INFLUENCE OF ITEM CHARACTERISTICS ON REQUIREMENTS DETERMINATION (INDUSTRY)

6 December 1948

CONTENTS

Page

INTRODUCTION—Colonel John Van O. Weaver, USAF, Faculty, ICAF..... 1

SPEAKER—Mr. H. Ford Dickie, Production Manager of the Aeronautic and Ordnance Systems Divisions, Schenectady Plant, General Electric Company..... 1

GENERAL DISCUSSION..... 14

CHARTS—Number 1..... 19
Number 2..... 20
Number 3..... 21
Number 4..... 22
Number 5..... 23
Number 6..... 24
Number 7..... 25
Number 8..... 26
Number 9..... 27
Number 10..... 28
Number 11..... 29
Number 12..... 30
Number 13..... 31
Number 14..... 32
Number 15..... 33

Publication No. L49-57

THE INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington, D. C.

INFLUENCE OF ITEM CHARACTERISTICS ON REQUIREMENTS DETERMINATION
(INDUSTRY)

6 December 1948

COLONEL WEAVER: Gentlemen, this morning we are gathered together to discuss that very intriguing question: "The Influence of Item Characteristics on Requirements Determination." I see many smiles. The lecturer this morning comes from a large industrial company. He will discuss the problem as it has been encountered in that organization.

As you recall, we have had two previous lectures on this subject, one from Dr. Steiner, who presented the problem from the level of the National Security Resources Board, and the other from General Montgomery, who attacked the problem from the level of the Department of the Army, General Staff. This lecture is the third and concluding one of the series on this matter.

Our speaker this morning has had broad training and varied experience with many important divisions of the General Electric Company since his graduation from the University of Kansas in 1935 as an engineer. I wish to welcome to our platform Mr. H. Ford Dickie, presently Production Manager of the Aeronautic and Ordnance Systems Divisions, General Electric Company, Schenectady. Mr. Dickie.

MR. DICKIE: Thank you, Colonel Weaver. I couldn't help smiling myself when I heard this subject the first time—"The Influence of Item Characteristics on Requirements Determination." I was stumped, so I went over to see our expert on methods. He read and reread the title, finally he looked very profound and said—"Huh?"

First, I would like to reduce the subject to its most elementary terms—just "Good Ordering," or, if you wish, "Determination of Economical Order Quantities."

Though Colonel Weaver has done me more than justice in his introduction, I would like to go just a little further and tell you a bit more about "my career." I had a very successful start in life—selling newspapers. I liked selling newspapers, because whenever one of those "crucial moments" came when you just had to have money for some real necessity, like buying a Valentine for your best girl, you had cash in your pocket, tangible liquid assets.

Then I thought I would graduate from just selling newspapers. Now, in Kansas when I was boy, it was the fashion to raise rabbits. Did any of you fellows ever raise rabbits, I did—lots of them. I worked much harder raising rabbits than I did selling newspapers: yet when one of

those financial necessities arose, I found myself without a cash surplus. It was all invested in rabbits, lettuce, and other phases of the business.

There had been just one oversight. I had not studied the fundamentals of inventory control. If I had gone to the encyclopedia, I would have found that, "Young rabbits breed when they are about six months old but they do not attain their full growth until they are a year old." To an inventory control man that means 26 weeks stock of raw materials and another 26 weeks of work in process.

Now, if a boy invests in one pair of rabbits when he starts high school, four years later at graduation he should show sales of around 200 full-grown rabbits and an inventory balance of 450 rabbits. This means he would have a large inventory of rabbits and would have cashed in on relatively few with little profit for his living expenses. So, long before my graduation from high school, I suspected that I should have stayed in the newspaper business.

Since no one here admitted that he knew anything about the rabbit business, maybe a chart will refresh some memories—chart 1, page 19. That chart shows the rabbit business as the artists at General Electric see it. Now let us investigate this newspaper business.

A newsboy finds he can liquidate his inventory investment every day and thereby realize 365 turnovers a year, or 366 on leap year. With an investment of $4 or $5, he makes a profit of around $1 a day.

Now, in chart 2, page 20, we see the Art Department's idea of a successful "newsboy" and a harried popcorn "merchant" with inventory trouble.

Let us look seriously at the broad, basic principles of any business. First of all, businesses are operated to make money. It is not just dollars that count either; it is the percent of return on the investment that determines success.

Let us say that the General here in chart 2, page 20, and I got together and we invested $1,000 in popcorn, machinery, butter, salt, and boxes. Chart 3, page 21—let us say we made $500 profit a year. That is exceptionally good because it is a 50 percent return on our investment If General Electric, on the other hand, made $500 profit a year, they would very soon go out of business, because, according to the last report I saw, it cost $22,500 just for postage and stationery to distribute the quarterly dividend.

So the point is this: It is the return on the investment that counts. You have a numerator of net profit and a denominator of total investment. That total investment, the denominator, is the thing at

which we want to look. In a large corporation, about 80 percent of that denominator may possibly be in inventory.

"Oh," you say, "that can't be." Stop and think. Every large corporation has a treasury department which holds bonds, cash, and liquid assets so the individual operating unit's investment is largely in buildings, machinery, and inventory. The former items are subject to depreciation which may be substantial in an older corporation. So, you find most of your investment in inventory. Where we operate a Navy Plant, so far as we are concerned, nearly 100 percent of that investment denominator is in inventory. So now we see that the control of inventory is all important as a basic fundamental in the operation of any business.

EFFECTS OF TOO HIGH AN INVENTORY

Let us assume that we go along with the General selling popcorn and forget about inventory control. He seems to have too much inventory. What happens when he has too much inventory? First of all, he loses a percentage of return on his inventory. Here we see the popcorn business with sales of $1,100 a year. We see that the cost of sales is $1,000, so the profit is $100. If there is $1,000 worth of inventory, there is a 10 percent return on the inventory investment. If we can reduce that inventory to $100, we would have a nice 100 percent return. So if the inventory is too high, the percentage of return on our investment is going to be too low.

Next, if the General has been operating with a $100 inventory and then decides to build it up to $1,000—then he has the problem of acquiring funds. He can draw it out of the bank, where he is getting interest on it, or borrow it and pay interest. Added capital has to be obtained, which is an expensive process plus either the loss of interest or the cost of paying interest.

Now, if the General had decided that he would like to have $1,000 worth of popcorn as his inventory, he has more potential deterioration to worry about. I understand that weevils, mice, and mold all attack popcorn.

Engineering advances can seriously effect his popcorn business. Let us assume that he has $1,000 worth of "Iowa Standard" popcorn. What happens where there is introduced a new "Super-Colossal" popcorn? Well, you can't sell Standard popcorn when there is "Super-Colossal" on the market. Of course, you can sell some of it, but as you try to sell it your sales will fall off and your profits become less.

You can try dumping the "Iowa Standard" on the open market. Let us assume that we do, and sell it for $500, a loss of $500. We have lost five years' profits by this one error in inventory management. That might be more technically called an obsolescence loss.

Now, more space is required for a larger inventory. The General has had to rent a whole barn in which to store his extra popcorn. There would be increased insurance on that added investment. He has extra physical handling expense, he will have to turn the popcorn over to keep it from getting musty. Then, of course, there is the possibility of a loss in a declining market, also additional taxes, so we do indeed have all sorts of inventory trouble.

EFFECTS OF TOO LITTLE INVENTORY

The foregoing problems are all premised on the fact that the inventory was too large. Let us assume that the General appreciates that $1,000 worth of inventory is too much and so he reverses his policy and carries only ten cents worth of inventory. What happens then? Ten cents worth is what you get in one of those small boxes in the corner store. There is a great deal of time spent by the General just running to the grocery store to buy another ten cent box of popcorn. To be more technical, you have a high ordering expense.

You have a low machine output because every time you must warm up the corn popper, and you will probably have to throw away the first batch which usually gets burned. Then just as you set up, you run out of popcorn and have to go back and purchase more. You have high spoilage because of short runs. You have high cost of material due to inadequate order quantities.

There is another very important point. You may have higher than anticipated inventory because of low shipments due to stock depletion. Your inventory goes up because you reduced it too far.

The above principle was forcibly brought to my attention while ordering transformer materials. I considered myself infallible when I first got out of college and with my 20-inch slide rule and a complete set of books on various materials, I started ordering transformers with a false confidence.

The Production Division was operating with about a two-month supply of porcelains on hand. They took up a lot of space that we needed for other things. So I decided I would fix that in short order. I started reducing and trimming down, and pretty soon porcelains were coming in just the day before we needed them. I was very proud of my first success in reducing inventory.

My overconfidence was short-lived because very shortly the kiln in the Porcelain Plant broke down—one of these tunnel kilns about 500 feet long—and so no porcelains came out. I had reduced the inventory of inexpensive pieces, but in the meantime we were getting in all that copper that goes into transformers and getting in silicon steel, tons of it a day, with nothing being shipped. We were getting steel sheet,

expensive insulating oil, switches, and connectors. We were getting in everything except those relatively inexpensive insulators.

So you can reduce inventory so far that you are running your inventory up by reducing your shipments. Never forget that, the best way to reduce inventory is to ship it out the back door. We will emphasize that again later.

Now, we see that we can't have too much inventory or we are in the same trouble as the General is in. We can't have too little inventory or we are in worse trouble, we are missing out on our shipments. So we have to control inventory. How are we going to do that?

First, we have to set up a measure of inventory. A measure of inventory is based upon the definition that:

$$\text{TURNOVER} = \frac{\text{Output (Annual Rate)}}{\text{Average Inventory}}$$

I think this chart shows it fairly well—chart 4, page 22. Assume we are going to buy and use 1,000 pieces during the course of the year. Say you bring in your 1,000 pieces at the beginning of the year. At the end of the year they have gone out the back door. Now, the average inventory during the year is 500 pieces. The total output is 1,000 and your turnover is two.

Maybe a better way of doing it is to order 250 pieces at a time and order four times a year. You then have an average inventory of 125 pieces, while still getting 1,000 out the back door. You have a turnover of eight. So first of all, we have to be able to measure the problem with which we are working.

The next point may well be emphasized because it offers as great a field for the Armed Forces as for industry. We should try to simplify the inventory problem, simplify it by standardization. Let us look at what one progressive company is doing today.

Here we see a standardization picture—chart 5, page 23. This is not a General Electric experience but to make it more effective I will tell you that it is a real example of a good, long-operating, efficient organization. You wonder how they could be efficient when they can do this sort of thing. It is my conviction that the same enthusiastic and intelligent approach will produce comparable results on the majority of manufactured products.

You see here in this chart a comparison of the old and new; the old setup had 15 catalogue numbers to cover a given range of applications, the new setup has only 6 catalogue numbers to cover this same range. Before simplification, it took 952 parts to make this one switch;

now it takes only 244 parts. There were 51 percent common parts before; now there are 94 percent common parts. Here is the payoff: They used to get out 550 switches per man per week. Now they get out 1,350 per man per week.

Next, I say that you have to analyze the problem. If your wife's budget is out of hand, you don't start by saying: "My dear, let me see what you are spending for salt, pepper, vinegar, tooth picks." No. You look into the meat bill. It is the same thing in industry, though less obvious. Too often we find no orders being audited because there are too many to start on or they are spending a large amount of time checking all the orders--chart 6, page 24. If they make a good study, they will find that by looking at 30 percent of the orders that went out, they could control 95 percent of the value of their purchases. Or if you need less control, you can audit only 10 percent of your orders and be controlling very close to 80 percent of the value of incoming materials. So for to control inventory: (1) Measure inventory, (2) standardize, and (3) analyze.

Then there is one other fallacy I would like to discuss (illustrated by chart 7, page 25). Let us assume that a raw casting is the first item of material to come in as illustrated by the start of the manufacturing cycle on the lower left. On this longest cycle item, the ordinate will represent time; the abscissa illustrates build-up of material, labor, and overhead dollars until you have the total value of the product. Let us say that the time across the horizontal is 10 weeks. The final column on the right is the total manufacturing cost of the product. No profits or commercial expenses have been added.

Now, the raw materials requiring the longest manufacturing cycle arrive first. Possibly the last item to arrive might be a name-plate screw which would be added just before shipment.

The usual approach to reducing inventory is to schedule incoming materials later, cutting down the protective stock. On chart 7, page 25, assume the time on the abscissa is 10 weeks. Obviously if 10 percent or one week is cut from the start of the cycle a very small area is saved. However, if one week is gained in the final test, shipping or final assembly, a real inventory saving is accomplished because one-tenth of the horizontal component is taken off the right-hand side of the triangle.

Don't gamble on receiving incoming materials at the very last second. Study the manufacturing cycle. If you can reduce a portion of the time cycle chart where the value is high, you can move the whole cycle to the left and make a very substantial gain. It is still shipping out the back door quicker that pays the big dividends. Prior

to studying the all important ordering theory, remember: (1) Measure inventory, (2) standardize, (3) analyze, and (4) reduce manufacturing cycle.

PROPER ORDERING

Now, we come to the special problem, proper ordering. This subject is badly underestimated by some and overcomplicated by others. It is handled in too many cases by relatively new employees. Too many organizations start their people out by having them do "just ordering."

First of all, to order properly you have to know what you need. You have to have a determination of requirements. And that, of course, is a long and complete study in itself. You can go to a punched card mechanical method of determining your needs. In more specialized or smaller businesses, you can use manual determination. Obviously to do proper ordering, you have to know what you need.

Next, you have to know what the procurement time is—chart 8, page 26. These few items are abstracted from about 10 pages of the procurement time sheets issued biweekly. Let us assume for a moment that we are going to buy something for our shipping room. If we need some corrugated paper, we have to allow a couple of months to get it. If we also need some gummed paper to go along with it and if we ordered them at the same time, what would happen? We would get the corrugated paper but the gummed paper would not be there for another month.

You say, "That is easy. Order them all six months ahead of time and you will be safe." First, there are many products you cannot obtain in six months so you can't use such a simple rule because it isn't workable. You have to know how long it takes for procurement by individual items.

Second, if you try to estimate what you are going to need any further ahead than you have to, you will very grievously aggravate the possible errors. If the transformer business were to estimate what they needed six months from now, they wouldn't have enough orders on hand to guide them; so they would be guessing what they needed, and they would be ordering the wrong quantities of many items and in some cases actually ordering the wrong things.

So it is not desirable to order too far ahead, because your estimates of requirements aren't so good when you order ahead as they could be if you waited as long as possible. On the other hand, if you order things too late, then you are certainly in trouble because you run out of stock and then no shipments.

In practice on these procurement time sheets you normally have another column which I hesitated to have put down because it might be

misleading. But at the same time that you supply the procurement time, you normally furnish protective stock data, usually expressed in weeks.

What is meant by "protective stock?" I mean what the textbooks usually call the "pillow." It is the amount that you have in the stockroom which theoretically you never have to touch. Just when you go to use some of the protective stock theoretically a new shipment comes in the door. It should arrive so you always have this protective stock.

Have you ever noticed any public utility companies that receive their coal a day or so before they need it? Indeed you haven't. They all have large coal yards. Their protective stock is high because of the unreliability of coal miners, at least annual strikes are a matter of record.

Of course, I don't need to tell you anything about protective stock, because last night's newspaper told me that the Government is contemplating putting something around from three to five billion dollars into stockpiling. That is nothing more than protective stock.

Lastly, we must know what we have on hand and on open order. To summarize, for good ordering you require: (1) Determination of requirements, (2) procurement time, (3) protective stock, and (4) amounts on hand and on open order.

ECONOMICAL ORDER QUANTITY DETERMINATION

Now we come down to the actual determination of the economical order quantity which is shown in theory by chart 9, page 27. As you buy larger quantities you generally obtain a better price per piece through the reduction of setup costs, etc. Conversely with the larger orders you have increases in insurance, rent, taxes, heat, light, stockkeeping expense, and depreciation. All those items build up as you buy more and more. The summation of these opposing factors results in the "best buy" line. You should seek not just the low point but generally the smallest purchase possible and remain in the low portion of the resultant curve.

Now that we have seen the graphic theory of economical quantity determination, let's examine the actual calculation of such a quantity. One large university advocates a very long and complex formula which seemed unwieldy so we selected a very simple formula involving the major principles.

(Chart 10, page 28).

$$Q = \frac{2\ G\ S}{CI + 2\ BE}$$

In this formula Q equals the economical quantity; G the cost of each order; and S the annual consumption. C is the unit price; I the interest rate on money; B the unit storage space; and E the annual storage charge in dollars per square foot. So you see, it can be reduced to a very simple formula.

Now, the profound professors suggested in their article that the cost of each order should be between sixty and eighty cents. Have you ever estimated the cost of placing a big steel order when the vice president and his staff fly to several steel mills? It is a long way from costing sixty cents per order. I don't know what it costs your government agencies to place an order, but it is unquestionably more than sixty cents.

The economical cost of each order has to be very carefully determined. Then you have to consider the interest rate on the money. If you put more money in, you have to figure the interest that you would be losing. Then there are carrying charges that we just mentioned. If we require more warehouse space, that means more rent and more insurance. There is also obsolescence to be considered. Then there is depreciation, or we can term it obsolescence. Then there is rent, heat, light, taxes, wages of stockkeepers, and similar expenses which must all be taken into account.

INTERNAL ORDERING

Now, you may say, "You have new girls ordering these materials. Can they carry out the calculation of all these elements?" The theorists—and I emphasize "theorists"—have worked out a way for them to do it. Chart 11, page 29, shows the alignment chart portion of an order card which makes economical order determination seem easy.

First, you determine the setup labor, then the direct material and labor per 100 pieces. These factors determine a constant, then you establish the weekly usage. With the factor relating setup and piece price and the estimated weekly usage, you can determine the theoretical economical order quantity.

There are other mechanical aids for making this calculation. Chart 12, page 30, shows the circular slide rule originated in our West Lynn Plant. The circular slide rule performs exactly the same function as the alignment chart only it is based on a different formula.

Incidentally, these mechanical calculators are not now in actual use in General Electric. The theory is all right but the practice is generally unsatisfactory.

The above formulae are derived for internal ordering. That is for ordering from one's own division like a punch press or a screw machine section.

OUTSIDE ORDER QUANTITY DETERMINATION

What about outside ordering? Chart 13, page 31, gives us a basis for examining outside ordering theory. Let's examine the item of copper bus bars shown. If you want to buy up to 500 pounds of copper bus bars, you would pay forty-seven and two-tenths cents per pound for a good grade. But if you get around a ton, you would pay only thirty-four cents. It is the same with hot rolled steel. You pay approximately four and eight-tenths cents for 500 pounds and it goes down to three and seven-tenths cents for 2,000 pounds.

You may ask "What is the problem?" Bus bar copper is good standard material, it deteriorates little, its potential obsolescence is low. The problem is how much is it economical to buy. Assume that you wished to buy two tons, about 4,000 pounds, of copper. If the copper was purchased in a quantity of over 5,000 pounds, it could be obtained at a more favorable price. How far should you go in seeking better prices? Obviously, you must obtain a satisfactory return on the extra investment.

On chart 13 we have tried to indicate a guide for such determinations If you increase the copper order from 4,000 pounds to 5,000 pounds, you have added so many weeks or months of additional stock. Since copper is a good basic raw material, the return on the extra investment doesn't have to be so high as if you were buying some finished part which might easily become obsolete or deteriorate. This chart is for one individual line of manufacture within General Electric. It does not apply to all of General Electric's products. It does not apply to more than the one line for which it was calculated.

You will observe on chart 14, page 32, that for basic raw material, you should obtain a two or three percent return on each additional month's investment when purchasing less stable finished parts. With price extra data you can calculate the amount you can save by increasing your order to take advantage of the next price decrease step. Divide the dollars you save by the extra dollars you invest and the answer is the percent return on your extra investment. If the return is adequate, equal to, or in excess of the required return charted on chart 14, page 32, then the larger purchase is certainly worth serious consideration.

Now, there is one more thing that must be evaluated, price extra. On chart 15, page 33, you see a steel plate $2\frac{1}{2}$ inches by 130 inches by 156 inches, silicon killed firebox quality. If you simply multiply the weight of steel by the unit price, you get a price of $506.25. However, you may be badly misguided because the unusual width will cost you $94.50 additional. This gauge will cost $6.75. The controlled phosphorus, sulphur, manganese, and silicon content adds another $100. The flame cutting to size will add $23. You still have to pay $56 for your freight So, it will cost nearly $800 for that plate instead of the first assumption of $506. So, the price extras cannot be neglected when you are

ordering and figuring the percent return on investment. The investment is often much larger than a preliminary opinion would indicate.

DEBUNKING MECHANICAL ORDER DETERMINATION

So, we have seen mechanical calculators, but declared them as primarily theoretical. Why? Because no mechanical slide rule, no alignment chart, can take into account design status. You must talk to the engineers and draftsmen and know their plans, know the timing of potential changes.

Then there is the maximum order quantity. Assume we depend on slide rule and calculate an order of one million stampings. What the slide rule forgot to do was to call up this tool crib operator and say: "Dwg 2435793—where does that stand?". The crib operator checks the record and says: "We have 900,000 punchings left on that die." That means that the die will have to be replaced after 900,000 more stampings. You can visualize the seriousness of your error if you had ordered a million pieces. They would have run 900,000 and then replaced that die, indeed an uneconomical order.

Let us come back to an even more popular case. You might employ the slide rule and order 20,000 of another punching, if you didn't stop to check the time between die grindings. Maybe they grind this die every 19,000 punchings. Don't you think you would save the cost of one setup by making 19,000 your order quantity? Actually they are going to punch 19,000 pieces, grind the die, and put it back in the press. You have an extra setup which the slide rule didn't know about and couldn't know about, but the good order clerk will save the extra setup expense.

Let me tell you another experience. It was a simple problem of ordering cork gaskets. We needed only two, so I added 50 percent extra for safety and ordered three gaskets. I was considerably rebuffed when the "long service" purchasing agent drew a big black pencil through the "3" and changed it to "12." I thought to myself: "When they finally throw away 9 out of those 12, I am going to call for an accounting." So I checked the invoice when it came in, to see how much more it cost, and there I read in rather small type across the bottom: "Minimum order quantity, one dozen." I followed that job through. Believe it or not, they required four gaskets on that job. I thought I had a 50 percent safety factor when they needed two and I ordered three. Actually they put the two on all right. Then the unit failed in test. They pulled the bushings and ruined the two gaskets. If I had had my way, the order would have gone out for three, we would have paid for a dozen and gotten three; then we would have had to reorder and pay for another dozen though we actually used only four. The order man must know the minimum order quantities.

Then there is the deterioration problem. I will tell you another story on myself. I was ordering steel tubes which are used on transformer

radiators. My calculations were profound and thorough as we ordered tubes right to the carload. This was in 1937 when the plant was very, very busy and there was little space for storage. We had room for only one carload inside so the second carload went outside.

About two-thirds of the second carload was eventually scrapped. We put a tarpaulin over the top and ends, we even built a temporary roof, but these expedients didn't keep condensation from collecting inside the tubes. Next, we had the carpenter shop make wooden plugs which we drove in the ends of the tubes. First, we put green wood plugs in, they dried out and fell out. Then we got some dry wood and made plugs; but they got wet and swelled up so we had considerable trouble getting them out. The simple solution was to buy just one carload of tubes which could be store inside, but the slide rule didn't know about that.

Then you have to consider turnover. If the General had a $100 cash inventory and then decided it would be better to have $1,000 worth of popcorn, he would have to arrange for the additional $900. Sometimes that is quite an expense if not an impossibility. The expense of getting that extra money and the interest that he would pay on it would more than counterbalance the gain in purchasing.

Of course, we don't generally consider availability of cash in a small part of a big business. Normally, there is an established turnover rate which is the guide for operations, and nonconformance is carefully watched by top management because collective overspending might seriously affect cash requirements for the company.

There is the possibility of a new manufacturing process affecting ordering. Let us assume that we make a slide rule calculation and determine and order quantity to be obtained from our own screw machine section but we are figuring them on the hand machine basis. We use hand machine prices on the slide rule and we come up with one quantity. But possibly the usage has increased to the point where we should be ordering for an automatic screw machine, so that your calculations are on the wrong basi entirely. You are feeding the wrong data into the slide rule.

There is the second operation, machine loading. Assume you ordered so many pieces from a hand screw machine and neglected the second operation. Then for that second operation, they went to the headers. The order quantity figure based on just the first operation was 50 pieces. The fact neglected was the header operator's requirement of 100 pieces just to get his machine set up. So you must not only look at the first operation, but the second operation as well.

Then there is the service requirement. We might calculate that we needed 25 large steel plates. Twenty five was the slide rule answer, but we needed them next Monday. You don't get $2\frac{1}{4}$-inch steel plates next Monday out of the mill. Obviously, you have to go to a warehouse, pay a

premium price, and so you buy just enough to last you through the procurement time plus a minimum protective stock period or until you can safely be assured of obtaining steel plates from a mill. The slide rule doesn't know about warehouses. So the amount of time it would take to get the desired material was the primary factor in order determination quantity. There are nearly always additional factors over and above the ones that you normally use in a slide rule calculation.

We had another problem which involved material for some Navy gears. The gears for the Navy required stock about 6 inches in diameter. We figured it all up on the slide rule and came out with a need for 4 feet. So we were inclined to order just the 4 feet. But investigation showed there was required a complete chemical analysis costing about $25. When the laboratory analysis expense was included in the calculations, the order quantity was raised to cover a full length bar. What do you do with what is left over? Well, the slide rule doesn't consider the substitution of other parts. Assume that this is 6-inch stock for gear blanks. Pretty soon the next order comes in and it calls for 5 3/4-inch stock. You have the chemical analysis and everything approved, so you are all set to go. You can very economically substitute the 6-inch stock that you have.

Another thing the slide rule doesn't know is the business cycle. Very few of us can interpret the business cycle. A lot of us try to, but certainly it is a recognized error of potential bankruptcy to have an excessively high inventory when prices crash.

Another odd example shows the requirement of experience to order properly. One type of control panel still requires slate which we obtain from Maine. We had the quarry deliveries scheduled by weeks, but when the order went to purchasing that same old buyer ran a black pencil through one of my weekly quantities, put it back in another week, doubling the prior week's schedule. I had the company's vacation schedule before me which showed a summer shutdown, but he scratched off a week later in the year. What I didn't know was that when it is "b'ar" season in Maine "they don't ship nauthin that week."

So my point is that there are many elements to be considered which you can't put on the slide rule. You can't put them on the alignment chart. You can't set them up in a group of charts. There is seldom a mechanical solution; experience, knowledge, and careful analysis must be continually exercised in good ordering. Worst of all people are mentally lazy and when you hand them a mental crutch they lean too heavily on it generally.

To summarize, let us bring this subject "home" by comparing inventory control and the economics of family management. Now, my point is this: in inventory control, it is the turnover that counts. In a home it is

turnover in the family that really counts, financially. It is not simply the number of children you think you can accommodate in your home; it is the turnover of those children.

If you can get your boy to go out into the world when he is 12 years old selling those very profitable newspapers, you will have to agree you are more than twice as well off financially as the father who puts his boy through the university to get his Ph.D. or M.D. degree and so has to support him until he is 24 years old. Just remember that equilateral triangle (chart 7, page 25), the high investment occurs with the nearly finished product. The longer you keep them around, the more it is going to cost you. You don't make your saving by adopting a boy when he is two years old because you only save two inexpensive years' maintenance. You are a lot better off if your boy flunks out of the university at the end of his sophomore year.

Now we have mentioned potential obsolescence. We have talked about turnover of children at 12 versus 24. The whole point is to get turnover. If you have an old model, a superseded design, then you have an old maid on your hands; and an old maid develops no turnover whatsoever. You are, indeed, in a most expensive predicament.

So I would conclude, not by warning you Navy men against old maids, but very seriously make a suggestion which applies to any of us working in a large organization. When we have decisions to make, we should generally, "Make those decisions exactly as if the business were our own."

QUESTION: I have a question on this die problem, on the regrinding of dies. Don't you have a shop expense set up to spread that over a number of orders? In other words, if you cut your punching operation to 9,000, and at that point the punch needs regrinding, then wouldn't your next order, even though it is only one-tenth as big, have to stand its share of that grinding expense?

MR. DICKIE: If you had an order for 10,000 of these water bottles here and the customer wants that exact quantity, you have no choice but to punch out 10,000 sets of parts. But, if you are producing for stock, manufacturing for anticipated orders, then it is more economical to run the die only up to the point where it needs regrinding. If you go beyond that point, you are spending money for an unnecessary setup as well as reducing the output of a punch press.

If you are building some special water snouts for a company that orders gold ones, you have to set up to run the exact number ordered and your actual expense would be charged directly to the order. But, you can save money when you are ordering for stock, that is an advantage of standardization. In ordering for stock, you can order a quantity that conforms with the most economical setup. If you tear that die down and regrind it and set it back up, it costs an extra setup. When you set up,

you should be able to run through to the next die grinding and it is most uneconomical to set up again for just a short run. The point is this: If you are in a highly competitive market of standard devices, you have to watch the costs very closely. However, on the order for gold ones, if the customer wants 10,000 of them and you have to grind the die after 9,000 and set it up again, the extra setup will likely be charged largely to the special order.

QUESTION: I would like to ask how you keep the order clerk informed of design obsolescence and design changes that come about. In other words, is there any established organization practice? How does the order clerk, the girl or whoever it is, keep informed on these other things that must be taken into consideration?

MR. DICKIE: May I relate General Electric's practice? We have a standard AN, which mean "Alteration Notice." An advance type of AN is sent up to the interested production sections at the time that the engineer first contemplates a change in design. At that time he might say: "Snout on water bottle drawing so-and-so contemplated to be changed from .090 to .060-inch brass." This alteration notice immediately comes in to the inventory control group which notes on its .090 brass order card the possibility of change.

The advance alteration notice will state there on the stock order card: "Any future orders for .090-inch brass for water spouts must be approved by undersigned engineer."

QUESTION: How many items is one order clerk expected to handle economically?

MR DICKIE: That varies widely. In one division, we had around 8,000 stock items. As I recall we had six ledger clerks. Various types of businesses have widely different problems in handling stock records.

If you have very active items versus inactive items, the man hours will vary substantially. The point is this: If you are making power transformers, you have no mass production. You make one, two, or three similar units at the most at one time. So the assignments and withdrawal entries will be for relatively few pieces at a time. It takes a lot of entries to check out 1,000 pieces.

But now assume you are making distribution transformers, like those you have hanging on the electric pole in your back yard. They manufacture them on a conveyor line and make thousands each week. When you draw out parts for those, you take out a whole load and set them beside the conveyor line. The ledger withdrawal there might well be 1,000 at a time. In the power transformer business the withdrawals are only two or three at a time.

Also when you assign or premortgage parts for these standard distribution transformers, the scheduler will advise you, "We will require these at the rate of 1,000 a week for the next 15 weeks." So the entry is one figure, 15,000 pieces. On the power transformers, where there are only one or two parts prescheduled at a time, we have to write down the assignments a few parts at a time.

So the problem is a widely varying one. The number of items handled per record clerk when making special fire-control systems for you gentlemen is obviously much lower than the number handled by clerks in a division making automatic toasters.

QUESTION: Have you taken item characteristics into account in enabling you as a production man to meet the schedule and produce the products? I wonder if you would comment on the thoughts going on in the minds of the sales department, or whatever department it is that is imposing requirements for finished products, as to how their thoughts may be influenced by item characteristics.

MR. DICKIE: General Electric has a very capable group of salesmen because most of our apparatus products are complicated. The large majority of our salesmen are engineering graduates well acquainted with our factory setup. They are not inherently interested in item characteristics. However, they are made very conscious of the problems occasioned by calling for very special parts or materials because the delivery promise we give them is generally quite long, reflecting the extra procurement time required for purchasing the special materials.

Many of the "special" products sold are basically standard but with special features added. There is still much to be gained in this field which you point out. Our favorite example is this: Assume you want a new Ford with stainless steel fenders on it. Do you think you go down and order one? Possibly, but the price, delivery, and special effort would probably discourage you. We have much to learn from the automotive industry.

At the present stage of standardization in the electrical industry, General Electric has preferred to be accommodating. We promise special apparatus nearly as quickly as standard items.

But we are coming to standardization, encouraging it by giving much better prices and deliveries on standard apparatus then specials. We are working toward standard components which can be variously assembled to give a wide variety of finished products.

QUESTION: If I understood you correctly, you said the salespeople are not concerned about item characteristics. How many toasters do you think they would sell if they required 220 volts? That is one item.

To go back to the General and his popcorn, why did he have so much popcorn? My contention is, simply because he did not consider the item characteristics of the product with which he was dealing. Perhaps his butter was rancid and people wouldn't buy the popcorn. Perhaps he used too much salt. The point I am trying to make is that it seems to me each manufacturer must consider item characteristics as they relate to his consumers before he can successfully manufacture and sell that item. Would you care to comment on that?

MR. DICKIE: First of all, the narrowness of my experience makes me feel that in your first statement you are correct and I incorrect. I am in the Apparatus Department at General Electric and the toaster and appliance business examples are not part of my everyday experience.

In the Apparatus Department we don't make much of anything that you buy at the corner store. Our apparatus runs from large turbines to fire-control systems. It is true that where you sell your things through the appliance store, there certainly has been a lot of standardization. We are trying very hard to bring about more standardization in our own more complicated and more specialized apparatus business.

Now, it is true that the salesman has to recognize what he is selling. I am probably prejudiced when I say that they don't do that as much as they could. I think there is always the possibility of better cooperation. I don't think our salesmen are ignorant of our requirements, but I think that there is still considerable progress that can be made.

QUESTION: I would like to interject the item of producibility as considered by the salesmen there in reference to these articles that you make. Wouldn't the producibility of an item be something the salesman would consider? Or is that entirely in the production field?

MR. DICKIE: Well, we will assume for the moment that he did not consider the possibility of manufacturing the item. He very quickly would have that brought to mind, because an order for most of the big apparatus doesn't come in originally as a sales order but rather as a proposition. If the salesman sends in a proposition which is unreasonable the quotation will be both high in price and long in delivery. However, the incoming propositions at GE come in to the engineers and they work very closely with the salesmen in offering to the customer something we are suited to produce.

If a customer should ask for some new equipment involving the latest ground spiral bevel gears which we are not yet set up to make, then a study to determine the advisability of adding the new and very special equipment would be required. If we decided to add the equipment we would likely have to add six months to the normal promise. The better solution might be to subcontract the special gears to some gear manufacturing specialist which solution would expedite shipment and probably not add

too much extra to the cost. There are generally solutions to any problem but their difficulty is pretty well reflected in the extra cost and longer shipment schedule.

COLONEL MICKELSEN: Mr. Dickie, may I compliment you on having translated a possibly nebulous title into a most interesting and edifying lecture. I think I express the real appreciation of the College for a most earnest and entertaining talk. Thank you very much.

(24 January 1949—750)S.

CHART 1

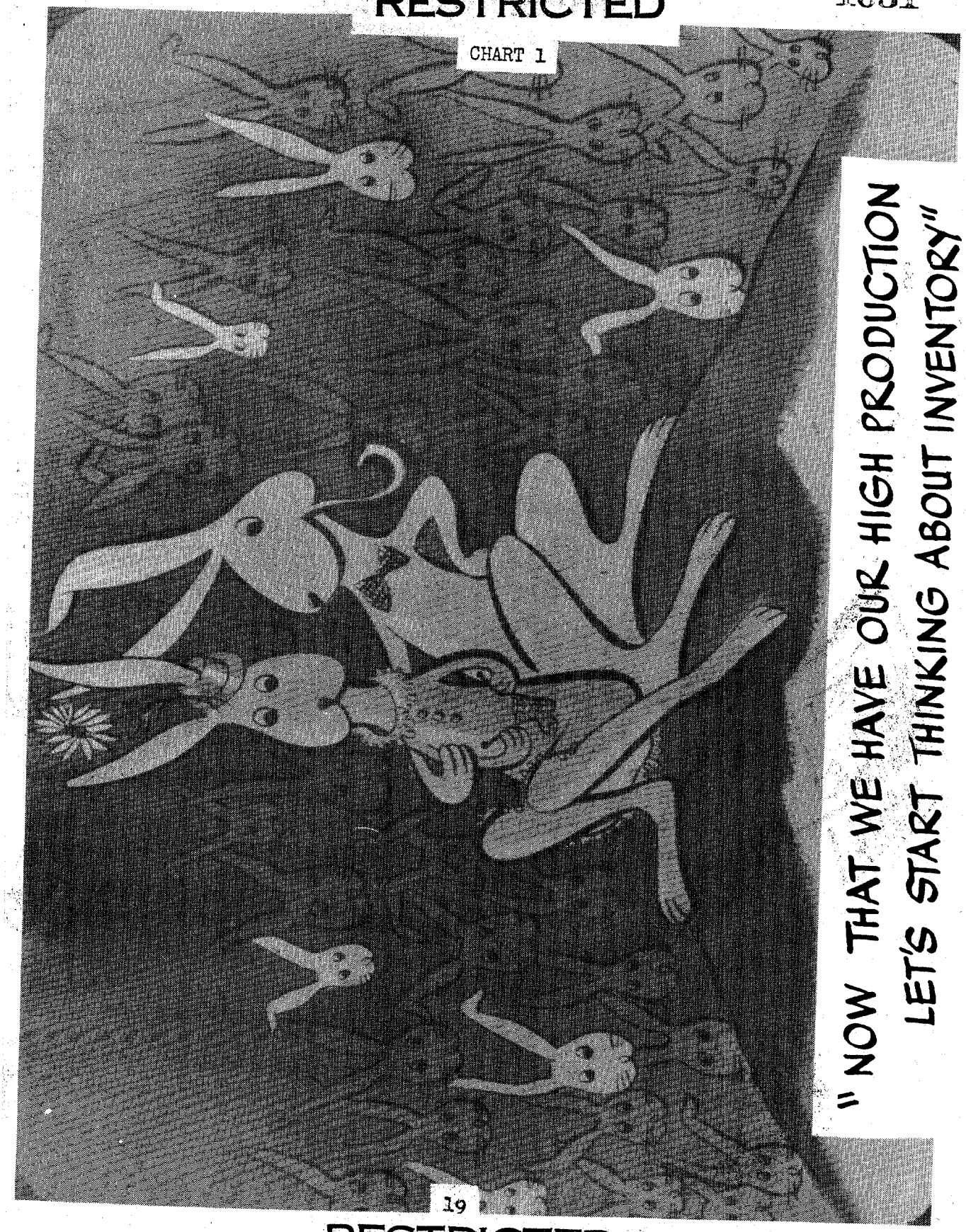

"NOW THAT WE HAVE OUR HIGH PRODUCTION
LET'S START THINKING ABOUT INVENTORY"

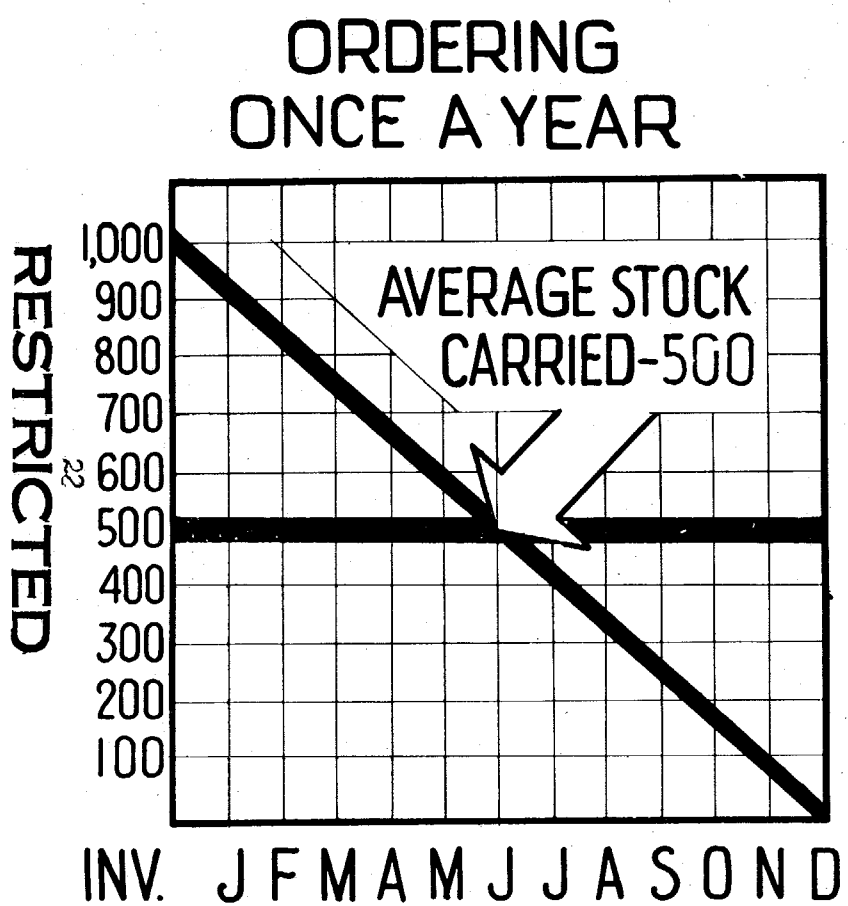
CHART 2

CHART 3

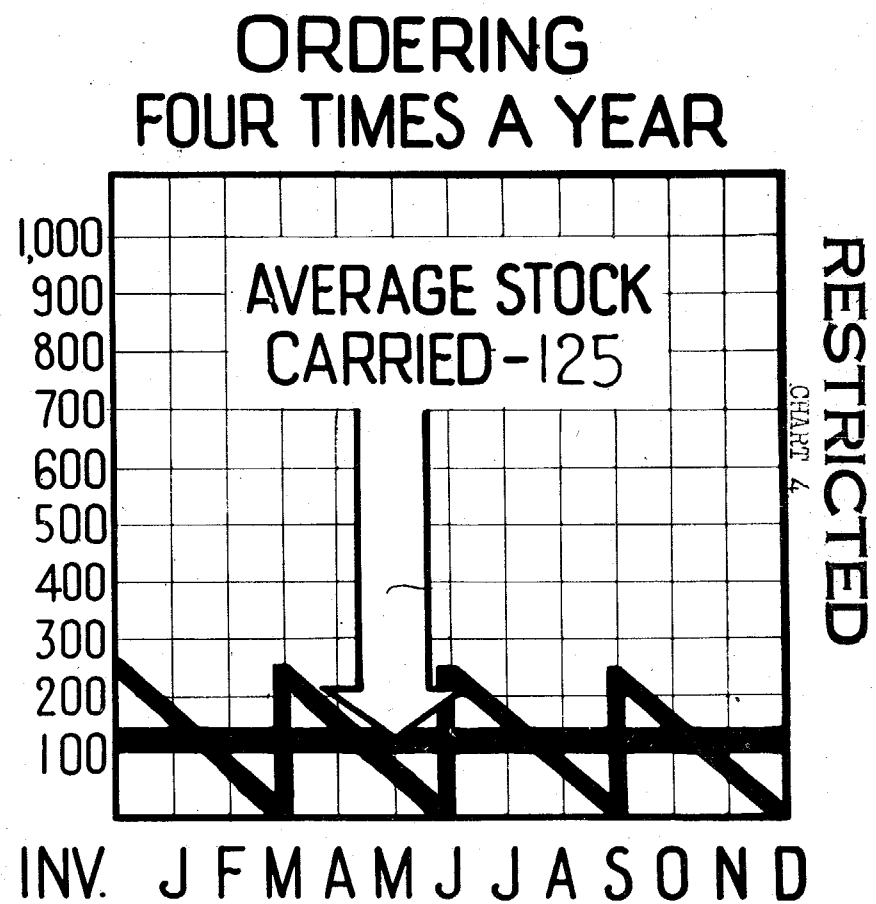
RETURN ON INVENTORY INVESTMENT

	1 T/O	2 T/O	10 T/O
SALES	$1100	$1100	$1100
COST OF SALES	1000	1000	1000
PROFIT MARGIN	100	100	100
INVENTORY	1000	500	100
RETURN ON INVENTORY INVESTMENT	10%	20%	100%

SIZE OF ORDER



TURNOVER=2



TURNOVER = 8

CHART 4

CHART 5

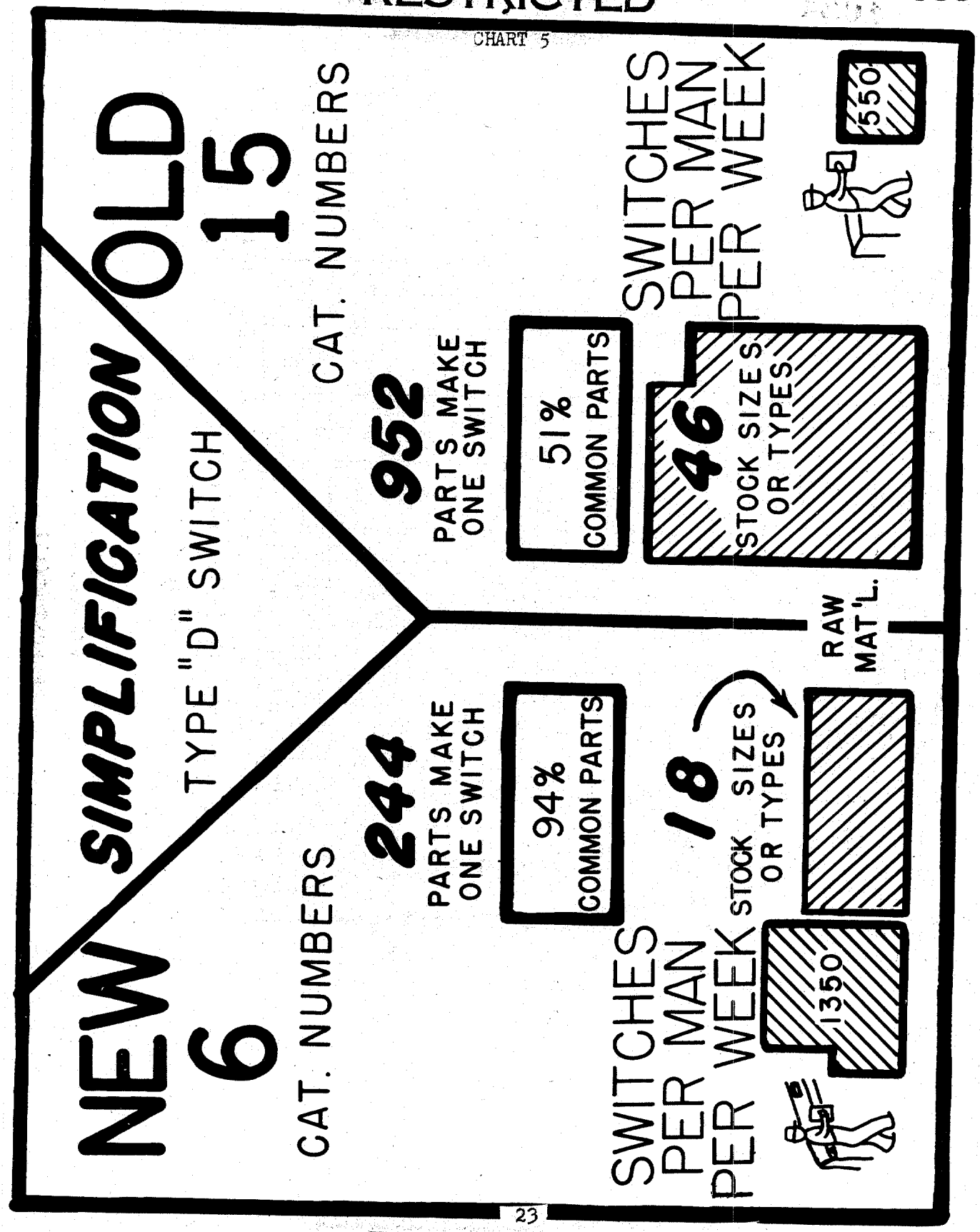
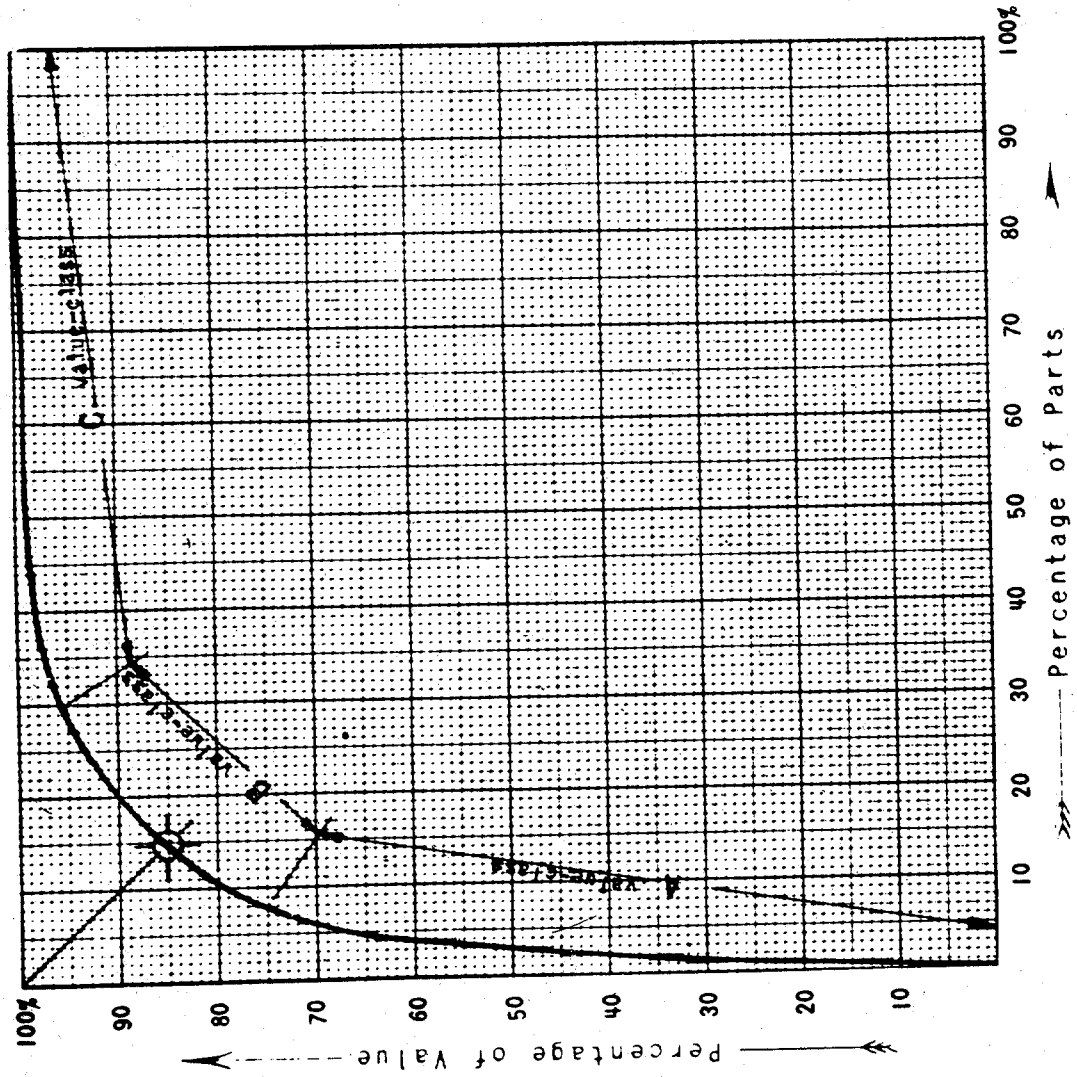
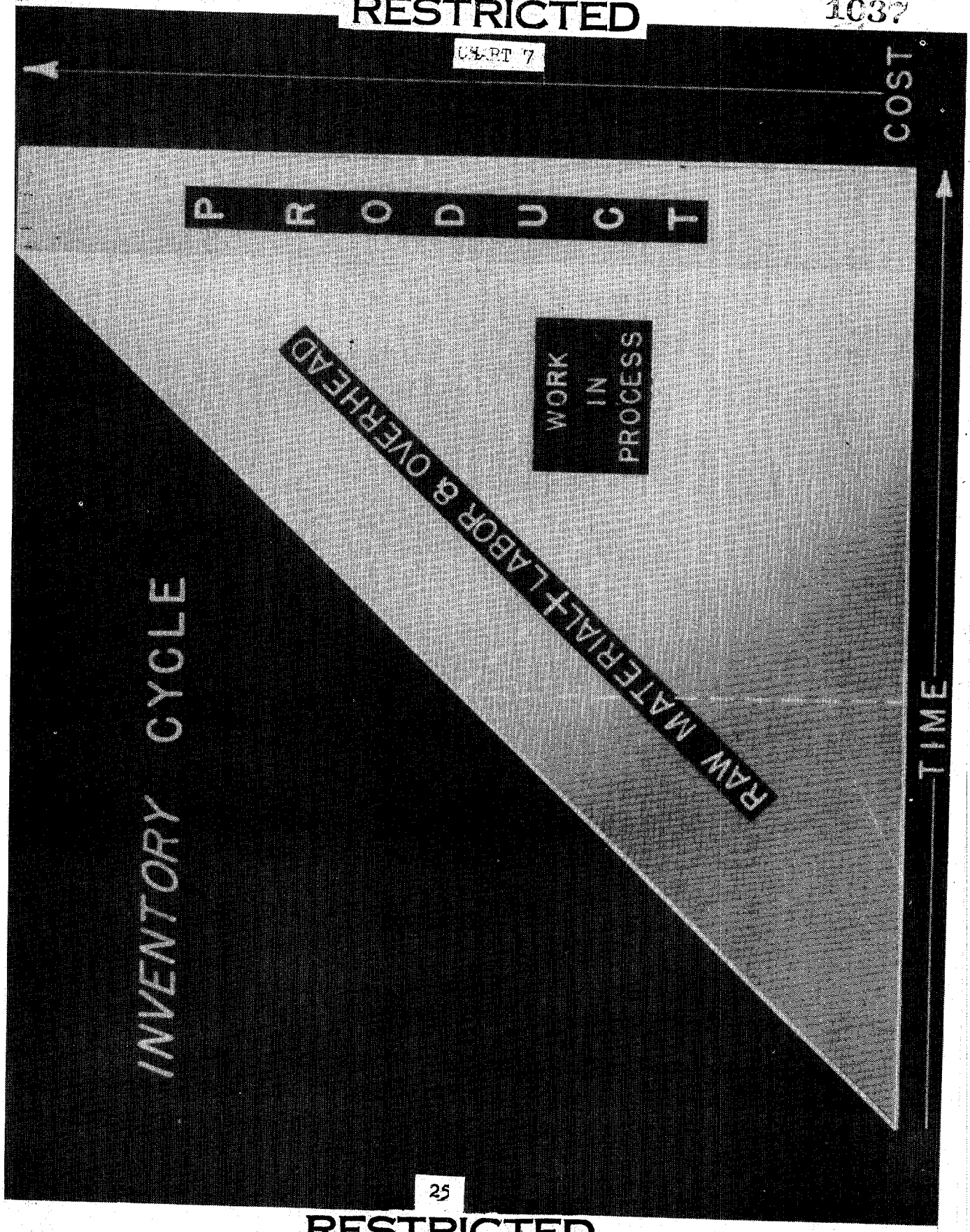

SIMPLIFICATION
NEW
6
CAT. NUMBERS
TYPE "D" SWITCH
OLD
15
CAT. NUMBERS
244
PARTS MAKE ONE SWITCH
94% COMMON PARTS
952
PARTS MAKE ONE SWITCH
51% COMMON PARTS
SWITCHES PER MAN PER WEEK
1350
18
STOCK SIZES OR TYPES
SWITCHES PER MAN PER WEEK
550
46
STOCK SIZES OR TYPES
RAW MAT'L.

CHART 6



TYPICAL
PROPORTIONATE

CHART 7


INVENTORY CYCLE
RAW MATERIALS + LABOR & OVERHEAD
WORK IN PROCESS
PRODUCT
COST
TIME

NORMAL PROCUREMENT TIME

(INCLUDES TIME REQUIRED FOR PLACEMENT OF BUSINESS AND TRANSPORTATION)

CHART 8

6 - 8 WEEKS

ACID, NITRIC
ACID, SULPHURIC
CARTONS
CLOTH
CONDUIT FITTINGS
FIBERGLASS
LEAD, PIG
OILS, SPECIAL
PAPER, CORRUGATED
PINS, COTTER
PINS, DOWEL
SOLDER
SLATE
TERMINALS
THREAD & TWINE
YARN, ASBESTOS

20 WEEKS

ASBESTOS TAPE AND CLOTH
BOLTS
FORGINGS, ALLOY STEEL
FORGINGS, CARBON STEEL
GASKETS, NEOPRENE
GASKETS, RUBBER
GEARS
HARDWARE
METAL HOSE & FITTINGS
RUBBER, ROD & SHEET
SCREWS, BRASS & STEEL
THERMOSTATIC ELEMENTS
TRANSFORMERS

10 - 13 WEEKS

BRASS, B11H18
BRASS, B11H16
BRASS, SHEET & STRIP
BRONZE, STRIP
BRONZE, ROD
CAPACITORS
CARBON RESISTORS
CASTINGS, STEEL
CASTINGS, DIE
CASTINGS, BRONZE & BRASS
CIRCUIT BREAKERS
CONTACT TIPS
COPPER
MOULDED PARTS, PLASTIC
MONEL
NAILS
NICKLE SILVER
PAPER, INSULATING
PAPER, GUMMED
RESISTORS
SPRINGS
YARN

CHART 9

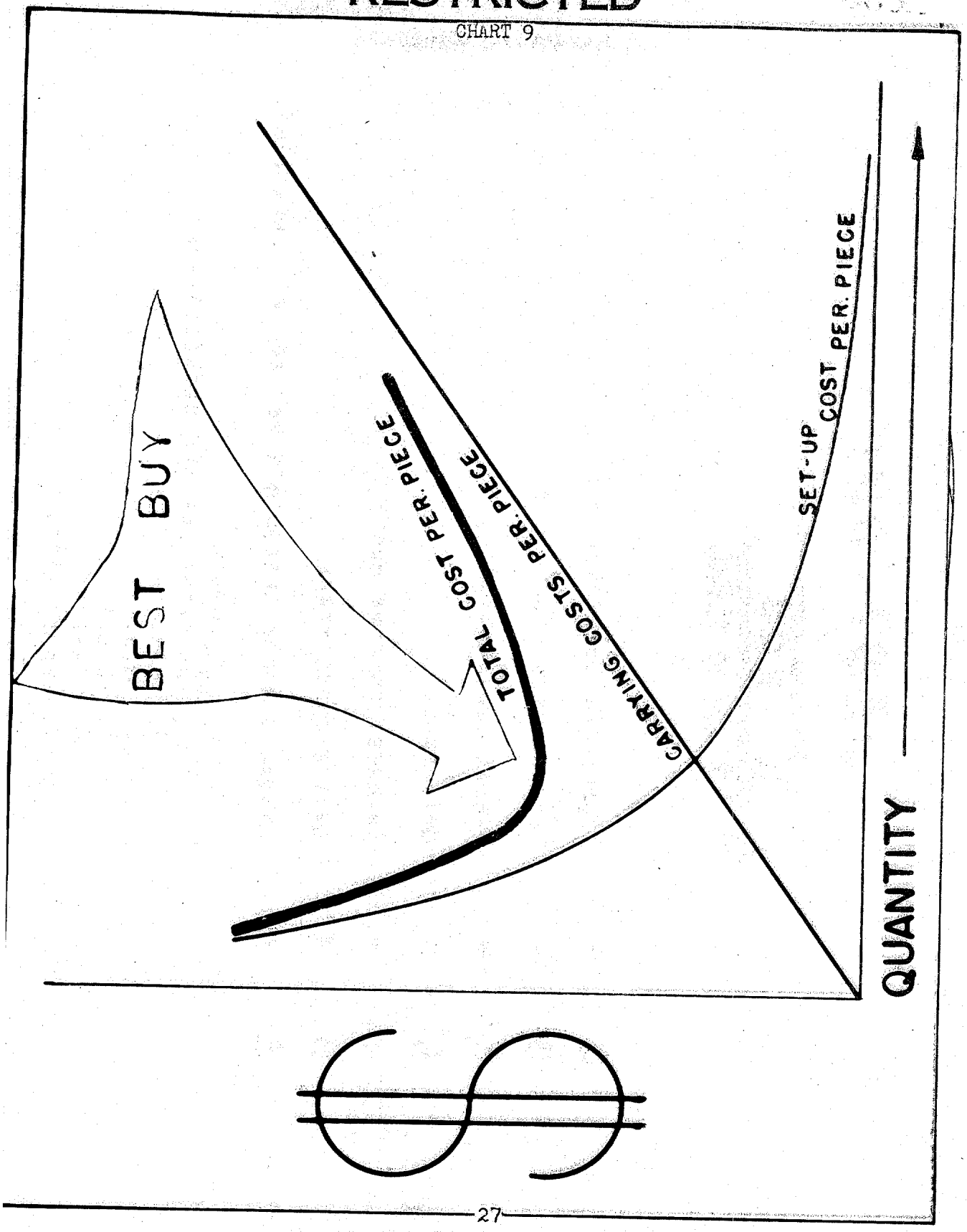

BEST BUY
TOTAL COST PER PIECE
CARRYING COSTS PER PIECE
SET-UP COST PER PIECE
QUANTITY

CHART 10

BEST BUY

$$Q = \sqrt{\frac{2GS}{CI + 2BE}}$$

Q	=	ECONOMICAL QUANTITY
G	=	COST OF EACH ORDER
S	=	ANNUAL CONSUMPTION
C	=	UNIT PRICE
I	=	INTEREST RATE ON MONEY
B	=	UNIT STORAGE SPACE
E	=	ANNUAL STORAGE CHARGE $'S PER SQ. FT. INCLUDING:

1. INSURANCE
2. OBSOLESCENCE AND DEPRECIATION
3. RENT
4. HEAT
5. LIGHT
6. TAXES
7. WAGES, ETC.

			Reason Obsolete			
der ber	Order Quantity	Available & Receipts	Due Dates or Bal. Due	19		
				J		J
				F		A
				M		S
				A		O
				M		N
				J		D
				19		J
				J		A
				F		S
				M		O
				A		N
				M		D
				J		T
				19		J
				J		A
				F		S
				M		O
				A		N
				M		D
				J		T
				19		J
				J		A
				F		S
				M		O
				A		N
				M		D
				J		T

26 weeks nor $100 value without the approval of the Supervisor of Inventory.

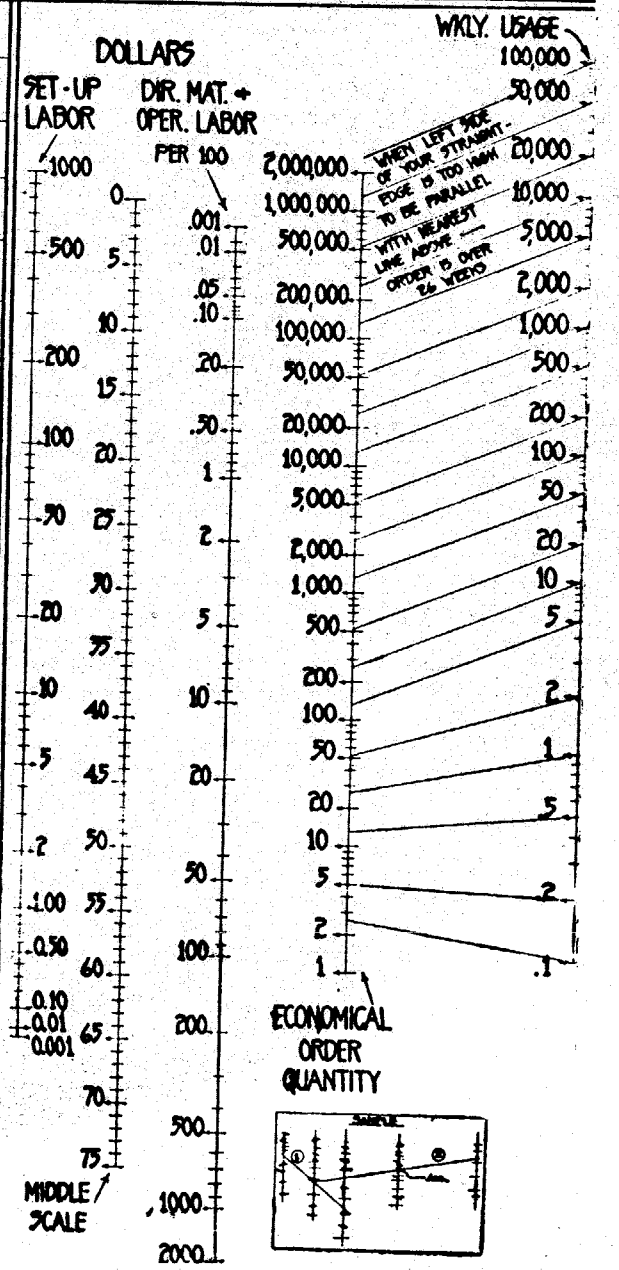


CHART 11

1041

1042

CHART 12

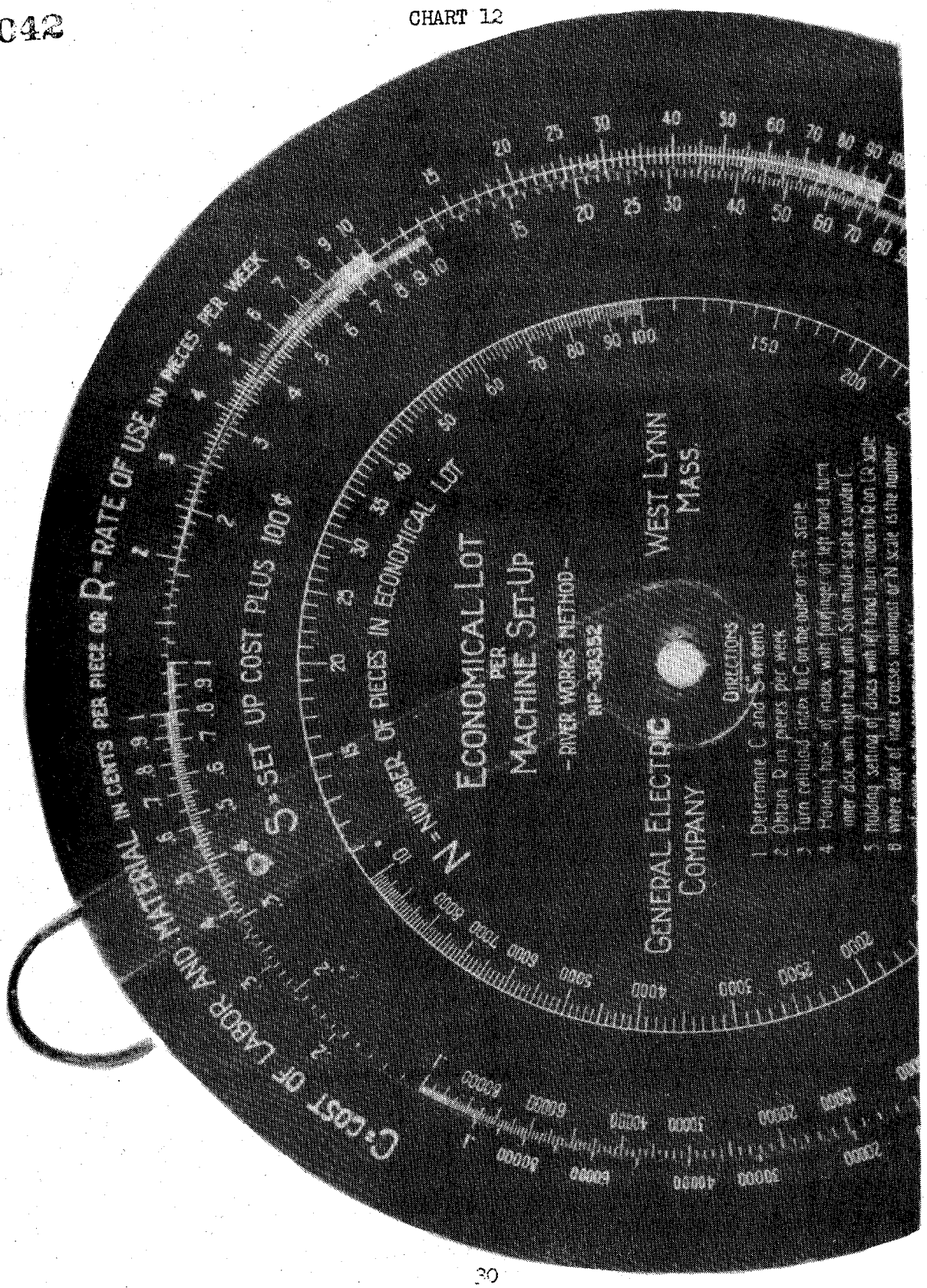


CHART 13

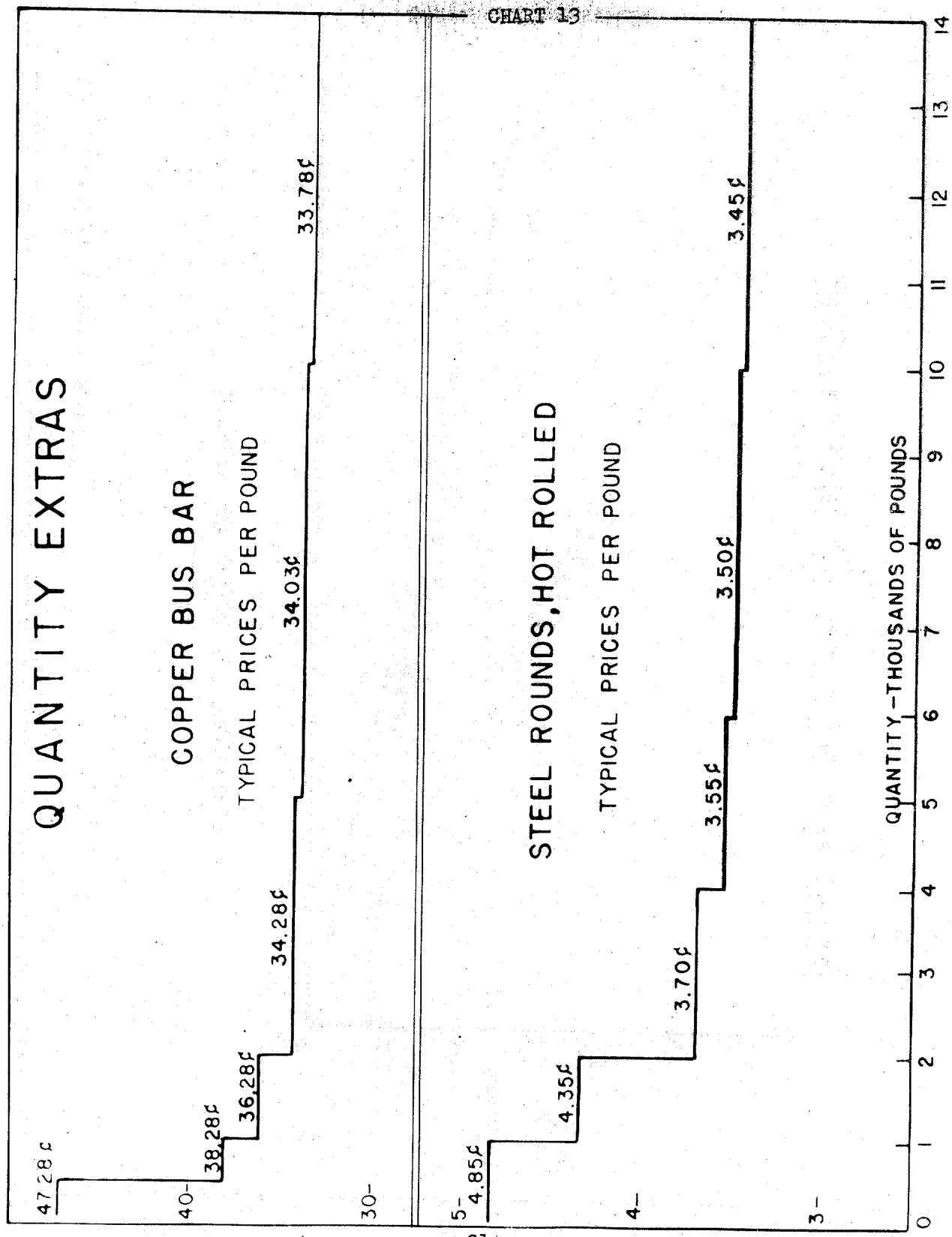
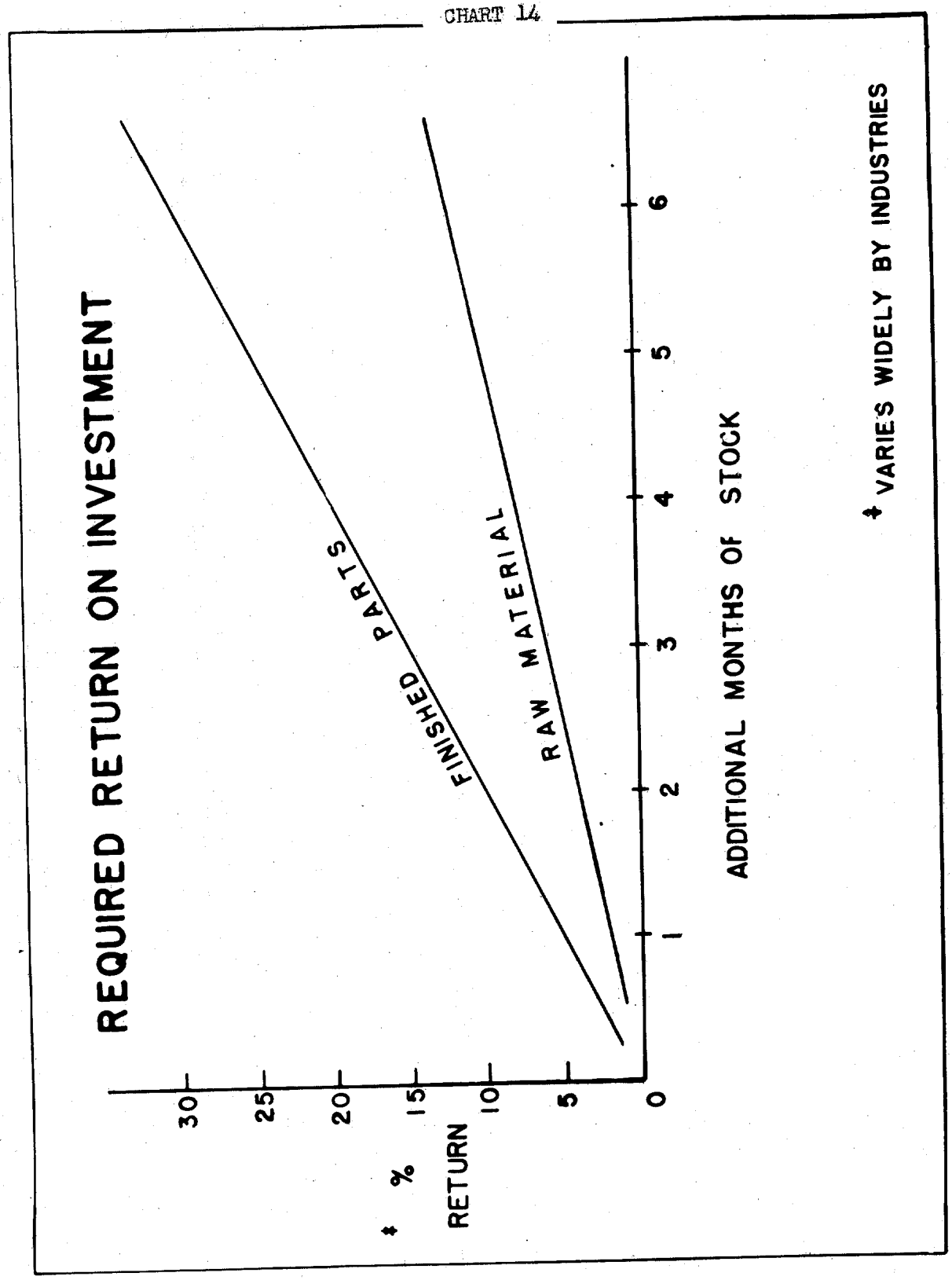

QUANTITY EXTRAS
COPPER BUS BAR
TYPICAL PRICES PER POUND
47.28¢
38.28¢
36.28¢
34.28¢
34.03¢
33.78¢
40
30
STEEL ROUNDS, HOT ROLLED
TYPICAL PRICES PER POUND
4.85¢
4.35¢
3.70¢
3.55¢
3.50¢
3.45¢
5
4
3
QUANTITY-THOUSANDS OF POUNDS
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14

CHART 14


REQUIRED RETURN ON INVESTMENT
FINISHED PARTS
RAW MATERIAL
30
25
20
15
10
5
0
* % RETURN
1
2
3
4
5
6
ADDITIONAL MONTHS OF STOCK
* VARIES WIDELY BY INDUSTRIES

STEEL PLATE

SILICON KILLED FIREBOX QUALITY

1 PLATE 2 1/4" x 130" x 156" WT=3500 LBS.

Steel Plate (Base)	$ 506.25
Extras:	
Width	$ 94.50
Gauge	6.75
Phosphorus	3.37
Sulphur	13.50
Manganese	13.50
Silicon	67.50
	199.12
	$ 705.37
Flame Cutting	23.83
Freight	56.70
TOTAL COST	$ 785.90