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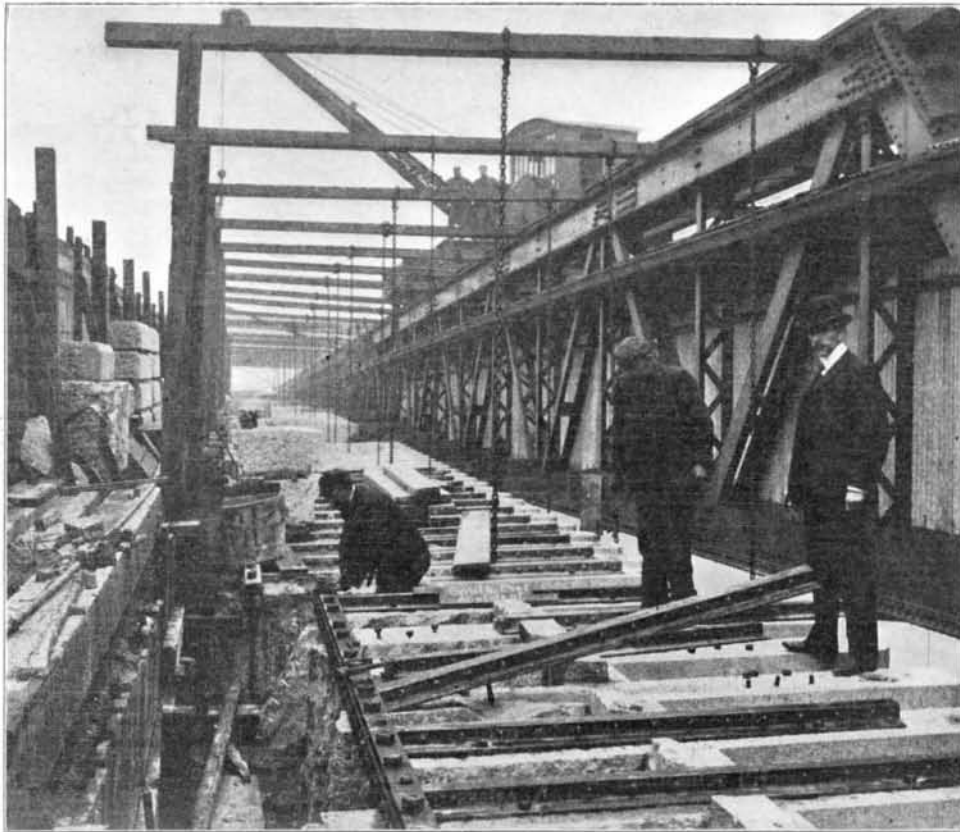
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### THE WIDENING OF LONDON BRIDGE.\*

By HAROLD J. SHEPSTONE.

AN interesting and at the same time difficult piece of engineering work now being carried out in London is the widening of London Bridge. For years it has been apparent to the authorities that this classic structure of Rennie is insufficiently wide for the heavy traffic it is called upon to carry. Indeed, for its size it is without question one of the busiest bridges in the world. On an average over 120,000 foot passengers and 25,000 vehicles cross it every twenty-four hours. True, a greater number of pedestrians as well as vehicles pass over Brooklyn Bridge in a like period, but it must be borne in mind that London Bridge is only 53½ feet wide between parapets, whereas its American rival has a breadth of 85 feet.

It was hoped when the Tower Bridge was erected, only a few hundred yards lower down the river, at a cost of over \$5,000,000, that it would relieve the traffic of London Bridge; but, as in all great cities, to make a new bridge useful, new roads leading to it must be constructed, and these in turn call for new shops, railroad stations, theaters, places of business, exchanges or other creators of traffic. In the case of London Bridge, the

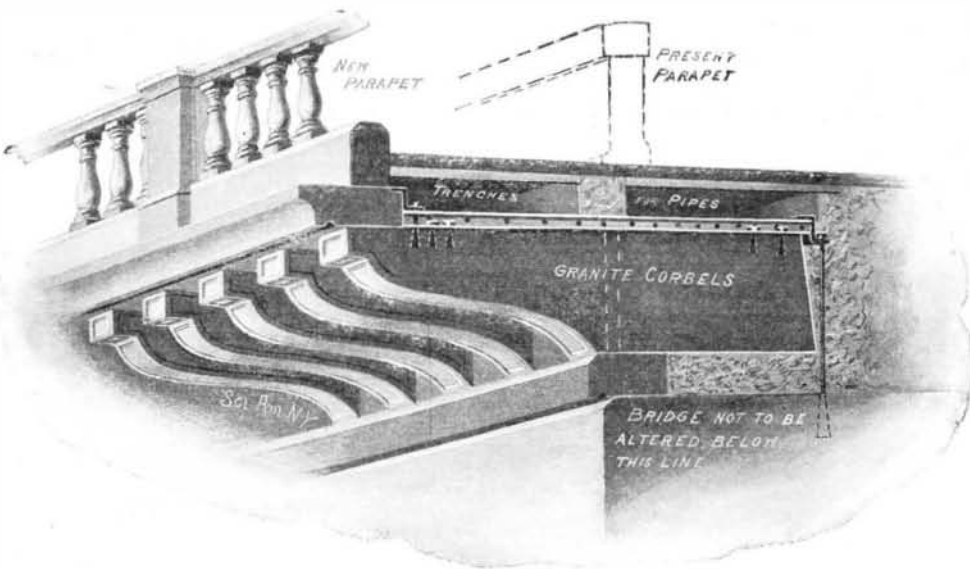


HOW THE CORBELS ARE BOLTED IN PLACE TO THE CHANNEL IRON ROD EXTENDING THE LENGTH OF THE BRIDGE.

pedestrian traffic is more inconvenienced than the vehicular traffic, chiefly because it is more difficult to marshal, and some three years ago the Bridge House Estates Committee of the Corporation of London decided to widen the footpaths.

The manner in which this work is being carried out is interesting on account of the stringent conditions under which the contractors have had to carry on their task. First of all, neither the pedestrian or vehicular traffic over the bridge, nor the traffic in the river, was to be interrupted. The committee further stated that in erecting temporary footbridges—which was a necessary feat seeing that the passenger traffic was not to be interrupted—"no scaffolding or staging in the line of the waterways or archways of London Bridge will at any time be permitted." It was also most essential that the finished structure should possess some architectural beauty. Two designs for widening the bridge were submitted to the committee, one by means of cast-iron cantilevers and balustrade, the other by adopting granite corbeling or cantilevers and an open granite balustrade. The granite scheme was decided upon, and in April, 1902, work was actively commenced.

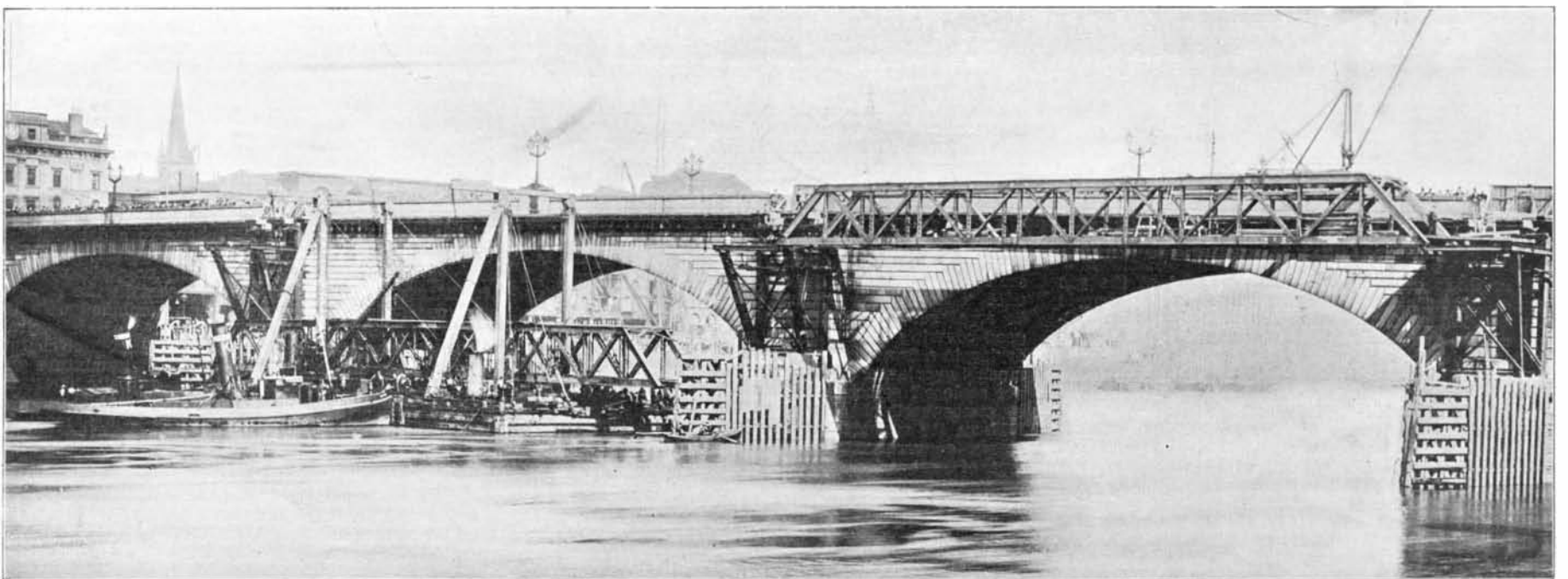
First of all, steel temporary footbridges were erected. They rest upon supports built up on the cantilevers of the piers of the main structure. There are two vertical



THE SCHEME FOR WIDENING LONDON BRIDGE.



ANOTHER VIEW OF THE CORBELS.



LIFTING THE STEEL GIRDERS INTO PLACE FOR THE TEMPORARY FOOTWAYS.  
THE WIDENING OF LONDON BRIDGE.

steel pillars 25 feet high, with two corresponding inclined supports which rake from the top inward toward the bridge. These four columns, suitably joined together, form cantilevers, resting on the projecting stonework of the bridge piers; while steel shoes, bedded in the granite masonry by concrete, are placed to distribute the pressure due to the weight. These bridges are placed sufficiently far away from the main structure to permit of the widening, and are tied together by steel ties, 12 inches wide and 1 inch thick, which pass under the roadway. In this way one bridge supports the other. The ties, of course, are carried right through the bridge.

Each of the temporary bridges consists of five spans, one of which is 157 feet, 7 inches in length, the four others being 145 feet, 5 inches long. The erecting weight of the largest span was about 75 tons. The method of lifting them into position was as follows: The span was built up upon a large pontoon which was moored near the site, then towed by tugs to the bridge, placed in the right position, and lifted on to the cantilever piers by means of four vertical derricks. The time actually occupied in placing a span was from fifteen to twenty minutes. It was no easy task; the tide at this particular spot runs at the rate of about four knots per hour. Not only do these spans supply the temporary footpaths, but they also serve as a track for four electric jib traveling cranes, two on each track, used for the demolition of the old work and the erection of the granite corbels, parapet, etc. In order to shut off the working of the cranes from the pedestrians, a galvanized roof has been built over the temporary footpaths, thus making a covered gallery right across the bridge on each side. These covered crossings are 12 feet wide and 12 feet high. At night they are lit by electric light.

As soon as these footpaths were ready, the footways across the main structure were closed. These were originally each  $9\frac{1}{2}$  feet wide, but when the new scheme is completed they will each be 15 feet wide, making a total additional width to the bridge of 11 feet. As already stated, this is being obtained by building out from the main edifice granite corbels which will support the new footpaths. They will project from six to seven feet over the existing masonry. On the outer end of these corbels will be constructed an open granite balustrade. Some 650 corbels are required in all, and over 600 are already delivered ready for setting. They have a length of 10 feet, 6 inches, are 3 feet, 3 inches in height, and vary from 15 to 18 inches in thickness. They are each tested to a 4-ton load, and it is interesting to note that a pressure of from 50 to 60 tons applied at the outer end is required to break them. They are laid about 18 inches apart, and firmly bolted into position by lewis bolts attached to a channel iron running across the whole length of the bridge, the lewis bolts going down into the existing masonry for a depth of 3 feet. After the corbels come the cornice, then the pinth, the balustrade, and coping. Some 1,600 balusters will be used in the work, each 2 feet, 4 inches high. The total height of the new parapet will be 4 feet, thus affording the pedestrians a clear view of the river and the shipping. It will give the bridge quite an artistic finish and will be an agreeable change from the closed parapet of the old design.

The granite that is being used in widening the bridge is being obtained from the same quarries that supplied the stone of which the bridge was built over seventy years ago. These are the famous Dartmoor quarries, which have been worked without any interruption for fully a century. For the past twenty-five years Messrs. Pethick Brothers, the well-known contractors of Plymouth, have held the lease of the land and have the right of quarrying over a thousand acres. The work of widening the bridge is being carried on for the City Corporation, Mr. E. Cruttwell, M. Inst., C. E., being engineer, and Mr. Andrew Murray, F. R. I. B. A., architect. The cost of the contract is put down as slightly over \$500,000, and the work is to be completed by next spring.

Of London Bridge and its predecessors much could be written. For ages it was the only crossing place of the tidal waters of the Thames. The first wooden bridge, built in 1008, was destroyed by storm and flood in 1090, while in the reign of Stephen a second wooden bridge perished by fire. Then, in 1176, was begun the first stone bridge, its erection occupying a period of no less than thirty-three years. During its long life of 750 years it had many strange and weird associations. Heads of rebellious leaders were placed upon its gates. Once a fire broke out at one end, and when the bridge was swarming with spectators the flames were carried by the wind to the other end, so that the crowd was trapped and 3,000 were burned or drowned. As early as the eighteenth century, the authorities were spending from \$10,000 to \$15,000 annually in keeping the bridge in repairs, but to no purpose, as the structure had become absolutely ruinous. In 1823 Rennie began the present bridge, which was built one hundred yards higher up the river than the old one, and was completed eight years later.

## COAL-TAR OILS IN THE MANUFACTURE OF PAINT AND VARNISH.

By DR. OSKAR MARKFELDT.

THAT thick black fetid liquid produced at the gas houses and coke ovens, and known under the generic term of coal-tar, is the basic material from which almost all the artificially prepared organic dyestuffs now in use are derived.

Placed in a huge iron still, holding as much as 25,000 kilogrammes, it is subjected to the direct heat of the fire and distilled, giving off besides ammoniacal water or liquor, a number of more or less volatile oils, from which by further scientific treatment the real raw materials are gained, which yield the very valuable and most brilliant and beautiful coal-tar dyestuffs, and better still the aniline colors.

By far the most valuable distillate from coal-tar is the so-called "light oil," meaning not heavy. From this, by means of a repeated distillation in smaller wrought-iron retorts holding from 2,000 to 2,500 liters, but in other respects the counterparts of the large

stills, benzol, better known as benzene, is freed from the tarry substances that were carried over with it in the first distillation, by being subjected to the direct heat of the fire. Benzene thus obtained is far from pure; it still contains the similar though less volatile compounds toluol and xylol, besides several other bodies in smaller proportions; further, it contains also acid constituents (such as the phenols or carbolic acid and its homologues) and bases. To remove these, the benzene is subjected to a washing process by agitating it with soda-lye to dissolve out the phenols, which uniting with the sodium of the lye form a salt and pass over into the aqueous caustic soda solution. Having absorbed the phenols, and thereby becoming of a greater specific gravity, the soda-lye settles to the bottom of the vessel while the benzene floats. The two are now mechanically parted by drawing off the benzene, which is again washed with an inorganic acid; in most cases, sulphuric acid of 1.3 sp. gr. is used.

After strenuous stirring for about fifteen minutes, the mixture is allowed to stand for an hour or two. The precipitates which are the acids containing the bases, are now removed and subjected to the pyridine treatment.

There yet remain in the benzene certain so-called unsaturated compounds, such as hexene and its homologues, which must be dissolved out by the use of stronger sulphuric acid solutions. After this operation, and in order to dispose of the excess of acid particles, the emulsion is washed several times with water, very weak soda-lye, and again with water; and now for the third time the benzene is thrown into a retort with a steam jacket and redistilled.

Two grades of benzene are common in the trade; the so-called 90 per cent benzene, which represents a product of which 90 per cent of its volume can be distilled over at a temperature of 100 deg. C.; and a 50 per cent benzene, of which only half its volume can be driven over under the same conditions. The first of these grades, because it is the oftenest employed, claims our attention particularly, since only this grade is used in the manufacture of varnish, chiefly in the making of the cheap asphalt varnishes. These cheap varnishes are extensively consumed in the iron industries and form a very serviceable substitute for the much dearer asphalt varnish, made from natural asphalt dissolved in oil of turpentine. Though the manufacture of these cheap iron varnishes is *per se* a very simple process, yet there are moments in the operation when considerable care must be exercised. It is no secret that the base of these cheap varnishes is the so-called artificial asphalt, that is the pitch or residue obtained from the distillation of coal-tar, and the question arises just which sort of the pitch is best adapted for the purpose. The quality of the residual pitch depends primarily upon the quantity of the heavy oils still remaining in it after the distillation, so that the presence of a greater or less quantity of the oils results in a softer or harder grade of pitch; and the drying properties of varnish, as also its power of resisting mechanical influences or attrition after drying, are directly traceable to the plasticity of the pitch. A soft pitch contains considerable volumes of oils that boil at higher temperatures and which, combining with the benzene, retard the drying greatly. Very solid or hard pitch, on the other hand, contains large quantities of free carbon, which is not soluble in benzene; in this case more pitch is needed and a considerable residue results. A medium hard grade of pitch is therefore advisable.

Usually the making of the varnish itself is conducted in this wise: first melt the pitch in a kettle over an open or direct fire and add the desired weight of rosin or gum; when these are thoroughly melted and combined, draw the fire and allow the caldron to cool down a little, after which carefully run in the benzene, stirring the while. Disregarding the danger of fire that attends this operation, which should of course be intrusted to only tried and careful workmen, it seems to me that my method, which makes use of a steam jacketed kettle, produces a varnish of a superior quality. I proceed thus: In a kettle with a steam coil, or a steam jacket about it (this latter is better) placed high upon a work bench, I put 100 parts by weight of 90 per cent benzene and to this add 40 parts of coarsely powdered rosin (colophonium), which, if continuously stirred, dissolves very quickly. To this add 90 parts of medium hard coal-tar pitch, also coarsely powdered, and with continued stirring warm the mass up to 50 deg. or 60 deg. C. After stirring from a half hour to an hour, and in order to prevent further distillation of the benzene, turn off the steam and run cold water through the jacket of the kettle until the heat of the varnish is reduced to the temperature of the day. It may now be allowed to stand for a time. When thoroughly settled, siphon off the clear varnish into a closed vessel somewhat lower down, where it will further clarify itself.

At some distance up from the bottom of the vessel there should be a cock through which the clear varnish may be drawn off into barrels. Little or no use has as yet been discovered for the residue, except, perhaps, the mixing of it with coal dust, sawdust, or peat to make briquettes.

Attending this process is only one disadvantageous circumstance, viz., the unavoidable boiling away of some of the benzene during the mixing, but if the operation be conducted in a closed receptacle provided with a mechanical stirring device, the distillate may be regained. A varnish made in this wise possesses good covering powers and a remarkable gloss, besides drying in a few minutes, a quality which is a matter of much importance to the consumer; moreover, it does not scale off smooth surfaces nor is it easily affected by atmospheric changes or conditions.

From its resemblance to glass and its remarkably glossy appearance, the pitch made from lignite—a sort of peat or bituminous carbonated wood—should be a supposedly good accompaniment to the pitch made from ordinary bituminous coal, for increasing the brilliancy and gloss of these iron varnishes. This is, however, not the case, as its presence is on the contrary a detriment, for it materially affects the drying qualities of the varnish and, if added in considerable quantities, will cause it to remain forever tacky. Ben-

zene being an excellent solvent for caoutchouc, which is also used as an ingredient in the manufacture of certain kinds of varnishes, it may turn out that rubber will some day be advantageously used in the composition of these inferior varnishes. As a solvent for crude rubber benzene has come more and more into use in the rubber industries, especially since its price has, in the last few years, been reduced to about one-third of its former value. This great cutting down of the price has been brought about by the increased production of coke (used for smelting and reduction) and the resultant by-products, so that there is now no fear of benzene ever again reaching its former high-water mark. Of the other coal-tar oils, creosote and anthracene are perhaps of even greater importance than benzene, since they are consumed in large quantities in the manufacture of paints and stains for the coating and impregnating of wood instead of iron. In creosote by far the greatest quantity of naphthalene obtained from coal-tar is found; indeed it is present to such an extent that on cooling it begins to separate spontaneously, and, if permitted to remain for a time undisturbed, still more will crystallize out. Similarly, from the heavy anthracene oils, if allowed to stand a while, will appear a crystalline pulp, of which the principal component part is anthracene and which is in itself the basic material from which are won the alizarine dyes so widely distinguished for their brilliancy and fastness. Both these oils in time spontaneously separate from their semi-solid constituents and under the name carbolineum occur in commerce in varied mixtures as preservatives and coatings for wood. The brand known as "Avenarius Carbolineum" is the best, and it is said to be prepared under a patented process which treats the heavy coal-tar oils with chlorine. This brand is distinguished by its reddish brown color and is of the consistency of syrup; it also commands a much higher price in the open market than the ordinary compounds of creosote and anthracene oils. In use the difference is readily appreciated, for the commoner mixtures become of a smutty, blackish hue when drying into the wood, especially where creosote oil predominates, while a coating of Avenarius Carbolineum retains indefinitely a beautiful nut brown color. This lasting quality led experimenters to seek means of improving its color, deodorizing it if possible, and correcting its viscosity, or, in other words, making it thinner. According to Dr. H. Nördlinger, the quality of coal-tar oils which are destined for the impregnation of wood is greatly improved if treated with a 1 per cent or a  $1\frac{1}{2}$  per cent solution of a water-soluble copper salt, say copper chloride, or by mixing their aqueous or alcoholic solutions and, after standing, drawing off the water stratum. Having determined upon an admixture, its treatment with the alcoholic or acetone solution of mercury, zinc, or cadmium-acetate, aluminium, zinc, or cadmium chloride, or zinc-protochloride will produce the same results as the copper salts. In the reddish brown color which makes its appearance almost immediately after applying to the wood, this carbolineum possesses its most attractive features for the buying public of to-day. Since these oils are required to sink deeply into the wood, they should not be thickened with any pigments, which would any way easily scale off after the coal-tar oils had left them on the surface, unless some of the binding material had been added. Just here comes in another of the numerous coal-tar products to help out the difficulty, the class of oil-soluble or fat-soluble azo-dyes. The greatest inconvenience in the use of the aniline colors arises from their tendency to fade under the action of light, but as the coating of tar oil even without any coloring matter turns brown with time, in this case the fading characteristic of the brown aniline improves, yes, completes the work. Indeed, in this manner a very durable covering for the wood is attained, while no impediment prevents the antiseptic oil from permeating the fiber and thoroughly staining it. Until recently carbolineum only existed in brown, but since the use of the azo dyes has become possible, it now appears in a variety of shades and one manufacturer puts up a brand which he facetiously dubs *Holz-doktor* (wood doctor). These various shades are of course similarly obtained by the use of the other oil-soluble aniline dyes.

From anthracene oil itself a brown dyestuff may be made, which will serve to color the carbolineum, if the oil be treated with nitric acid followed by a thorough washing first with water, then with a weak lye, until the solution is freed from all the acid particles. Nitric acid has a very violent action upon the oil; accordingly this operation must be performed with extreme care, especially if the preparation of large quantities is undertaken. Sample boards which had been coated with some of the carbolineum tinted with anthracene oil that had been subjected to the nitric acid treatment failed to show any deteriorating effect upon the coloring matter, of which only from 5 per cent to 10 per cent was necessary. Having mentioned above the azo-dyes which are used to color oils, fats, wax, etc., it may not be amiss to give here an important circumstance in their manufacture. They are obtained from a diazo-compound or diazotized base (aniline, toluidine, etc.), and a phenol, mostly beta naphthol (written usually  $\beta$  naphthol). Now in order to obtain the clearest possible color-tone in a dye which is derived from  $\beta$  naphthol, it is of paramount importance that there should be absolutely no alpha naphthol (written usually  $\alpha$  naphthol) present in the  $\beta$  naphthol used, since the former, when combined with the same diazo bases, will produce a dye of an entirely different character, so that if the  $\beta$  naphthol contain even a trace of  $\alpha$  naphthol, a coloring mixture will result which unites two radically opposite dyestuffs. Moreover, the dye made from  $\alpha$  naphthol is more or less water-soluble, a circumstance which must be taken into account if a durable coloring matter is to be produced. For this reason it is very necessary to be able to determine the amount of  $\alpha$  naphthol present in a given sample of  $\beta$  naphthol, and Mr. J. Prochazka and Mr. H. N. Herman\* show us just how this may be accomplished. "Convert the  $\beta$  naphthol into a naphthol-sodium by boiling together 15 grammes of

\* Journal Soc. Chem. Ind., 1897, 294.