mobilization planning. It is not too economical from the point of plant space, but on this job, for example, we had to set up a line capable of building about 125 Matadors a month. However, our contract calls for building only one a working day, which is about 22 a month. So while this production layout was designed to meet the higher figure, we put in only enough tools to build the 22 per month.

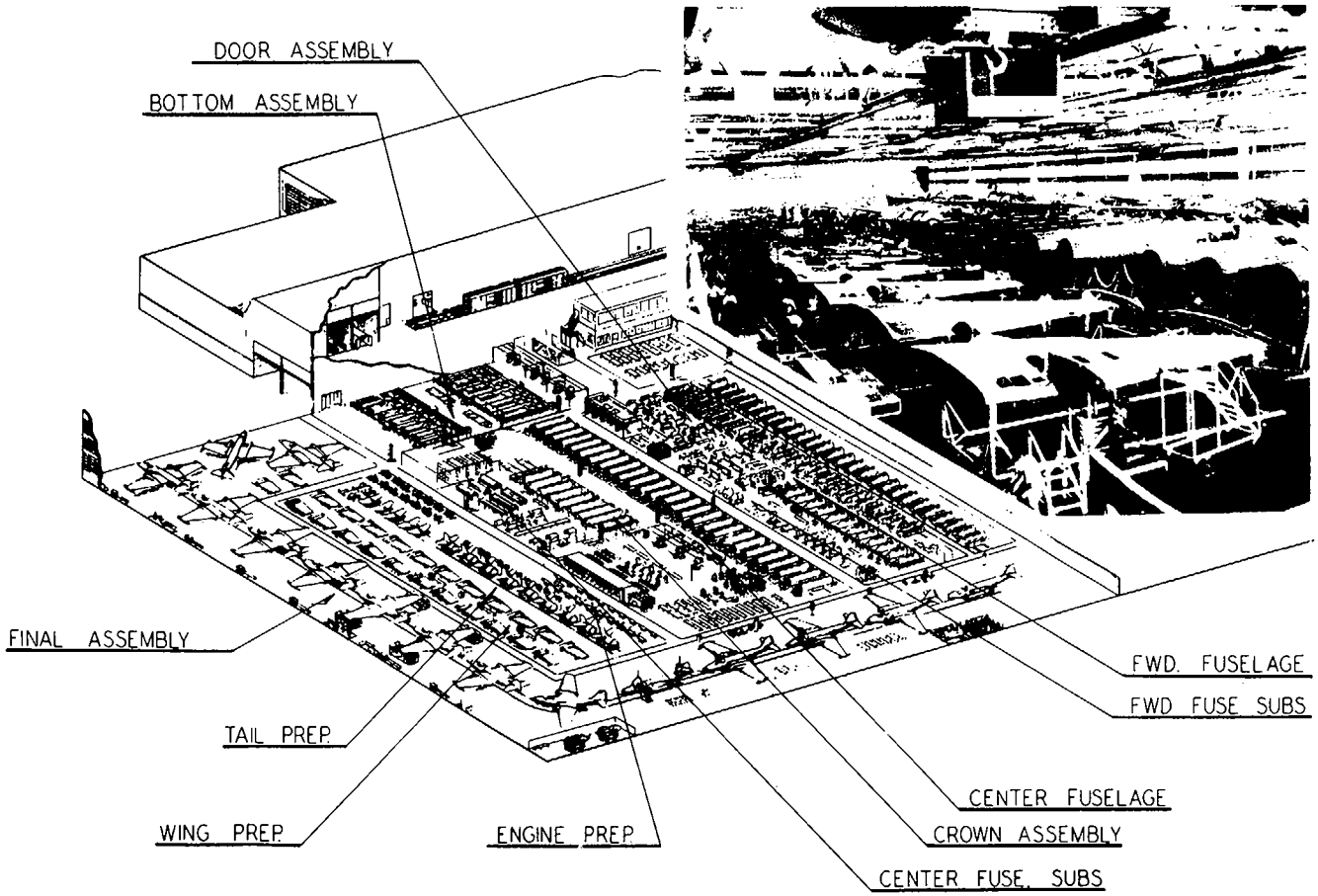
Those of you who are coming to the plant on Friday will see this space all laid out. Actually, we have found we don't have to assemble the Matador so we have eliminated the assembly-line space. This layout has gaps in it so if we had to increase production in a hurry, we would only have to add additional tools to run the rate up from 22 to 125 a month.

Chart 13, page 25.--We have the same type of layout for the B-57. I am afraid it is too detailed for a cursory explanation. It is better for the planning people to spend a lot of time laying this out in the most economical way possible. In the final analysis, less time will be spent on assembly.

Chart 14, page 26.--In the next series of charts, I want to illustrate how we have come to the conclusion that if you have the slightest idea of what you are doing, you profit in the long run by doing it right in the beginning. A few years ago we spent a lot of time building a couple of experimental tools that were good for a few airplanes. When we had to build a lot of them, we were not too well off.

CHART 13

B-57 LAYOUT



1401

1402

TYPICAL EXPERIMENTAL TOOLING

WOOD & MASONITE
CONSTRUCTION
1 TO 10 AIRPLANES

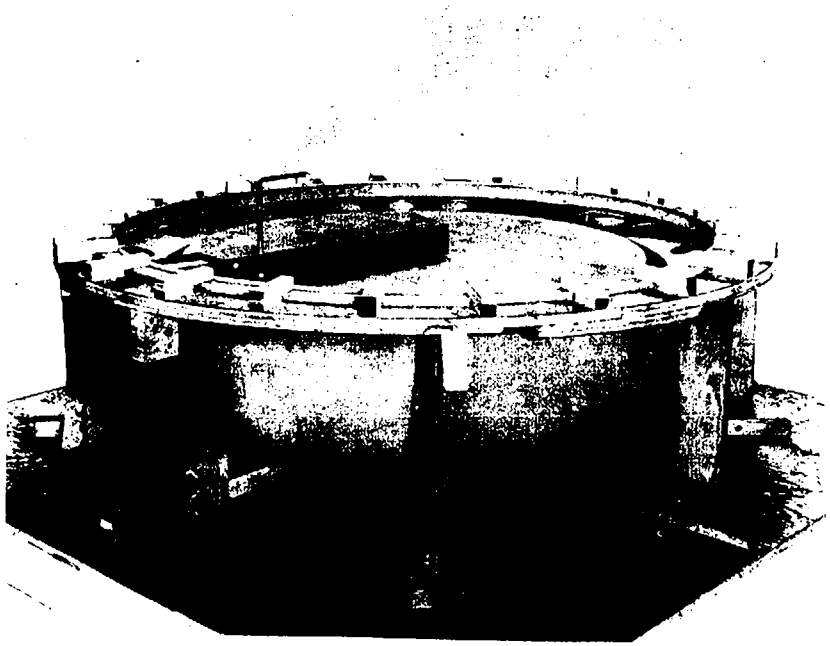


Chart 15, page 28.--This is the type of tool seen in most aircraft factories today. It is primarily made of steel and masonite. This tool is for the aft-fuselage section of an airplane. As indicated on the chart, it is used in the construction of from 10 to 200 aircraft. If you are going to build 250, as in the case of the Matador, it is best to go into another form of production tooling.

Chart 16, page 29.--Here is a high-production tool for the automatic drilling of the fuselage on the nose subassembly. All of these are automatic drills. The missile section is moved into the fixture, aligned, and drilled. Of course, the tooling in an aircraft plant nowhere approaches the tooling in an automatic factory.

In conjunction with tooling, I want to talk about the new fabrication techniques that are coming into the picture. The one that was experimental the last time I was here is structural bonding. While it was experimental, we didn't dare use this on an airplane. We used it on missiles.

Chart 17, page 30.--Centered in this picture is a metal honeycomb. Actually, it looks like honeycomb on a screen. Aluminum skins are wrapped around it, and the entire structure is fitted into this large tool. The tool is contoured to the outside shape of the honeycomb core so that the backs of the tools press tightly against the aluminum skins. As you can see, the tool is used to apply pressure and heat. The heat passes through electrodes in the blanket; the pressure through the pressure bags. Different pressures can be applied to different areas. In this manner, an entire wing can be fabricated. Tools like this are expensive, but nowhere near as expensive as manpower. Moreover, once you have them, you can really do a job.

There are other new techniques coming into use. For example, we will be getting into stainless steel. We don't know an awful lot about it yet. Also, we are playing with titanium. In short, a whole field of fabrication techniques is coming into play in the aircraft industry. These techniques will have an important impact on the mobilization picture.

Chart 18, page 31.--To go into adhesive bonding a little more in detail--this is the Matador; the wing, fins, and stabilizer are made of honeycomb. We have now reached the point where we are making stabilizers and fins on piloted airplanes out of honeycomb. They are put together with FM-47 adhesive instead of with rivets. Right now,

CHART 15

LOW PRODUCTION TOOLING

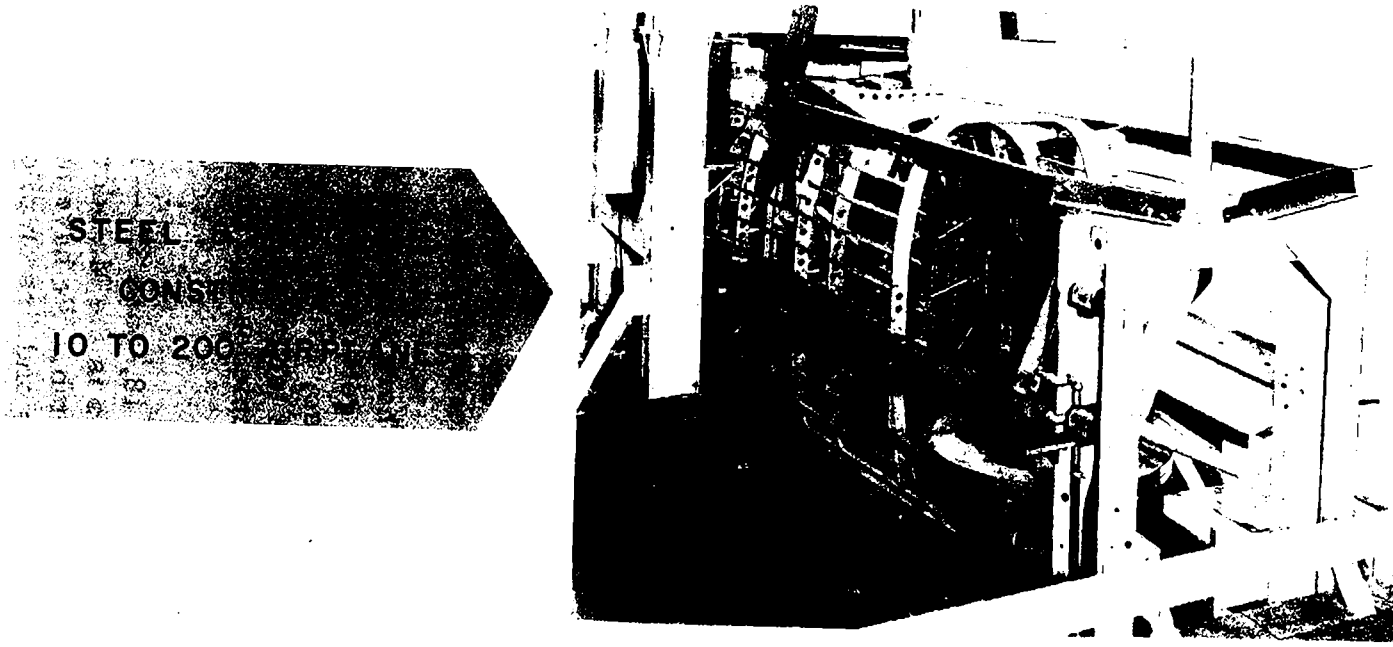


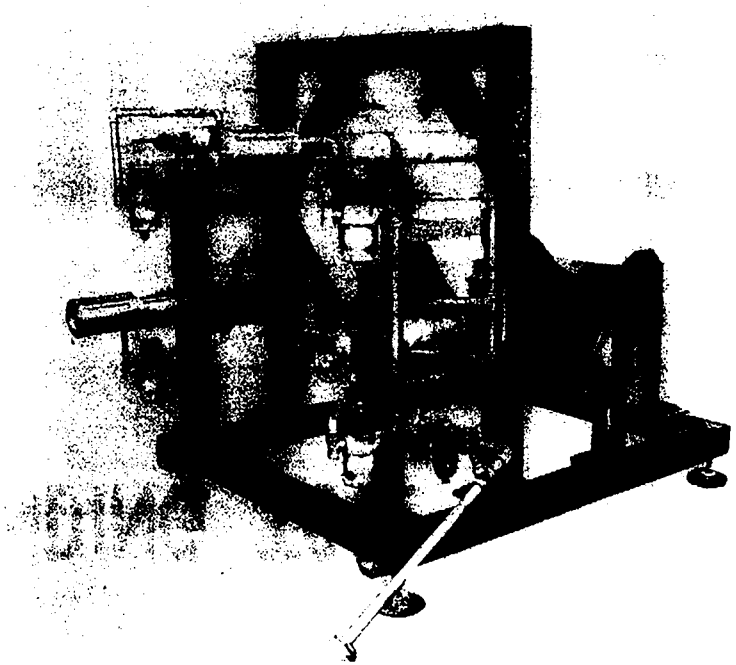
CHART 16

HIGH PRODUCTION TOOLING

STEEL CONSTRUCTION

CONTROLLED AUTOMATIC OPERATIONS

200 TO 10,000 AIRPLANES



1405

CHART 17

WING BONDING TOOL

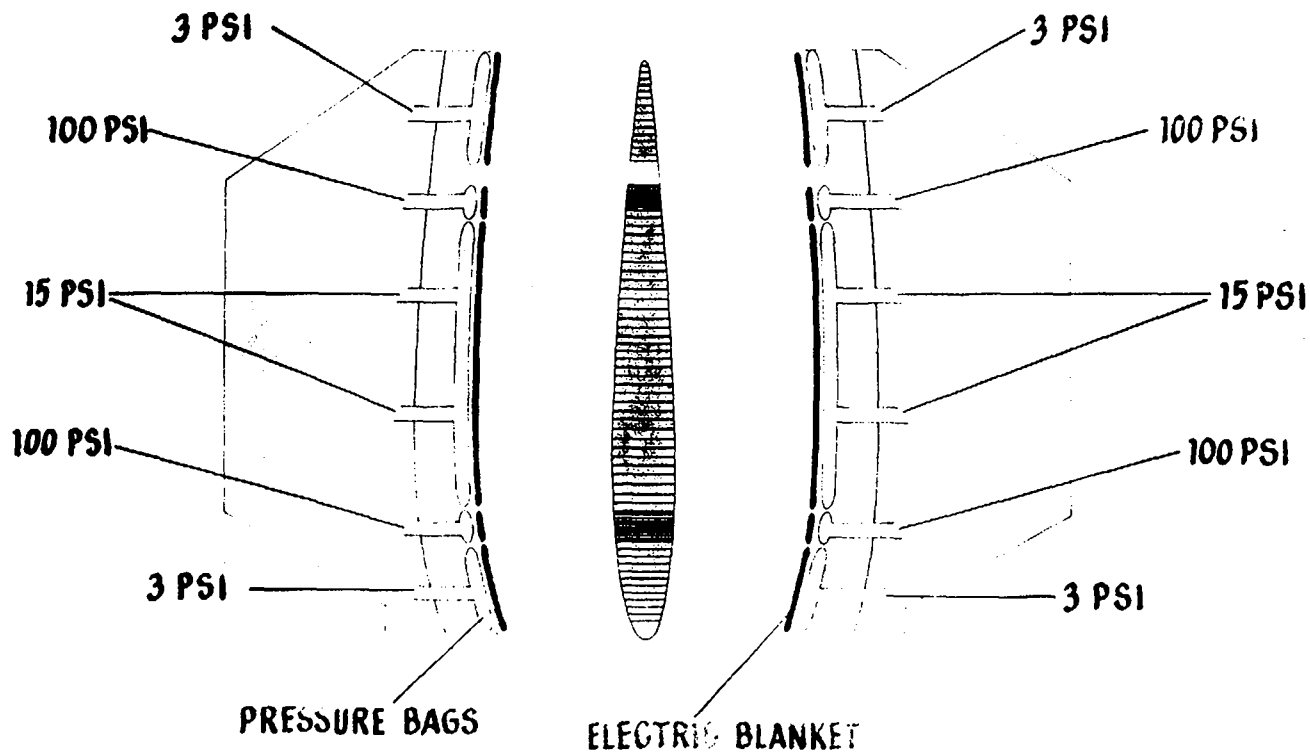


CHART 18

we are building an airplane in which the complete wing surface, tail sections, and high percentage of the fuselage will be fabricated out of honeycomb. Those of you who are coming to our plant on Friday will probably be quite interested in seeing this process.

Chart 19, page 33.--This is a picture of all the details that go into a conventional stabilizer. It says that there are 3,000 parts, and I guess you will have to take our word for it. All of these parts have to be riveted together.

Chart 20, page 34.--Now that we're building this same stabilizer by the honeycomb method, the 3,000 parts is reduced to less than 500. This is only half of the picture because the payoff is what you save in man-hours per pound.

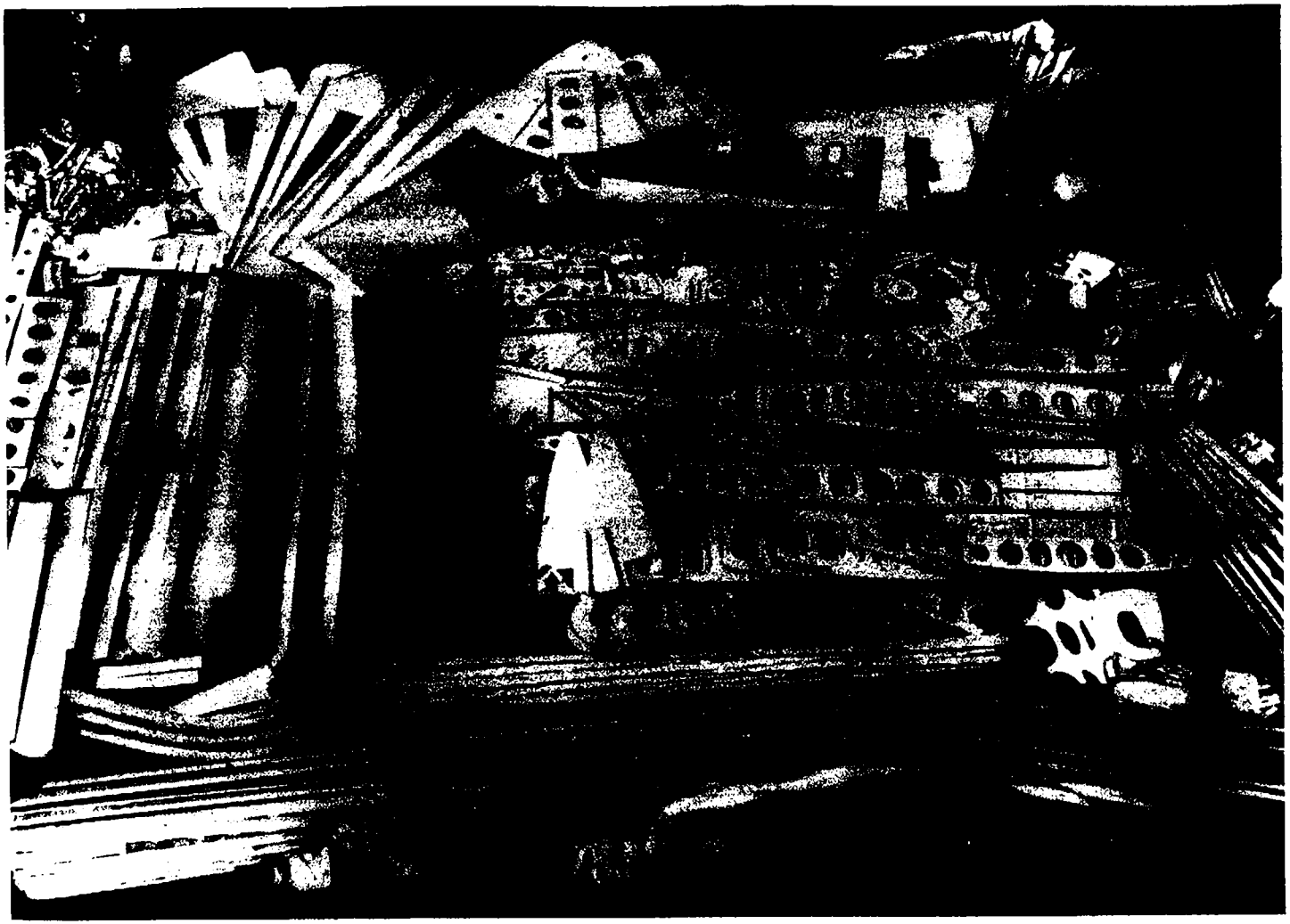
Chart 21, page 35.--We thought at first when we began using these new fabrication techniques that the slope on this curve would be rather flat. However, we have found that the slope is practically as good as one representing a regular riveted structure.

For example, on the 200th missile, there were actually 1.4 man-hours per pound; on the airframe alone it was much lower. Electronics, which constitutes a large part of the Matador, is rather intricate. Now that we have built 300 Matadors, we have done better than this curve. We are really sold on this technique, not only because we get good structure, aerodynamics, and so forth, from it but it also saves dollars.

One of the significant reasons we have been able to save a lot of time on the missile is that when we began this business of manufacturing them, we got a lot of know-how from airplane folks. Now the lines of knowledge have crossed and some of the lessons we learned from building missiles are feeding back into the airplane end of the business.

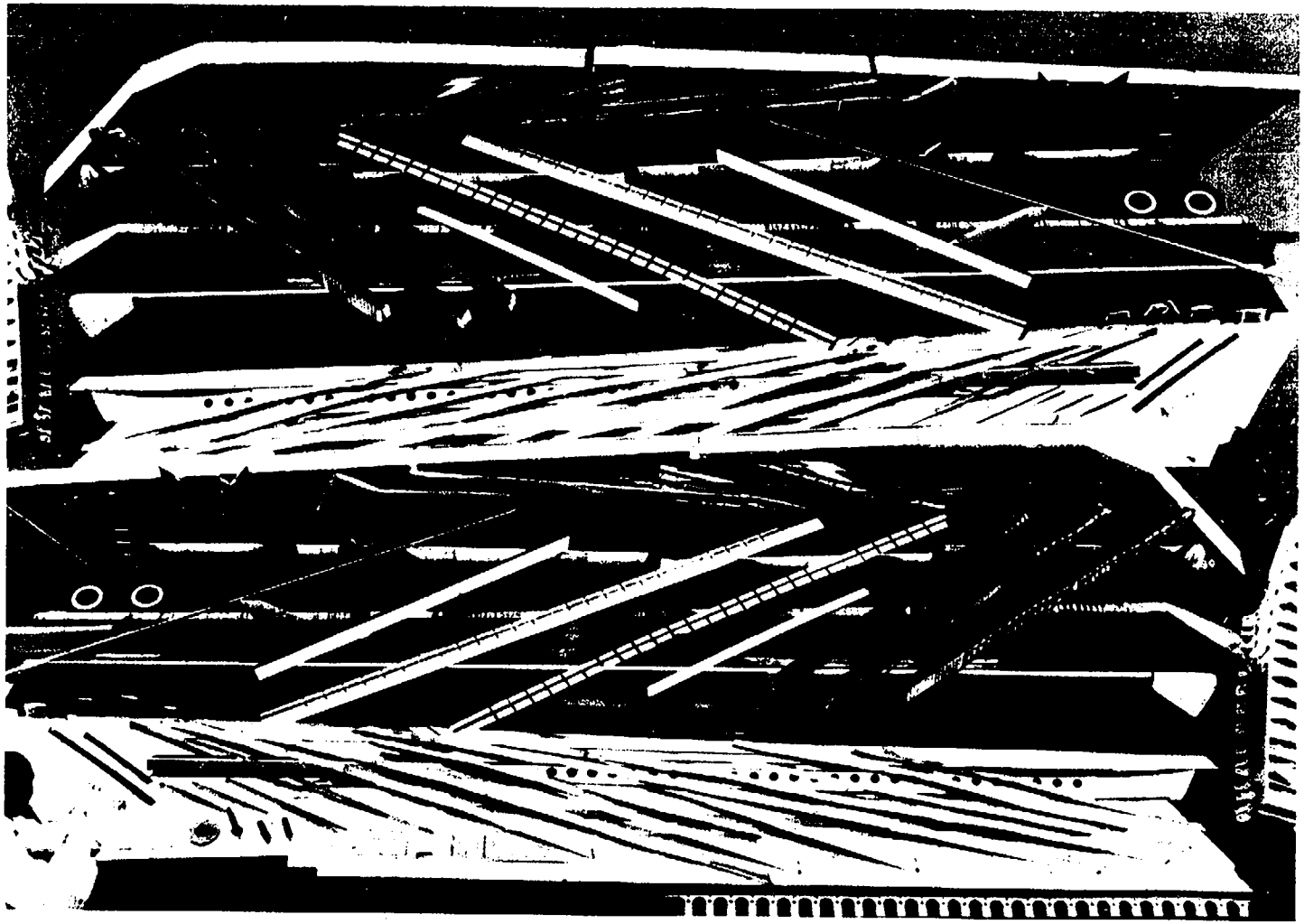
Chart 22, page 36.--One of these lessons originated with the Matador tools and techniques. We found that we could build separate sections and get complete interchangeability, not only of structure but of electronics. We found, also, that it was no longer necessary to assemble the missile at the plant, so the assembly time was eliminated. Now missiles are shipped from Martin in seven sections and everybody is happy.

CHART 19



CONVENTIONAL ASSEMBLY CONTAINS
MORE THAN 3000 PARTS

CHART 20



MARBOND ASSEMBLY CONTAINS

LESS THAN 500 PARTS

CHART 21

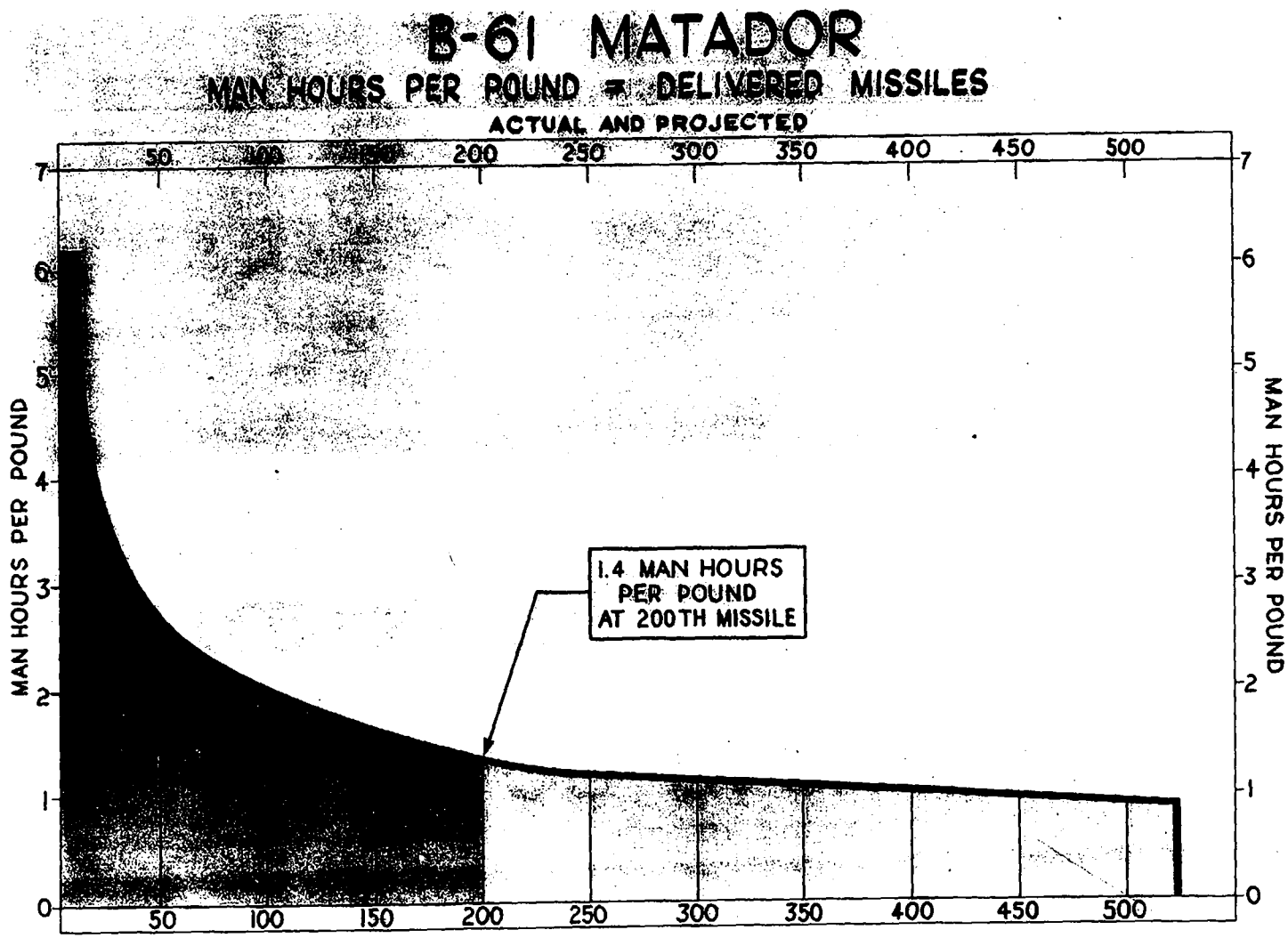
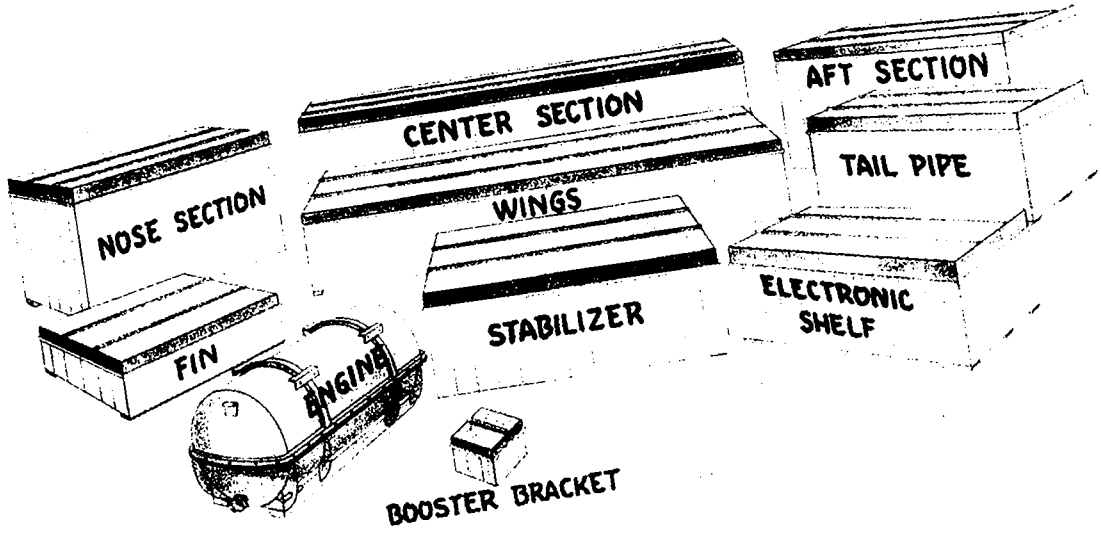

B-61 MATADOR
MAN HOURS PER POUND ÷ DELIVERED MISSILES
ACTUAL AND PROJECTED
MAN HOURS PER POUND
1.4 MAN HOURS PER POUND AT 200TH MISSILE
0
1
2
3
4
5
6
7
50
100
150
200
250
300
350
400
450
500

CHART 22

MATADOR PACKAGING

OLD METHOD



TOTALS...

TARE..... 14,765 lbs.

CUBAGE... 3527 CU. FT.

Chart 23, page 38.--When we first began shipping Matador packages to Europe, weight was something of a logistics problem. So we went into a new packaging program. Our engine people were able to reduce the weight as much as 32 to 34 percent. This is significant, not only as it pertains to guided missiles; it follows that there is no reason why, under a mobilization setup, we would have to build subassemblies at small plants and then ship parts to the central plant to be assembled, tested, and flown away.

Actually if this program is followed and these techniques applied, there is no reason why we can't build each subassembly in a separate package and ship it to a forward area--especially, fighters and interceptors. We feel that this trend has a genuine future.

That concludes my talk. This last chart speaks for itself.

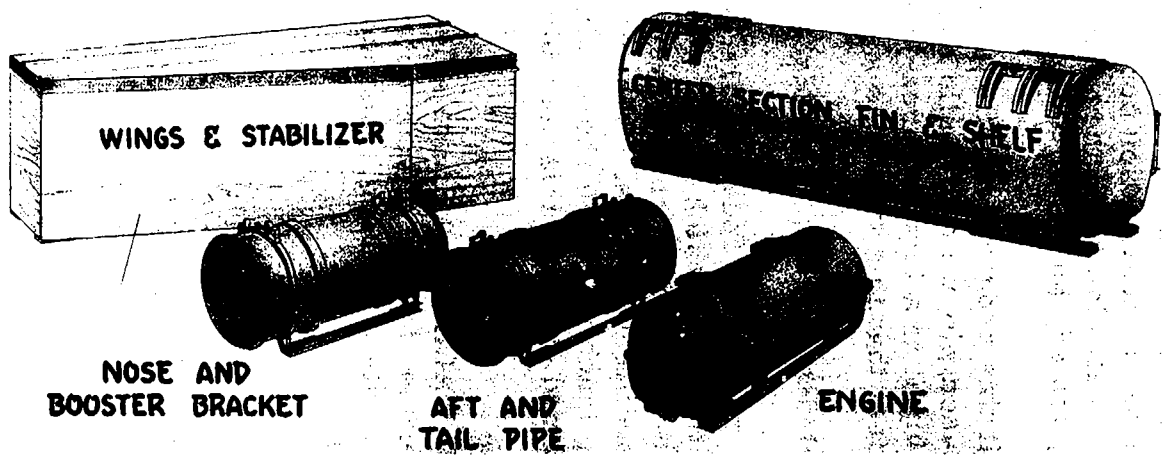
Chart 24, page 39.--Today we are getting airplanes and missiles out of the Martin plants which can go where they are needed and be used on the missions for which they were designed--without passing through five modification lines. What we used to do was build the beautiful flying machine shown above, when we actually got to use it, however, it turned out to be this horrible conglomeration you see flying below.

COLONEL WALKER: We have enjoyed having you with us again today, Mr. Bergen, for one of your outstanding presentations. We certainly appreciate the strong, continued support given us by the Martin Company.

(3 May 1955--250)S/feb

MATADOR PACKAGING

NEW METHOD



TOTALS...

TARE.... 10,016 lbs.
CUBAGE... 2350 CU. FT.

SAVINGS	
TARE....	32%
CUBAGE..	34%

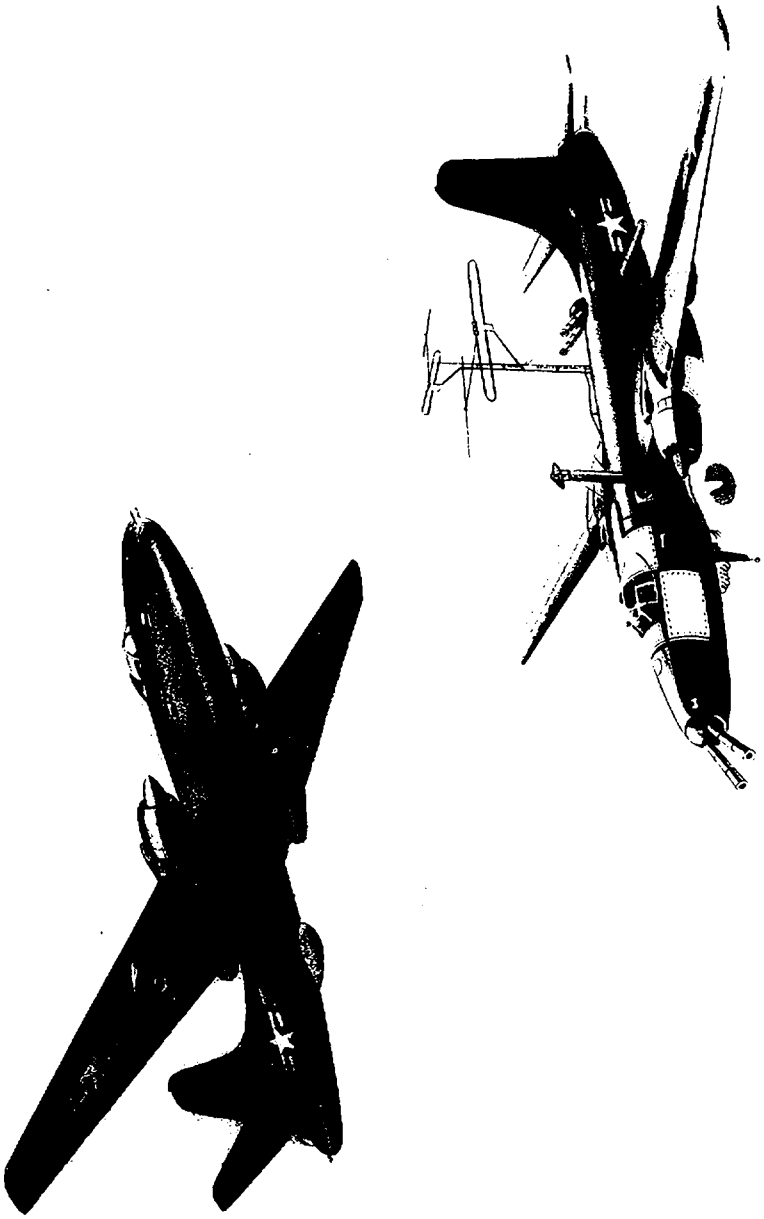



CHART 24