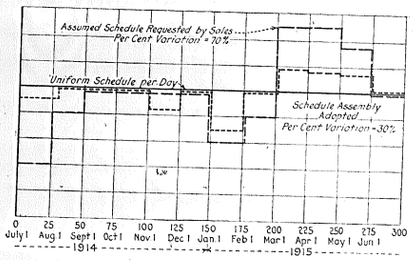

Figure 2

The final assemblies, however, were made according to a variable schedule as shown in Fig. 2.

In arranging the variations of the assembly schedule, a variation in labor of not more than 30 per cent was permitted; i.e., not over one man in every three on the assembly force was allowed to be changed, two-thirds of the force thus consisting constantly of trained men. The cars were assembled according to the assembly, as shown in Fig. 2, and the high-cost materials noted above were ordered for delivery to agree with this schedule. The capital invested in inventory was thus kept at minimum, both for purchased and manufactured parts.

Determination of Lot Sizes

Several factors enter into the determination of the most economical size of lot to be used in manufacture. The first and most important factor is previous experience with similar product as a general guide. The following specific considerations must be taken into account:

Small lots are indicated by:

a. High cost of material
b. Large unit bulk of material
c. Long time required for various operations on a part
d. Probability of change of design
e. Reduction in inventory
f. Conservation of floor space
g. High unit weight of material
h. Use of perishable materials in processes
i. Early entry of part into sub-assembly.

Large lots are indicated by:

a. High average cost of machine set-ups
b. High dispatching, inspection and trucking charges
c. Rapid production, even with elaborate set-up
d. Reduction of spoilage
e. In general, all preparation charges should be satisfied with largest possible lots.

A number of formulas have been prepared at one time or another for the mathematical determination of lot sizes. The more accurate of these are based upon material cost per piece, time required for operations, interest charges on material in process, rental charges for space occupied, wage rates, etc. Accurate formulas, taking all these facts into consideration, lead to cubic equations which are difficult of solution. The author has found it preferable to determine lot sizes by trial and error rather than by applying a formula.

Manufacturing to Order

A plant manufacturing to order obviously cannot plan its production in advance of the receipt of orders. Preplanning in this case involves only the analysis of the order to determine the material that must be purchased and the time required to procure it, and to determine the operations that are necessary, the sequence in which they shall be performed, and the time at which they shall start in order to meet the delivery date specified in the order. These determinations must be made with reference to orders already in process, and the new order must be fitted into the manufacturing schedule in such a manner as not to create disturbance. The purchasing is often simplified by the fact that most manufacturing concerns of the class under discussion operate in a somewhat limited field as regards product, and the raw material used for all orders is of the same character. Thus a company specializing in hoisting and conveying machinery will use for practically all of its orders pig-iron, sheet and bar steel, alloys and certain standard manufactured products such as rivets, bolts, pillow blocks, chain belts, etc. These it will keep on hand in sufficiently large quantities to fill its requirements over a certain period, purchasing in large lots whenever the stock falls to a predetermined minimum. If the analysis of the order shows that there is sufficient raw material available to fill it, production can begin at the earliest date on which machine capacity is available.

Another class of manufacturing which is to order, but which has many of the characteristics of manufacturing to stock, is found in certain phases of the textile industry. In the manufacture of woolen fabrics for dress goods, orders are taken by means of samples for varying quantities of product of different grades and patterns from numerous customers. The small orders for each fabric are combined into single manufacturing orders, from which a manufacturing program is built up. Since the samples are sent out and orders taken before the manufacturing season starts, the mill is enabled to plan a production program in its entirety before actual production begins.

Manufacturing for Stock and Order

Where manufacturing for stock predominates, the stock program is laid out as heretofore described, and the product made on order is fitted into the stock program. This may be accomplished by ascertaining what proportion of the machine capacity is not utilized over a given period for stock manufacture, and then scheduling the special product through this excess capacity as if the balance of the equipment did not exist.

Where the stock production is of minor importance, it is scheduled on the basis of the excess machine capacity available. In doing this, if the stock program extends beyond the time for which special orders on hand will utilize the equipment, care must be taken to reserve sufficient capacity to handle future special orders. The capacity so reserved should, in general, be equivalent to the capacity which has been required for special work during some definite preceding period, say for a period of from one to six months.

The Purchase and Storage of Material

In purchasing material these considerations must be taken into account:

a. Quality
b. Price
c. Time of delivery.

Quality is important, especially where the final product must meet specifications as regards strength, durability, etc. It is also important in that it may affect the time required for completing the processes in manufacture, and if of different quality than that upon which the manufacturing program is based may require much more time at each operation. The program then cannot be carried out as planned, except at the expense of overtime or the utilization of more machinery and men than were contemplated. It is poor economy to substitute material of unknown quality for that of proved quality to gain a slight advantage in price.

All things being equal, the lowest priced material is to be desired. If, however, the quality is lower, or delivery cannot be insured at the desired time, price becomes less important than other considerations. The time required for delivery is extremely important in laying out a manufacturing program. Since production cannot begin until there is material upon which to work, ample time must be allowed in which to procure material. It is advisable to tabulate the maximum and minimum number of days required for each item of material that is commonly bought, as a guide in placing orders. The reputation of the seller for keeping delivery promises should also be considered, and preference given to the one who can be relied upon, rather than to one who will promise a prompt delivery but whose promises are unreliable. It is better to accept a later delivery date, with the knowledge that it will be met, than an earlier date where there is reason to doubt that delivery will be made on that date. Another factor to be considered is whether the material shall be bought from the mill or from a warehouse or jobber. Purchases from the mill usually cost less, but the time required for delivery is longer. Whenever possible, mill purchases are advisable.

It should be borne in mind that the shortest time required for the execution of a manufacturing program is the longest time required to procure any item of material plus the time required for the longest process through which that material must pass. The importance of accurate forecasts of the time necessary for purchasing is thus evident.

In the routine of establishing a manufacturing program then, the first item is to ascertain when the first orders for material must be placed. To do this it is necessary to work back through all the processes of production, starting from the time when the finished product must begin to leave the factory. The methods of doing this are explained later. This analysis of the operations fixes the time at which the material for each process must be available. To this time is added the length of time necessary to obtain prices and secure delivery. Having thus fixed the number of days that must elapse between placing the order for material and the completion of all the manufacturing operations, exact dates can be set for the beginning of each event in the production program. This is known as scheduling.