ORIENTATION AND FUNDAMENTALS OF PRODUCTION

25 January 1951

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CAPTAIN MARCY: Gentlemen, if instead of being comfortably seated, as I assume you all are, in Auditorium "A" of the Industrial College, you were occupying the same posture in your favorite movie palace, the program to follow would be entitled "Preview of Next Week's Big Attraction." This preview will be presented by Colonel Cave. But before I relinquish the platform to him, I have a few words to say.

You have now completed a cycle; that is, you have had at least one treatment from each of the six branches of the Education Division of the Industrial College. On behalf of all the members of the Production Branch, I will say that we are happy to have you back under our control.

We have had one significant change in the Production Branch since you completed the Technological Progress Course. Colonel Meetze has heeded the call of the wild and is, or soon will be, chasing Rocky Mountain goats out in the vicinity of Denver. He has been replaced by Colonel Kleff, who is down front.

As you all know, the courses that you have completed to date, through the excellent presentations of the Procurement Course over the last few days, have been in the nature of background courses for the real meat of the course which we open this morning in Production. With all due respect to the other branches, we hope that you, too, feel this is somewhat of a homecoming, and I think it is appropriate that we take a run-down, or give a sort of thumbnail sketch, of what you should have learned if you had been awake at your lectures and had done the required reading in the other branches in the course thus far.

First, in resources, as you know, in many of the vital raw materials necessary for the support of a war economy, we are scraping the bottom of the barrel. In some cases we are digging deeply under the barrel. The picture is indeed dark.

In manpower we also have a dark situation. You know by now that we are going to have to depend on women, children, the aged, the halt, the lame, and the blind.

The situation in requirements is not bright. We have been unable yet to develop means of determining what or how much of anything we want; and even if we could, we couldn't add them up.

In procurement, we can procure the things we need but we also have a dark situation. We don't know how we are going to pay for them.

Now, the Production Course proposes to lead you out of this area of gloom and despair and put you on the paths of truth and light. We propose, over the next eight weeks, to give you an understanding of how we are going to produce all those things, through technological progress, from our deficiencies in resources and with our shortages in manpower, produce all the things that we cannot determine our requirements for and don't have the money to buy, and produce them in time so that we can get them declared surplus and dispose of them before we find out we need them.

Now, Johnnie, I've got them warmed up. Will you take over?

COLONEL CAVE: Gentlemen, I would like to spend the first few moments on a bird's-eye view of the course planning. You will find--and I assume that most of you have at least given a look at your curriculum book--that there are several areas of study laid out. Those areas were very carefully chosen, with two principal ideas in mind.

First, we intended that they be timely. I don't believe you will find any subject, within the scope of your studies and your report requirements, that will not be a hot area in the days that lie at least immediately before us.

The other point was, generally, to take four areas in this wise:

The first area is factors that affect all production. There are no reports required in this area, but those factors are subjects that we are going to discuss today and in the next week. They include, of course, such things as facilities, conservation, conversion, production engineering, product engineering, quality control, and inspection. There are others. I am just ticking off some of the more important ones.

One area of study is in basic processed materials, such as rubber, chemicals, and light metals--every single one of them a critical area at this time. The newspapers attest to that each day.

The third is an intermediate area which all too often is not given much prominence but which is of basic importance, and that is textiles.

The fourth area is final products. That area includes tanks and automotive equipment and electronics, two report areas; and two others which are lecture areas only this year--one, aircraft, and the other, shipping.

As Captain Marcy has already told you, we don't propose to make experts out of you. That is far beyond our scope. But, as you all know, this business of production is a team job. As a matter of fact, we in the military are not in the production business at all; production is industry's job. Some of you may recall a book that is on your reading list, "The Industry-Ordnance Team," written by General Campbell after the last war, in which he stressed this cooperation. Now, if we in the services are going to work in a team with industry, we've got to have a pretty good idea of what the other fellow can do, what his capabilities are and what his limitations are. For that reason, we feel that the principal purpose of the Production Course is to give you a good background on the important tasks of the other members of the team.

Of course, another thing that I hope we do is to remove from your minds the mystery and the jargon that go with the technical aspects of production.

Finally, we would like to bring a sense of order into what I am sure, in many minds, is a bit of confusion. The things we are going to talk about principally are things that you can see, feel, and hear.

Now a word about the curriculum itself; that is the requirement that you have on reports. We have scheduled conferences for each group, with the individual instructors, for tomorrow afternoon at one thirty. There is a schedule for those conferences on the student bulletin board.

Finally, as in your last course brevity is emphasized in reports, particularly in the body of the reports.

Gentlemen, you will recall that at the beginning of the year General Vanaman spoke to you in outlining the whole course, and you will recall one of his charts, which we have here. I would like to just bring it out and refer to it for a moment. (Chart 1, page 11. Foundation of the National Economy.)

All of the elements which support what he terms the four M's, which in turn support the national economy, are not on this chart, but the more important ones are. As you get into the Production Course, you will see that every single one of these elements in turn supports production. We could just as easily erase "national economy" on this chart, call it "production," and you will find that the same factors are employed.

There is one word of caution. These four M's are very useful, but they are a little bit too pat. There are many others just as important, and you will run into those if you haven't already. There is money, for example. And one that I think deserves much attention--it has already

been expressed in your Manpower Course--is motivation: How do you get people to produce when there just aren't enough people, machines, and materials? What are the incentives?--money is not always the answer

Now let us take a look at modern mass production--not that all production can be called "mass production," but there are some characteristics which are important to understand. (Chart 2, page 12. "Characteristics of Modern Mass Production.")

First, invariably, is a breakdown of productive effort into simple elements. Second, of course, is the extensive use of semiskilled and unskilled workers. The skills of the artisan are built into the machinery; thus, we have, generally, the extensive use of complicated and automatic machinery and equipment. Finally, but by no means least, is the interchangeability of parts.

All of these are the outgrowth of a basic approach: It is the group that produces. This gives rise to what I shall call two additional characteristics: first, the requirement for highly detailed plans and organization to control this infinite number of details; and, of course, always time--plenty of time!

These characteristics have an effect on the production problem. Let's break it down and take a look at it. (Chart 3, page 13. "Breakdown into Simple Elements.")

If I could go back for just a moment to where we left off in Technological Progress last fall--we ended up with the development prototype which, we decided was suitable for production: It met the military characteristics and it looked as though it could be produced.

Now the prototype or development model is turned over to the production people, and all too often, as many of you know, the production man takes a look at it and throws up his hands. The production people have the job now of producing this in quantity. In any event, the first thing they must do is analyze this development design from the production standpoint.

I would like to digress for just a moment to show you some of the potentials of the analysis by production-minded engineers of what has seemed to be a very satisfactory item. I don't believe there is anyone here who is not familiar with the Thompson submachine gun. That gun was developed, of course, long before World War II. It actually had been developed over a period of about 20 years, and during the early part of the war some parts of it were still under development. It had 73 parts in it, and the initial cost to the United States was about $240. It was complicated. It was difficult to train men to use it, to train men to assemble it, disassemble it, and maintain it.

A production organization, skilled in the techniques of mass production, was given the job of producing a submachine gun by mass production methods. It was told, "Don't use any patents, make this thing simple, and meet certain other characteristics." They finally came up with that M3A1 "grease gun" that you saw up at Aberdeen. It was vastly superior to the Thompson as a fighting weapon. You will recall that at Aberdeen it was put in a box of dust and in a shower, and thrown in the mud--and still it could be fired immediately! You could never have done that with the Thompson.

That job was not made or developed by the old small-arms manufacturers. It was made by a subdivision of the automotive industry. Many of its parts were made of stampings and it had very few machined parts. As an index of ease of production, it cost $19.85.

That is an idea of what can be done by using mass production techniques in a very simple bit of equipment.

Before the manufacturer can get going on a setup, he must know how many of an item are required. The problem is entirely different if 100,000 must be produced from what it is if 10,000 must be produced; and, in turn, if 10,000 must be produced rather than 100. Not only must he know how many complete units must be produced, but we have all had bitter experiences with the oversights pertaining to spare parts, and he might just as well integrate his spare parts production planning right now. Of course, there are two other elements: When is the first one needed, and at what rate must the item be produced? All these elements have profound influences on the final setup.

Having looked at the requirements side of the ledger, let's take a look now, through the eyes of the production engineer, at his capabilities and what is available to him. What does he have to do the job? What is the raw material situation? Exactly what raw materials does he need? What are the specifications for them? How available are they? Are they critical materials? All too often the development design is full of critical materials that cannot be obtained in large quantities. What machines are available in the plant? This is a very important question. Often the plants just don't know everything that is available to them in the way of machinery--what tooling and what gages.

I would like to digress, gentlemen, for just a moment, because it is on this problem of machines that we get our real leverage on our manpower problem. I don't know how many of you got up to the General Electric train exhibit recently, but if one man worked hard enough at a machine they had there, he could produce about a tenth of a horsepower; and if he generated a tenth of a horsepower, a relay in the gadget tossed him a cigar. It could be done, but General Electric didn't put out many cigars; it was not done very often.

It has been shown that the electric capacity available per worker is proportional to that worker's output. So on the problem of productivity we find that, with 13,000 kilowatt hours available to the average American worker, he has a productive capacity in the ratio of seven to one versus his Russian counterpart, who has something less than 2,000 kilowatt hours available to him.

The problem of facilities also comes up. What facilities are available? By "facilities," I don't mean just the buildings. There are a lot of things that go with them, some of which we take for granted--power, communications, water.

Water has recently come into prominence as a factor to be reckoned with, and it is a very important one. I have some statistics which I won't enumerate in detail, but I will give you two or three of them. To produce a ton of steel takes from 10 to 15 thousand gallons of water. To produce paper, 25 to 100 thousand gallons of water per ton are needed. To produce such a simple item as beer takes 15 gallons of water per gallon-and that figure does not include the stuff they leave in the can! Water must be considered.

So must air, as a matter of fact. Those of you who had anything to do with aircraft engine production during the war know how many of the plants had to be air conditioned in order to produce satisfactory engines.

These are all factors that pertain to facilities.

Of course, materials-handling equipment is another, a very important one; and, again, it gives you terrific leverage on the manpower problem. A little later during the course we will have some industrial motion pictures which you will see. One of those is on materials-handling equipment. You will see, as you probably all have seen in your experience a slight, young girl of maybe 18 or 19 years of age working a fork-lift truck, which is capable of turning out work equivalent to that of 7 to 10 bull gangs made up of 10 or 15 men. So through our machines we are going to take a great big chunk out of that manpower problem.

Another thing that must be assessed is the problem of standards. If this development design has a lot of uncommon parts in it which could just as well be standard parts, by shifting them to the standard parts the production engineer is going to save a lot of time, effort, and facilities and shut off that lengthy time that is needed to get into production.

I have mentioned manpower already, but I would like to break it down a little further. Considering the job that must be done, there are certain steps that must be taken. They are simple, but let me just check

them off. First, the work itself must be divided into jobs--the production planning is just that detailed; second, men must be found and trained to do the jobs--let's add women and children to that, too; and then, as I already indicated, there is the problem of stimulating the men to want to do the jobs. All too often, in organizing these men who are going to do the job, the fact is overlooked that the job can be set up and the men can be obtained, but unless the men are stimulated to want to do the job we don't get out the production we need. The results must then be measured, see how the job is done, find out what the facts are, how to get the facts, how to bring the facts together so that they can be analyzed, get a standard against which we can compare them, and then, of course, take action based upon those facts--all part of the organization and control of a large production organization.

Of course, after this gadget has been broken down into its component parts, the engineer must decide which parts can be manufactured in the plant of the prime contractor and which ones should be subcontracted for. you have heard a great deal already about subcontracting, and I would not want to digress at any great length on that, but there are a few points that might be worth bringing out in connection with the auto industry, which is one of the biggest businesses of the lot.

It has been reported that during World War II the entire auto industry had over 25,000 subcontractors located in 1,300 cities--plus a few--and in 44 states. It is also reported that of every dollar that was on a prime contract, 56 cents went to the subcontract, in the auto industry. That is an indication of how much the prime contractor decided he did not want to make in his own plant but have made elsewhere.

When all these things have been considered, he arrives, then, at his production design, and this is a lengthy process, consuming most of the time that we have been talking about. The design consists of drawings and the specifications, and that is the first big hurdle.

We already have a first approximation on it at least, but we must determine how to manufacture each part, and this requires a detailed list of the operations requirements, in sequence, from the time the raw material enters the plant until it goes out on the other end--what material, what operations to be performed, with what machines and what tooling, what gages, what fixtures, how long it takes--specifically measured right down to a fraction of a minute--and, of course, the manpower required to do it. (Chart 4, page 14. List of Operations Requirements.)

When we have that, the next job is to consolidate all of this, and determine and obtain the machine tools that are required. (Chart 5, page 15. Consolidate Operation List.)

It takes a great deal of judgment and close liaison between the research and development engineer and the production engineer at this point. It should be emphasized that the liaison does not and should not have to wait until this point in the time sequence. It should be going on back in the development period.

I would like to cite an example, and I mention it because I think it is important. Frankly, I get a little bit worried sometimes and think we get too much concerned over all our shortages. We say we don't have enough materials and we don't have enough men; then I look at some of these examples from the last war of how we just knocked the spots off our production problems through using new techniques in production.

You know from your own experience that pipe is generally made, and has been made over a period of years, from seamless steel tubing. On the other hand, guns, which are actually a tube, were not so made. For many years they had been made out of forgings, which means taking a great big hunk of metal, cutting off a lot of it, forming it into a cylinder, machining off a lot on the outside, boring a lot out of the inside, and rifling it; it takes time, machines, man-hours, and it takes a lot of material that must be thrown back to scrap.

During the war, there was a company that decided it could use the seamless steel tubing in making guns. Formerly, this job of forging and machining various types of gun barrels took from 720 to 15,000 man-hours depending on the caliber. By using the seamless steel tubing method the time was reduced, it varied from one-half to 20 man-hours. That does not say anything about the machine tools that were saved, or the materials that were saved, or most important, the man-hours saved.

Another example is the manufacture of a breech ring for one of our guns. This used to take 45 hours on 21 different machines. By using a broaching process, the time was reduced to 15 minutes on but four machines

Those are the things that a production engineer must consider as he starts planning mass production of any of these items: Which ones of these tools can he use without upsetting the military characteristics and requirements of this fully developed item?

Having decided which tools he is going to use, the problem now is releasing these items for manufacture and purchase—some will be made in their own toolrooms; some will be purchased elsewhere—the tools, the fixtures, the jigs, as you see them enumerated before you, and others. These are simply the more important ones.

There is the matter of the bill of material, which must be released to the purchasing department for it to go out to try to find the materials, running the hurdles of controlled materials plans, and all sorts of other shortages and bottlenecks.

The deliveries also must be scheduled so that they come through smoothly, otherwise the end item itself stops coming off the line. You had a lecture sometime ago in which one of Ford's production men told you just how much of a build-up they had to keep in order to insure uniform production, and that was for only 1,099 components, I believe. It was a terrific job.

Of course, the materials-handling equipment must be secured, and that is very often a time-consuming job.

Inspection and test procedures must be set up, including quality control. Although that is a most important element and deserves more time even now, you will hear a very fine lecture on the subject and will have a chance to discuss it in a seminar, so we will pass over it lightly. Quality control is the method by which you insure uniformity and, again, this interchangeability that is so important.

Finally, of course, you arrive at the plant layout so that you have an uninterrupted and uniform flow throughout the plant.

Gentlemen, this is not presented to you in great detail, and it is not presented to you with the emphasis of time, in its treatment now, that it deserves. I have tried simply to sketch the outline of a mass production problem--and, again, we all recognize that all production is not mass production.

Now, in order to bring this right down to the grassroots, we have selected an 18-minute sound motion picture which will bring out most of the things I have covered. This picture has been carefully selected, it has a minimum of advertising in it, and it stresses every one of the things that I have mentioned, plus others. It was made immediately after World War II; so in parts it is not up to the moment, especially in the last part.

(A 16 mm. sound motion picture produced by General Motors Corporation "An American Miracle," U.S. Army Misc. No. 7784) was shown.)

COLONEL CAVE: Gentlemen, it has been said that there are three things that deter the Russians from attacking the West: (1) the atom bomb, (2) the air power of the United States, and (3) probable internal disturbances in Russia. I would like to suggest to you that there is an all-important fourth--the infinite creativeness and resourcefulness of 150 million Americans.

That is not new; it is not new at all. You will find in the library, General von Hindenburg's memoirs after the First World War, in a book entitled "Out of My Life." This is what he said about it:

> "Her brilliant, if pitiless, war industry had entered the service of patriotism and had not failed it. Under the compulsion of military necessity a ruthless autocracy was at work, and rightly, even in this land at the portals of which the Statue of Liberty flashes its blinding light across the seas. They understood war."

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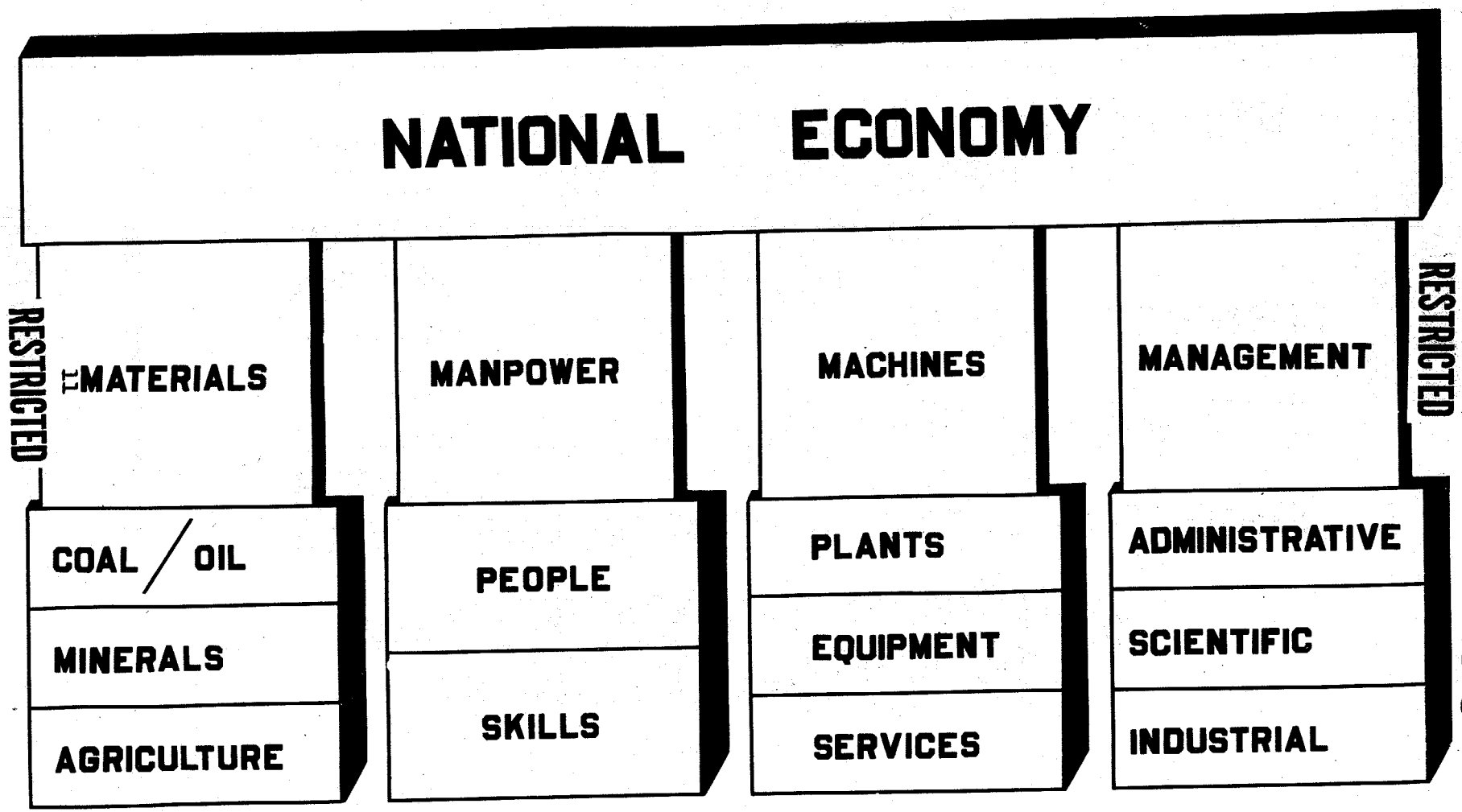
CHART I

FOUNDATION OF THE NATIONAL ECONOMY



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RESTRICTED

CHART II

CHARACTERISTICS OF MODERN MASS PRODUCTION

1. BREAK DOWN PRODUCTIVE EFFORT INTO SIMPLE ELEMENTS.
2. EXTENSIVE USE OF SEMISKILLED AND UNSKILLED WORKERS.
3. EXTENSIVE USE OF COMPLICATED AND AUTOMATIC MACHINERY AND EQUIPMENT.
4. INTERCHANGEABILITY OF PARTS

ALL OF WHICH REQUIRE

5. **HIGHLY DETAILED PLANS** AND **ORGANIZATION**

AND

TIME

RESTRICTED

CHART III

BREAKDOWN INTO SIMPLE ELEMENTS

ANALYZE THE DEVELOPMENT DESIGN

CONSIDER

REQUIREMENTS

HOW MANY ? INCLUDING SPARE PARTS

STARTING WHEN ?

AT WHAT RATE ?

AND

PRODUCTION CAPABILITY AND AVAILABILITY

RAW MATERIALS

MACHINES, TOOLING, AND GAGES

FACILITIES

MATERIALS HANDLING EQUIPMENT

STANDARDS

MANPOWER AVAILABLE

PRODUCTION DESIGN

DRAWINGS

SPECIFICATIONS

CHART IV

LIST OF OPERATIONS REQUIREMENTS

IN SEQUENCE

RAW MATERIAL

OPERATION TO BE PERFORMED

MACHINES

TOOLING

GAGES

TIME

CHART V

CONSOLIDATE OPERATION LIST

DETERMINE AND OBTAIN MACHINE TOOLS REQUIRED

RELEASE DESIGNS FOR MANUFACTURE OR PURCHASE

TOOLS	DIES
FIXTURES	PUNCHES
JIGS	GAGES

BILL OF MATERIAL

RELEASE FOR PURCHASE WITH DELIVERIES SCHEDULED

MATERIALS HANDLING EQUIPMENT

INSPECTION AND TEST PROCEDURES AND REQUIREMENTS

PLANT LAY-OUT