Journal of Accountancy

Volume 54 | Issue 3 Article 4

9-1932

Automobile Tire Industry

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The Automobile Tire Industry

By L. Park

As one sits and listens to his radio, he may hear the announcer state that the programme is sponsored by a company which manufactures 32,000 different articles of rubber. If the listener is in a thoughtful mood he may start going over in his mind some of the articles made of rubber and then begin to wonder how the world ever existed without them and how they are made. That automobile tires and tubes are essential to present-day life and must represent a large part of the rubber industry's production may next come up in his train of thought. Most people take such things for granted and have no idea how a tire-manufacturing company operates, and a great many have the idea that tires are stamped out like so many doughnuts.

Discovery of Rubber and Development of the Industry

Except for the discovery of rubber and the process of vulcanization, the industry would not exist and the automobile could not have been developed to its present state. It would, therefore, appear to be in order to comment briefly on these discoveries before starting the real subject matter of this article.

The first knowledge the civilized world had of the existence of rubber was when Christopher Columbus, on one of his early voyages to America, found the natives playing with a ball having a peculiar and surprising elasticity. These balls were made from a milky substance called latex which flows from rubber (hevea) trees. Exposure to the air or to a certain amount of heat caused this latex to coagulate. In this coagulated form some of it was shipped to England, Germany and other countries. One of its first uses was to erase pencil marks, etc., by rubbing; hence it got the name rubber. It was subsequently used for other purposes such as waterproofing clothing, footwear, etc., but in its unvulcanized condition it was not a commercial success due to the fact that heat made it soft and sticky and cold made it hard and stiff.

Chemists all over the world were experimenting with this substance in an endeavor to compound it or treat it in some way so that it would retain its elastic qualities and at the same time would not be so greatly affected by changes in temperature. Finally

in 1839, Charles Goodyear, an American, who had been experimenting for some nine years, accidentally discovered that when the crude rubber was mixed with sulphur and the compound heated, a substance was formed somewhat in the nature of leather. This was the discovery of the process which has subsequently been called vulcanization. After this discovery the development of rubber for commercial purposes was quite rapid.

The greatest impetus given to the rubber industry was the invention of the automobile. Some idea of the tremendous expansion resulting from this invention may be obtained when it is considered that in 1900, sixty-one years after the discovery of vulcanization, about 27,000 tons of rubber were used, whereas in 1927 over 500,000 tons were consumed. The improvements in the method of manufacturing tires and their quality have been continuous. Most of the improvements in the quality of tires have resulted from the research of chemists, who, among other things, have discovered some ingredients which, when used in compounds, accelerate vulcanization, improve wearing ability, etc.

Prior to the coming of the automobile, changes had occurred in the sources from which the crude rubber was obtained. In the early days of the industry, the crude rubber was obtained from the wild trees in the jungles of South America and Africa. In 1876, Sir Henry Wickham shipped some rubber tree seeds from Brazil to England, where they were planted in Kew Gardens, London, and the young shoots were shipped for planting in Ceylon. This was the beginning of the development of the production of cultivated rubber, with the result that, today, approximately 95 per cent. of the rubber consumed in the world is obtained from the plantations of the middle east. One of the important things to be noted is that the British started the cultivation of rubber and they were followed by the Dutch, so that while the United States is the greatest manufacturer of tires, two other countries control most of the essential raw material.

This lack of control of the rubber market has been very detrimental to the tire industry in this country. Wide fluctuations have occurred in the price of rubber, some of which have been caused by artificial means. Rubber has sold as high as $3.00 a pound and during 1930 was sold below eight cents a pound. On January 1, 1920, rubber was 55 cents a pound and on December 31st of the same year the price had dropped to 16 cents. In

November, 1922, the British, with a view to protecting their investments in rubber plantations, passed the Stevenson act, restricting the amount of rubber that could be exported from British possessions. The effect of this restriction was gradually to increase the price, up to a dollar a pound. In the meantime, more and more trees in the plantations of the Dutch and natives were coming to maturity and additional acreage had been planted. In 1926 the price had dropped to 40 cents and in 1928, when the restrictions were terminated, the price was down to 18 cents. It would appear, therefore, that the rubber producers only received a temporary relief from the Stevenson act, which will probably be more than offset by low selling prices for several years, due to overproduction.

A minimum cost of producing rubber and delivering it in Akron, Ohio, would be 13 cents a pound, but this would include no return on the capital investment. One cent a pound would represent a return of approximately 1 per cent. on invested capital.

The wide fluctuations in rubber prices have been the cause of large inventory losses, which apparently have exceeded any gains resulting from the same cause.

Very keen competition exists among tire manufacturers and heavy losses have been incurred as a result of cutting sales prices. This condition has been aggravated by the fluctuation in crude rubber prices. When there was a drop in crude rubber prices the company which had a small inventory would be able soon to reflect this decrease in the price of its finished product. The other companies had to fall in line and absorb the loss. When the price of crude rubber went up, the company having the largest inventory was able to retain lower selling prices until it had exhausted its stock. In this case other companies, which wished to compete, had to retain these selling prices for a similar period and had to absorb the extra cost of the higher priced rubber. It is said that during the last ten years, five hundred million tires have been sold at no profit and the conditions referred to above are mainly responsible for this unsatisfactory showing.

The tire industry, being practically dependent on the automobile industry, has developed in step with it. Like the automobile business, tires were first manufactured by numerous companies. Gradually most of the smaller companies were absorbed by the larger companies or went out of existence in other ways. Today four companies produce two-thirds of the tires manufactured in

this country. Three of these companies' main factories are in Akron, Ohio, which is, of course, the center of the tire industry. The other company's main factory is in Detroit, Michigan. These companies have other factories in this country and in foreign countries. The placing of the main factories in Akron would seem to be rather a matter of chance than of design or necessity.

Manufacturing

Each of the factories of the big companies covers a considerable acreage and, when producing to capacity, each employs from 10,000 to 20,000 people. Owing to the fact that the business has grown from year to year, various factory buildings and their necessary equipment have been added from time to time. As a result of this gradual development the factory facilities vary to some extent. The most recently constructed buildings have been laid out with the view to permitting a continuous flow of manufacturing processes. The older buildings are not so well adapted to this purpose and it is necessary to make an increased use of conveyor systems and other methods of transporting materials from one process or department to another.

The manufacturing operations are departmentalized to a considerable extent, each department being in charge of a superintendent, manager or foreman.

Construction

Rubber gives flexibility to the tire, but, without additional strength, this flexibility would soon result in destruction of the tire in use. The additional strength is obtained from cotton cord and fabrics, hence the names "cord tires" and "fabric tires." In building fabric tires a square woven fabric was used. The cross threads in this fabric rubbed against one another and wore out, and, furthermore, the heat caused by the friction was detrimental to both rubber and fabric. It was mainly due to this cause that 3,000 or 4,000 miles was the maximum mileage obtained from these fabric tires and, if they were used on the present high-speed automobile, the mileage would be much less and driving would be very hazardous.

Today pneumatic tires are made up of a number of plies of rubberized cord fabric. The cords in this fabric run only one way and are held together by the rubber. A square woven fabric

is still used for the last ply of the tire, as it tends to distribute the load on the tire.

The importance of these cords and fabrics is seen when it is considered that the strength of the tire is dependent on their quality. Furthermore, the cost of fabric per tire is about equal to the normal cost of rubber per tire. The large companies have their own cotton plantations and textile mills for producing their own fabrics.

Some of the other raw materials used in manufacturing tires and tubes are compounding material, such as sulphur, zinc oxide, lamp black, solvents, etc.; reclaimed rubber; bead wire; solid tire bases, etc.

Crude rubber is usually stored in a darkened room or cellar, where the temperature is neither too hot nor too cold, as both light and extremes of temperature have bad effects on rubber. Cotton fabrics are best stored in rooms where the air is dry. The fabric has to be absolutely dry when the rubber is applied to it.

The departments in the processing division prepare the crude rubber and other ingredients for use in the manufacturing departments. Present consideration is limited to the tire industry, but it might be of interest to note that the operations described here are practically the same regardless of what the final product is to be. The operations in the manufacturing departments, of course, vary according to the product.

The first step in the processing division is the receiving and storing of rubber. The rubber is unloaded from the cars and trucked to the storage space, where any covering is removed. As has been previously stated, most of the rubber used today comes from plantations and, as this rubber has been washed before shipment, it can be used in the condition in which it is received. Only wild rubbers, poorer grades of plantation rubber and rubber for special purposes are washed.

When it is necessary to wash the rubber, it is passed between corrugated steel rolls over which water flows. By passing the rubber back and forth between the rolls and setting them closer and closer together, new surfaces are exposed and the dirt is washed away.

Before the rubber can be used for manufacturing, it must be dried. Various methods of drying are used. Under one method the rubber is hung in a room through which dry, warm air is

blown. Another method is known as the vacuum-drying process. A third method, which is now being more commonly used, is one where air containing some moisture is blown over the rubber. It is found that this latter method dries the rubber more quickly than dry air.

The rubber is now ready to go to the mixing and milling department to be mixed with the other compound materials. Owing to the consistency of rubber, it is a difficult ingredient to mix; therefore it is run through the mills several times to make it more plastic before adding the other compounds. In some cases a special machine, known as a plasticator, is used for this purpose. The mills used for mixing consist of two hollow iron rolls, one of which travels faster than the other. As already stated, the crude rubber is first run through these rolls, which tear and knead it. The various other ingredients making up the rubber compound, which have previously been carefully weighed and put in metal containers, are then added, until all are mixed together. In order to obtain a uniform mixture, the mill operator cuts diagonal strips of the compound from the rolls and puts them back in the mill at a different angle. During the mixing process considerable heat is generated and cool water is run through the rolls to prevent vulcanization.

In ordinary circumstances batches of from 250 to 300 pounds are mixed in a mill. Sometimes the mixing is done automatically in machines known as "Banbury mixers." In that case the batches average 750 pounds. These mixers are automatically timed, a dial indicating when each ingredient is to be added and showing when the mix is complete.

After the mixing is complete, the resulting compounded rubber is ready for its various uses, which are determined by the formula under which it was prepared. Some of it goes to the cement making department, some to the calendering department and some to the tread and tube departments.

In the process of manufacturing most rubber products, it is necessary to use rubber cements. These cements are made from compounded rubber to which are added certain solvents and then converted into a liquid form.

Some of the compounded rubber, which has been prepared in the mill room, has to be rolled into sheets or applied to fabric before it is ready for use in the tire-building department, bead-making department and other departments.

These operations are carried out in the calendering department. A calender is a machine having three hollow steel rolls set one above the other. When it is desired to "sheet" the compounded rubber, the rolls usually run at the same speed. The compound is fed in between the two top rolls which causes it to spread over the middle roll. It then passes between the two lower rolls and the thickness of the sheet is determined by the distance these rolls are set apart.

Before applying rubber to fabric, the latter is ironed and warmed in order to eliminate moisture and that better adhesion may result. The compounded rubber is fed in between the two top rolls and the warmed fabric between the two bottom rolls. In this case the middle roll travels faster than the bottom one, thus squeezing or "frictioning" the rubber into the fabric. Sometimes it is necessary to apply the rubber to both sides of the fabric and this is done by either rerunning it through the calender or by using a special dual calender.

The sheeted stock and the frictioned fabric, as they emerge from the calender, are wrapped in rolls of cloth to prevent the various layers from sticking together.

It was stated above that the fabric was warmed before it was fed into the calender so that better adhesion would result. For the same reason the rubber compound must be warm but must not be heated to such an extent that it begins to vulcanize. In these circumstances, the rolls are supplied with steam and water so that the temperature may be carefully regulated.

At the present time practically all pneumatic tires are of cord structure and it is, therefore, desirable to comment on the preparation of cord fabric. Some companies use a woven cord fabric, which is known as "woofless" fabric, as the cords all run the length of the fabric and only sufficient small cross cords are used to hold the other cords in place. When this kind of cord fabric is used, it is calendered in the same way as any other fabric.

A different procedure is used by other companies. The cords (about 1,600) run from spools and pass though a comb-like arrangement, which spaces them the proper distance apart. The cords then pass through a tank of rubber solution and from there over several heated rollers. The heated rolls dry and semi-vulcanize the rubber, which consequently holds the cords together and forms a rubber fabric which does not require any further processing before being used in building a tire.

Solid tires are gradually being superseded by pneumatic tires, but apparently they will be used for some time where heavy loads are to be carried and speed is not essential. Solid tires are built on steel bases or bands. The outside surfaces of these bands are grooved so that when the rubber is applied, it will make a sort of dovetail joint. The bands are first cleaned with a sand-blast and the polished surface is then covered with a thin coat of rubber cement to prevent oxidation. The bands are heated and are mounted close to a calender in such a way that sheeted hard rubber composition emerging from the calender is rolled directly on them and pressed into the grooves. Sometimes two lots of sheeted stock are applied. The first contains iron filings and adheres better to the band, and the second contains no iron filings and is of a composition which, when vulcanized, will not be as hard as the first sheet.

The band is now ready for the application of the tread. The tread may be applied in the same way as the hard rubber base, that is by using a calender and applying layer after layer of sheeted stock. One objection to this method is that what might be called the grain of the rubber runs straight around the tire and if the tire is cut, a strip is liable to be torn out of the tire when it is in use.

To eliminate this apparent defect, treads are "tubed." The rubber compound is fed into a tubing machine and a spiral in it forces the rubber out through a die. The die is in the shape of two treads, base to base, and therefore a double tread extrudes from the tubing machine which is cut or "split" by a wire. These treads are cut into proper lengths, the cut being made at an angle so that when they are applied to the bands, a better and stronger splice can be made. The advantage of this tubing method is that the spiral causes the grain of the rubber to be circular and, if the tire is cut when in use, the cut will not spread.

After the tread has been applied, the tire is ready to be vulcanized or, as it is more commonly called, "cured." The tires are placed in steel molds, in which the tread design has been cut, and the molds are lowered into a vulcanizing pit. The molds are heated by steam, while hydraulic pressure forces the rubber into its proper shape. After the heat has been applied for a specific time, the tires are vulcanized. The molds are taken from the pit, cooled, the tires removed, trimmed and inspected, and they are then ready for delivery or storage.

Pneumatic tubes are manufactured by various processes. One process is known as the straight pole-laminated process, in which the rubber stock is rolled on straight metal tubes, wrapped and then cured on these tubes. Another process is known as the curved pole-tubes process. The stock is put through a tube machine, blown on curved poles, cured and then blown off the tubes. The subsequent operations in both the above processes are the same. The tubes are cut to length, the ends skived, a hole is punched for the valve, the valve is inserted and the ends are cemented and vulcanized on a special machine. The tubes are now complete and after being given a water test, they are packed in cartons or, if they are for automobile manufacturers, they will be put in casings.

Another method of manufacturing tubes, which is now commonly used, is the molding method. The rubber compound is put through a tube machine and the continuous tube that emerges thereform is cut into lengths, valve inserted and ends are joined before curing. The tubes are placed in individual vulcanizers, which also act as molds, and are then inflated and cured. These vulcanizers work automatically, being timed to open and close so that the proper time is given to vulcanization.

Pneumatic casings are the most important item produced by a tire manufacturing company. They are displacing solid tires more and more each day and are much more costly to make than tubes. In describing the operations necessary to produce a finished casing, it is impossible to cover these operations in proper sequence. Different parts are prepared in various departments and these are subsequently conveyed to the tire building department.

The rolls of fabric stock, as they come off the calenders, are sent to the stock-preparation department, where they are to be cut into strips of the proper size to be used as plies on the tire. The fabric stocks are cut into strips on machines called "bias cutters." The fabric comes down over a roller and a long knife placed at an angle of 45 degrees makes the cut, the machine being set so that each cut will be a specified distance from the preceding one. As a result of making the cut at an angle of 45 degrees, the cord in the strip of fabric is diagonal and this adds greatly to the strength of the strip and the tire.

Most of these strips are used for plies on the tire and, when such is the case, they are usually cut to length and the ends joined,

thus forming a "band." Some go to the bead department for use in building the bead.

In the tread department the rubber compound, received from the mill room, is first warmed and then is put through a tube machine, from which it emerges approximately the size and shape of the finished tires. The tread is cut to proper length, the cut being made at an angle, and it is then "booked," that is, each tread is separated by cloth to prevent sticking. The treads are now ready to be sent to the tire-building department. Sometimes the tread is applied to thin sheeted stock, known as a "cushion" before being cut into proper lengths.

In the tire-building department two methods of construction are in use. The larger sizes of tires are built on iron cores, which are the size and shape of the inside of the tire that is to be built. The smaller sizes are built on a flat drum and are subsequently drawn into shape by a machine using a vacuum. The operations and component parts used in both methods are practically the same. More plies are put on the larger tires and they are usually applied in the form of a band, whereas on the drum they are applied as strips and then joined.

All the parts for building the tire are placed conveniently for the builder. He first takes a band of the rubber-impregnated fabric and fits it evenly over the core. Over this he places another band with the cord running at right angles with the first. This operation is continued until the required number of plies has been applied. During this operation, the bead is inserted, usually after half of the plies are on the core. Strips known as "chafing strips" are put on the sides to protect the bead and a breaker strip of square woven fabric is put over the last ply. The tread is then applied and joined, and finally come the side walls.

The building of the tire now being complete, the core (or drum) which is collapsible, is removed, the tire is inspected and then conveyed to the curing room.

The operation of curing or vulcanizing a pneumatic casing is similar to that described for solid tires, except that it is necessary that an air bag be inserted in the casing and inflated before it is put in the mold. After the casing is cured it is trimmed, inspected and flap is inserted. Tires for the retail trade are wrapped by means of a patented machine and then stored, but if the tire is for an automobile manufacturer, it is usual to insert a tube and partly inflate it.

In the above description reference has been made to flaps, air bags, beads and valves. All of these except valves, which are purchased, are usually manufactured by the companies in special departments.

In storing the finished product, some consideration has to be given to atmospheric conditions, which must be temperate. The air must also be free from chemical elements that may be deleterious. The tires are piled up row upon row, each row being placed so that the center of the tire is over where the two tires below touch. This is called "lacing" and makes it almost impossible to upset the pile.

In the manufacture of tires, the control of production plays an important part. Production should be planned ahead and must be in keeping with sales. The first thing, therefore, that must be done is to make a careful estimate, in units, of the next twelve months' sales, basing this on the prior twelve months' experience and taking into consideration the current business conditions. Next an estimate is made of the inventory, which should be on hand at the end of the period. By taking into consideration the inventories at the beginning and end of the period and the estimated sales during the period, the estimated production for the twelve months is obtained. In order that efficient use may be made of plant facilities, the total production is equalized by months, as nearly as possible, care being taken, however, that seasonable fluctuations shall not reduce the inventory below a margin of safety. Adjustment will, of course, have to be made from time to time in the production schedule, if sales and conditions do not conform with forecasts.

On the basis of the monthly production order and with the use of formulæ, the amount of raw materials, etc., required each month can be determined and instructions can be issued to the purchasing department as to the amounts of these materials which are to be ordered.

The purchasing of the chief raw materials has to be in the hands of experts. The large companies have representatives in Singapore, London and New York, who keep in close touch with the rubber market. Apparently there is very little "hedging" of rubber purchases. A great deal of the cotton for fabrics is grown on the companies' own plantations and experts have to grade this cotton and supervise any purchase from outside growers. Particular care must be given to the purchasing of other

compounding materials and they are continually subject to analyses and tests.

Perpetual inventory records are kept of all raw materials. The records of crude rubber are kept by grades, but they are usually further subdivided into lots in order that information may be available of the shrinkage resulting from washing and cleaning. Shrinkage in other raw materials is also an important factor and is recorded at the points where it occurs in the various factory operations.

Manufacturing Costs

A standard practice of cost accounting has been formulated by the Rubber Association of America, Inc., and this practice is followed fairly closely by the large companies. This costing procedure covers all rubber products, but only that part relating to tires and tubes is of interest here.

As has been shown, the manufacturing is done departmentally and the costs are kept on this same basis. It follows, therefore, that the costs of a finished product of one department may be the material cost of another department. Consequently, the original raw materials soon lose their identity. Material costs are also somewhat complicated as the result of wastes and shrinkages in various departments.

A unit cost per pound is obtained for the cost of unloading and storing and this is added to the invoice price of the rubber and the rubber is transferred to the washing and drying department at this cost. In the latter department the cost of washing and drying is added and a unit cost per net pound is obtained. The mixing and milling department is charged with the crude rubber at this unit cost and is also charged with the costs of compounds at a unit price, including cost of sifting, weighing and shrinkage. The mixing and milling department obtains a unit cost per net pound of compounded rubber, which is the cost at which it is transferred to other departments. The same procedure is followed in each subsequent operation.

The labor costs are greatly simplified by the fact that all labor is on a piece-work basis, though of course, to arrive at piece-work rates, considerable labor is involved in making scientific time studies.

So far as possible, expenses are charged directly to departments. Where this can not be done, the expenses are first ac-

cumulated and then distributed on some equitable basis, such as meter reading, engineers' estimates, number of employees, floor space, etc.

The overhead expenses of each department are applied as a percentage of direct labor, except as hereafter described. In the mixing and milling department and the calendering department, expenses related directly to the mills and calenders, such as cost of repairs, depreciation, power, insurance, taxes, etc., are applied on a machine-hour rate basis. In the curing department, two bases of distributing overhead are used. Depreciation on molds and the cost of air bags is applied to the cost of the product by specific application and all other expenses are distributed on a heater-hour rate.

Depreciation of the various fixed assets is based on an annual rate and is charged on the straight-line method directly to the productive and non-productive departments. The latter includes depreciation on buildings, building improvements, etc., which is charged to a fictitious department set up and termed, "general plant department." Owing to the rapid development of the tire industry, with the consequent changes in equipment, obsolescence is often a major factor in determining depreciation rates. Rates are determined from past experience and forecasts of the future. Adequate records are maintained and frequent inspections are made so that rates may be adjusted when conditions warrant such adjustments.

The cost of major replacements and renewals and the cost of new equipment, if replacing similar equipment, is capitalized and the cost of the asset which the replacement or renewal supplants is credited to the asset account, and the reserve for depreciation is charged for the amount of accumulated reserve. The difference between the depreciated value and salvage value is charged or credited to profit-and-loss account.

Repairs to plant and equipment, etc., are undertaken by the company's own maintenance department. Estimates are made of the cost of repairs before they are authorized, in order to determine whether the expense is warranted or it would be more economical to replace the item.

Detailed plant ledgers are maintained either on cards or loose-leaf ledgers. It is usual to designate plant items by numbers and to arrange them departmentally so that the monthly charges to each department can be readily determined. Where items are

moved from one department to another, transfer orders are issued and the costs of making the transfer are charged to the current operations of the department to which they are transferred.

Charges to the plant ledger include prime cost, transportation charges and cost of installation. If the installation is done by one of the company's own departments, a fair proportion of that department's overhead is included.

A summary of the annual depreciation rates recommended by the Rubber Association of America, Inc., is as follows:

	Per cent.
Land appurtenances	5 to 10
Buildings:	
Buildings	2 to 5
Stacks (brick)	3
Stacks (steel)	10
Bins (concrete and brick)	5
Bins (wood)	20
Building equipment	4 to 10
Office furniture and fixtures	10, 15, 20, 25
Machinery and equipment:	
Machine shop	8, 10, 15
Rubber manufacturing machinery	10
Plant and miscellaneous equipment	10 to 100
Power plant	6.67
Automobiles	50 first year 25 second and third years
Molds, cores and poles:	
Tube poles and curved mandrels for tubes	20
Flap molds	50
Tire molds:	
Solid tires	33.33
Pneumatic	50
Miscellaneous dies and molds	10 to 100

Payments of royalties are made for the use of patented machines. These royalties are usually charged as a separate item of cost to the department using the machine or patented process.

Distribution and Sales

Having produced tires, it is necessary to sell them or perhaps it is better to say that if they can be sold they can then be produced. Owing to the extensive territory covered by the large companies and the intensive and bitter competition, the sales organizations and expenses are quite large and costly. The sales

division is made up of a large organization at the company's head office, and each branch has its own organization. One company has over seventy branches in the United States and thirty branches in foreign countries. The head office propounds all company policies as to sales, advertising, etc., and the branches carry out these policies and make most of the direct "contacts" with the trade.

The sales organization is divided into departments, which, to a certain extent, conform to the classification of sales. The sales are classified as to kinds of tires such as:

(a) Pneumatic casings and tubes,
(b) Truck casings and tubes,
(c) Solid truck tires.

The above classifications are further broken down into the various types of customers as follows:

(a) Manufacturers (automobiles and trucks)
(b) Mail-order houses
(c) Subsidiaries
(d) Dealers
(e) Export

Sales to manufacturers of automobiles and trucks, mail-order houses and subsidiaries are usually handled by the head office. The trade with the automobile manufacturers is probably the most competitive field in the tire industry. It represents approximately 30 per cent. of the industry's output and in all probability little profit is made on this division of the business. However, it is considered a good form of advertising, as it is expected that, when replacements are necessary, the individual car owner will have the tendency to purchase tires which will match those already on his car. Consideration must also be given to the fact that, although no book profit may be realized, a certain amount of overhead and fixed charges is absorbed by these sales.

In recent years considerable numbers of tires have been sold by mail-order houses. These tires are manufactured for them by the various tire companies in accordance with the specifications of the mail-order house, which include special styles of tread and their own trade name. Only a small margin of profit on these sales is realized by the company manufacturing the tires and, owing to the small margin of profit at which they are resold by

the mail-order house, it would appear that the development of these sales has had, on the whole, a detrimental effect on the tire industry.

The large companies restrict their sales almost entirely to the wholesale trade. However, a considerable volume of retail business is done through subsidiary companies. This retail business has recently expanded, particularly in what are known as "one stop" stations. These stations not only sell tires but automobile accessories, tire repair service, gas and oil, etc. The companies have different policies regarding the operation and ownership of these stations. In the case of one company, they are owned and operated in their entirety by a subsidiary and the latter is entirely owned by the parent company. In another case, the manufacturer owns 51 per cent. of the individual station and establishes its operating policies. The dealer owns the other 49 per cent. and is actively in charge of its operations.

Replacement sales represent approximately 65 per cent. of the total sales volume and it is through these sales that the company expects to realize the greater part of its profit. As has been indicated, part of the replacement requirement is filled by mail-order houses and subsidiary companies, but the major part is handled by dealers. The company's branches sell to the dealer at wholesale prices, the trade discount allowed him off list-prices varying according to the product but averaging about 30 per cent., and in addition he is given a volume bonus. This volume bonus has the tendency to restrict his activities to one make of tire.

The usual terms on which the tires are sold to the dealer are thirty days net or 2 per cent. discount for payment within ten days. The dealer, in selling the tires to the retail trade, allows discounts in some cases. Under normal conditions the maximum discount allowed to the retail trade is two tens off list-price, and this maximum is only given to national organizations which operate large fleets of trucks and cars.

Export sales represent approximately 5 per cent. of the total sales volume. There is a decreasing tendency in export sales because of prohibitive tariffs, but this situation is being offset by the construction of foreign branch factories.

Large appropriations are made for advertising; and practically all forms are used, including radio, magazines, billboards, car cards and sundry pamphlets and other literature. Most of the advertising is the direct expense of the manufacturer, but in the

case of special localized campaigns, it may be carried out on a coöperative basis whereby the dealer bears a part of the expense.

Owing to the large territory covered and constant developments in the automotive trade, statistical and other information is essential, and the research and statistical department is an important adjunct to the sales division. Some of the data it must compile and keep up to date are as follows:

Automobile industry:

As sales are dependent on the automobile industry, it naturally follows that all possible information regarding this industry must be available. The most vital statistics are the records of car registrations by states, which are broken down into classes, models, etc. These data are valuable in forecasting replacements and fixing sales quotas. Automobile companies' production schedules, sales, forecasts of future business, changes in styles, speed, etc., are valuable in forecasting the tire industry's production, and in addition are very useful in the sale of original tire equipment to the automobile manufacturer.

Gasoline consumption:

Statistics of the gasoline consumed by each class of motor vehicle during a given period form a basis for determining the mileage cars have run and are one of the factors in estimating replacement requirements.

Miscellaneous:

Improvements in roads affect the tire industry in two diametrically opposite ways. They cause a decrease in the replacement demand as the wear per tire-mile is decreased, but this is offset to a greater or less extent by the fact that improved roads result in increased mileage per auto but more particularly in increased 'bus and truck transportation. It follows that data regarding road improvements must be kept but must be used in conjunction with other statistics and surveys.

Distribution and Sales Costs

Owing to the keen competition and the large territory covered, the cost of selling and distributing is no inconsiderable item. Furthermore, it will vary considerably according to the style of tire, i.e., truck, 'bus and automobile; and class of customer, i.e., manufacturer, mail-order, dealer, export and subsidiary. As an

example of this variation let us take merchandise-distribution expense, part of which will be chargeable against all classes of sales, whereas very little advertising expense is chargeable against sales to auto manufacturers, mail-order houses and special brand sales.

In such circumstances, selling and distributing expenses are prorated to departments, which conform with types of products. In the larger manufacturing companies, the departmentalization of expense can be carried out quite extensively, with the result that distribution of each department's expense on the basis of per-dollar sales will give more or less accurate classified costs.

Administrative expenses are departmentalized to various extents according to the requirements of the company. The cost of the administrative departments is distributed on the basis of net sales dollars.

Financial Accounting

The general financial records of a tire company do not differ to any great extent from those of any other manufacturing business. It seems hardly necessary to state that all the departmental costs and expenses that have been referred to are recorded in subsidiary ledgers and that these records are represented by control accounts in the general books. The transactions of factory departments are recorded in the factory ledgers, which are represented by the factory-ledger control in the general ledger. The factory-ledger control is charged in total with cost of materials, supplies, labor, and all direct and indirect manufacturing expenses and these items are entered departmentally and in detail in the factory ledger. In a like manner, the account is credited with the actual cost of finished products, the cost of items which are to be capitalized, expenses which are to be deferred, cost of work done for the selling and administrative department, etc. After these entries have been made, the balance in the account represents the value of work in process and, of course, it should be in agreement with a trial balance of the factory ledger. Physical inventories of work in process are taken periodically and the factory ledger control and the factory ledger accounts are compared with them and adjusted, if necessary.

The departmental expenses of the selling and administrative departments are similarly recorded in subsidiary records with control accounts in the general ledger.

In making an audit of a tire company, one of the most important things to be considered is the examination of the inventory. Particular thought will have to be given to the market price of crude rubber and textiles, not only as to their effect on the valuation of the raw materials, but also as to their effect on the value at which these materials are included in finished products and goods in process. Comparison of market prices of crude rubber and textiles should be made with the prices at which commitments have been made for the future delivery of these materials. It would seem advisable that if the market prices were less than the commitment prices, a reserve should be set up for the difference, in order that the subsequent operating period may be relieved of any cost in excess of that at which the materials could be bought for spot delivery.

In the past, the wide fluctuations in the market prices of rubber have been immediately reflected in the selling prices of the finished product. A close examination should, therefore, be made of the finished-goods inventory prices in order to ascertain that they will permit a fair margin of profit.

A scrutiny should be made of all contracts with dealers or other customers with a view to ascertaining any liabilities, direct or contingent, that may exist. It should be seen that adequate reserves are set up for cash discounts, trade discounts, freight allowances, rebates, volume discounts, guarantees, price declines, etc. In the Rubber Association's balance-sheet, these items are apparently included under the title, "reserves for bad debts, etc."

Particular thought must be given to the depreciation of the fixed assets. Owing to the rapid and continuous development of manufacturing methods, the effect of obsolescence and inadequacy of equipment must be given full weight. Where rates of depreciation are based on normal operating conditions, the conditions prevailing during the period under review should be investigated. If the operating hours are in excess of normal, an increase over the normal rates of depreciation should be considered.

Future of the Industry

To attempt any definite forecast of the future of the tire industry would, of course, be absurd. However, one may reach an opinion of the future if a study is made of past experience, present conditions, trends, etc. It has been stated that the tire

industry has made no net profit during the last ten years, and it might be well to review the causes to see if they are now eliminated. The two chief causes were the wide fluctuations in crude rubber prices and keen and bitter competition.

One reason that the fluctuations in crude rubber prices so greatly affected the companies was the fact that production methods called for a six months' supply to be on hand. These requirements have now been reduced to a supply for two or three months so that the danger of loss from this source has been greatly reduced. It is estimated that the present sources of rubber can produce crude rubber much in excess of the demand, and it does not appear probable that the price of rubber will be such a vital factor as it has been in the past. Of course, the control of this product is still in the hands of foreign countries, which can raise the price by artificial means, but it is not probable that they will resort to this procedure after their unfortunate experience with the Stevenson act.

Competition has improved in some ways. The number of competitors has been reduced through mergers, etc., and it is predicted that more mergers will shortly take place. This should result in making competition more business-like. That keen and unbusiness-like competition still exists was recently shown by a drastic price-cutting war. However, it may be that the effect will be beneficial, as it has probably brought the large companies to the realization that their competitors are too large to be overcome by such tactics and that the main result is large losses to all concerned.