lot of one thousand pounds of a certain rubber, and that we are called upon to supply at intervals the same product. We may have exhausted one or all of the original raw materials. Let us assume that it is the vermilion only which has been exhausted. We find it necessary to purchase a new lot. Will it adequately serve our purpose? If we submit it to a chemical test the chemist's report may advise us that we have purchased mercury sulphide (HgS); that in it there is no free mercury, no free sulphur, no trace of anything deleterious, and only a minimum of moisture; apparently a satisfactory purchase from the chemical standpoint of composition. But this same report would have been rendered whether the sample tested had been black mercury sulphide or the more familiar orange or deep red vermilion, so that a chemical test in such a case is wholly inadequate to determine the usability of the new purchase. There is a test, however, to which the raw material may be subjected that will unfailingly determine whether it should be accepted or rejected, and that is the practical one of how the material actually behaves when incorporated in the product in which we intend to use it. To judge this satisfactorily we cannot, however, go on successively comparing the last lot received with the immediately previous purchase. On such a basis of comparison one might start with a brilliant orange and finally arrive at a deep red or black. If materials were selected on such a basis the only hope of detecting the error would lie in the customer, who might be in possession of an earlier specimen of the product in which a different lot of material had been used and therefore in a position to make direct comparison. Consequently we set aside from any originally accepted product, i.e., the first lot manufactured, a sufficient quantity of the product as a standard sample against which subsequent comparisons can be made. When the first manufactured lot of a compounded product is made, a sufficient quantity of each of the raw materials entering into the product is also retained as a standard of acceptable character. In the case of the vermilion cited, we would have set aside a quantity of this material from our first manufactured lot, so that for the fifth, sixth or any subsequent lot or batch of the product to be manufactured we could compare the raw material then available against the standard which we had selected. These samples of the finished product or of raw material so set aside we designate as "history samples." On any complaint or disagreement as to quality we can make a direct comparison of the history samples in our hands, which have been maintained under reasonable storage conditions, against any complaint sample submitted, with the full assurance that the aging factor, since it would be the same in both cases, can in no way influence our judgment in any comparison we might make. In order to know with which history to compare any product under investigation each and every unit package carries a lot number on the box in which it is packed. The manufacturing history card to which this lot number refers shows clearly the raw materials that were used, the formula composition, the processes of manufacture through which the product passed and the workmen who were engaged in producing it.

Each of our raw materials as it is received is given an identifying lot number. A separate stock sheet is made out which is debited with the material received, when this has passed the necessary tests and has been accepted for use. The stock sheet is credited with such raw materials as are withdrawn for manufacture and each credit entry shows the disposition of the stock. This system has the added advantage of acting as a perpetual inventory, subject to frequent physical check-up as the individual lots of raw materials are exhausted.

The time at my disposal prevents my going into details in regard to the method of testing raw materials, but as this in essence is practically identical with the plan employed in checking each manufactured lot produced, I will cover this phase of the subject only.

Let us assume that we are ready to manufacture, say, the twentieth lot of a certain red rubber. We assure ourselves from our stock records that we have on hand sufficient quantities of each of the necessary raw materials of tested lots to produce the desired quantity of the product required. The formula for an initial manufacturing batch is then entered on a production card and carefully checked. The lot numbers of the various raw materials used are indicated. The workman weighs the necessary ingredients and compounds them, or mixes them together. When this initial batch, which we will assume to be one hundred pounds, has been completed, a sample is selected from it and a sample from the history file of the previous

lot manufactured is also taken, together with a sample from the standard or original lot manufactured. These three samples are put through the same process of vulcanization and finishing that will be followed by the customer in using the product. If this trial batch of the new lot of rubber to be manufactured compares, within established tolerance limits, with the previous lot manufactured and with the standard, the initial batch of the new lot to be manufactured is approved and the mixer can then proceed with confidence to use the raw materials at his disposal in accordance with the formula given. If any adjustment is necessary to maintain the new product within reasonable limits of the standard, it is made at this time. Manufacture does not proceed until such approval has been given. Subsequently, as each one-hundred-pound unit batch is finished, a sample is selected from it, and when all the units required are completed these samples are all vulcanized and completely finished at one time under identical conditions, which conditions are exactly those the customer should employ, in accordance with our directions, to obtain the most satisfactory results. A careful examination and test of these finished pieces determines beyond question whether the quality has been maintained or not, and no question is thereafter admissible on this point. The quality is there and we know it. It has been tested in a direct, practical way and we can confidently market the product knowing that it has fully met the specifications and that it will do what we claim for it.

In another type of manufacture, dealing with mechanical devices, tools or appliances, in which the factor of interchangeability plays a part, I will trace briefly the several steps we believe it necessary to observe in order to lay a proper foundation for maintaining quality production. First an idea is suggested, sometimes accompanied by a sketch, a sample or an inventor's model. This may originate within the company or be presented for consideration from some outside source. The first point to be determined is whether the idea is of such a nature that it will fit into our scheme of manufacture or merchandising. We must determine whether it has merit and whether we want it. To settle this question we have an authorization committee consisting of the president of the company, who views the matter from a general policy standpoint, the vice president in charge of sales and the vice president in charge of production; each considers the project from his respective angle. The treasurer of the company is also a member of this committee and our patent attorney is present at all meetings. A favorable decision by this committee authorizes the issuance of a development order which turns the project over to our engineering or research force.

In the next step, design is completed and a developmental model is made. During this stage the design is changed as often as necessary and the model is altered and refined until it fully meets all the requirements. When this has finally been accomplished it is approved. The authorization committee again reviews the matter and if satisfied authorizes production. This act makes the article from this point a regular product of manufacture and sale.

Production drawings are then made and finished parts, from which a shop model is constructed, are produced. Following actual production, certain refinements may appear desirable and workable tolerances be established. Finally, we arrive at standardized production drawings, supported by a complete, finished manufacturing model. This, then, is "the law and the prophets." No changes in standardized production limits are permitted except upon the approval of the dimension and inspection divisions. No changes in material, design, construction or finish are permitted without the approval of the research and development divisions.

These are the principles involved in quality maintenance, and growing out of them we have our model room, our photographic department for visually recording all standards and all changes, and our blue print system, which is a very important link in the chain of quality production.

All blue prints are from tracings of the standardized production drawings, and are made in sufficient quantities to be distributed to each department involved in the manufacture of any particular product. They are of a standard size, uniformly bound, and a record is kept of every outstanding print. Before any new lot of manufacture is started all prints pertaining to it are recalled and are stamped with the date subsequent to that on the order authorizing manufacture. This insures the incorporation of any authorized changes, in limits or design, which may have been made since the previous lot was manufactured. Such changes ap-