

DYESTUFFS.*

BY

LOUIS JOSEPH MÁTOS, Ph.D.,

Technical Chemist and Chemical Engineer, National Aniline and Chemical Company, Inc.,
New York City, N. Y.

MR. CHAIRMAN, LADIES AND GENTLEMEN:

IN addressing you this evening upon the subject of Dyestuffs, I am not unmindful of the wide extent of the subject and also of the very great amount of information and data, both general and technically special, that has been given to the public from various sources, since August, 1914.

During this intervening period, and particularly during its first twelve months, when there was manifested so much concern regarding the probable supplies of coal-tar colors for our several dye-consuming industries, the wildest rumors regarding the possibility of dye production in this country were current, and there was hardly a day but some new and far-reaching discovery was announced, in the columns of the daily papers, that would unlock the tightly-closed secrets of the German dye makers, and unlimited quantities of much-desired anilines would flow forth.

We know now that much of this wild publicity was the result of a total misconception of what dye production is, and the very great majority of those who were to relieve the serious dye situation are now at labor in other fields.

The dye industry, like many other fields of activity, has been developed by gradual stages through the years, and from the most modest beginnings. It has grown and increased in importance from the time when the artistic ideas of peoples were in a very crude state.

From the very earliest times of which we have record, there is evidence that certain coloring matters of organic origin were in use, the two most important being indigo and madder, and it is interesting to note that these two items have come down to us continuously to the present.

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It is not necessary to burden you with a list of those coloring matters quoted in the Scriptures, but it may be interesting to record the fact that in Europe, prior to 1600, the art of dyeing, even at that time had attained considerable importance on account of the skill of the dyers. There were currently employed at that period:

Indigo, Madder, Litmus, Brazil Wood, Lac Dye, Kermes, Buckthorn Berries.

These several dyewares, or the coloring matter extracted from them, were mostly used for dyeing woollen fabrics and linen.

During the long years between 1600 and 1860, there were gradual additions to this old list of natural colors, which then included besides Indigo, Madder, and the astringents—Sumac and Gallnuts—Peachwood, Camwood, Barwood, Sanders Wood (tropical woods); Cochineal (Guatemala); Fustic (Cuba); Weld Quercitron Bark (Pennsylvania); Cutch and Turmeric (Burma and Mexico). With this line of dyewares, the dyer was in a position to meet most of the demands made upon him for dyeing not only wool, but cotton and silk as well.

In certain localities, notably in parts of France, some coloring matters obtained from plants indigenous to the region in which the dyer worked, were used. Among these dyewares may be included safflowers and saffron, the former much employed for a most beautiful shade of pink, and the latter for a shade of yellow.

As the fame of the dyer's products and skill spread, the interest of dyers in other localities became excited and the desire to produce similar results was aroused. In consequence, the secrets of the dyer, handed down from father to son, were jealously guarded, so that competition might not be able to duplicate their work. We have evidence of this condition when we examine the recipes extant in old formula books of dyers of past generations, notably in the production of the so-called "spirits," those mysterious compositions of tin and certain acids, which were designated largely by misleading names.

The dyer of the period, prior to the introduction of the coal-tar dyes, was indeed a real master craftsman. While he may not have had the refined surroundings of the dyer of the present nor the highly developed scientific aids that are now so common, he produced results that are to be regarded as marvellous. When we read old notes and recipes, and bring to our mind the uncertain

composition of the various "infusions" that the dyer employed, we are compelled to acknowledge that the workman of the period was one who really knew his trade.

The "infusions" or "liquors" made use of at that time, were largely weak liquid extracts made by boiling the crude natural dyewares with water, then straining and using the stock solution as the dyer's demands required. At other times, such as for logwood, a given amount of the ground wood was simply boiled out, and the total amount of infusion so obtained was employed for one batch of material to be dyed. This crude method of operating was the origin of the now highly-developed logwood industry which flourishes both in this country and in Europe, especially in France, from which country, the very finest logwood extracts have come.

There were other natural dyewares analogous to logwood, which occupied a prominent position in the catalogue of active coloring matters, and which include peachwood, barwood, sanders wood, and other similar woods, the majority of which are natives of the tropics. They were chiefly used for producing red, brown and many compound shades upon wool in combination with logwood. These woods were imported and ground, and the ground or rasped wood was sold to the dyer, who made the infusions as his requirements called for. Some of these now scarce and curious dyewares were used in Philadelphia even as late as 1895, where they were employed for producing shades upon heavy carriage robes, and in dyeing seal plushes. From that time until the outbreak of the war, the decline in the use of those products was rapid and complete. When the war curtailed many of the artificial colors, the dyers had to fall back upon these antiquated coloring matters, and after a time, some were imported and sold at unheard-of prices on account of the great demand and scarcity of stock. Afterwards, when domestic producers of artificial colors began to make deliveries, the market for the older dyewares fell off again. It is curious to note, however, that during the "dyestuff famine," when these antiquated coloring matters were brought to light, very few dyers knew anything about their application, and, as a consequence, the dyed material that was delivered from mills did not measure up to the usual current standards for fastness, and therefore, dyes were condemned off-hand, when, as a matter of fact, the fault was not with the

dyestuff, but with the inexperience of the dyer, due to his unfamiliarity with the dyestuff he was using.

There are to-day many experienced cloth dyers who are expert in the application of logwood—for be it remembered that logwood has always been a standard dyeware for black on wool, and against which artificial blacks for the same purpose are judged—and these same dyers are absolute failures when it comes to using other colors. The same remark applies with greater force to the dyeing of silk. There are no dyestuffs of coal tar origin that can duplicate the well made logwood blacks on this fibre. Black dyeing in the silk industry is a trade by itself, and deservedly so.

Indigo has been handed down to us from the earliest times as the one blue color that has been regarded as having a degree of fastness far in excess of any product yielding the same shade. It is a native of certain portions of the tropics of both hemispheres, but the greatest amount of natural indigo has by far been produced in British India.

Indigo, as it appears in commerce, is the blue coloring matter obtained by oxidizing the juices of the indigo plant. The plant at maturity is cut and carted to the indigo factory where it is placed in huge vats, water run on, and the whole allowed to ferment. At the proper stage of fermentation, the liquors containing the indigo in a chemically reduced state (indigo white) are run off and agitated, either by being whipped by hand or by revolving light paddle wheels. This agitation causes atmospheric oxidation of the indigo white, which is soluble, to indigo blue which is insoluble and precipitates. This precipitate is then filtered and the cake pressed, then cut to proper size and branded while still moist, and finally dried. It is then ready for the market.

Indigo as a source of blue color, for textiles, has had an unbroken period of use for centuries. It is employed in dyeing both wool and cotton; the former by means of both so-called "vats" and as "extract," the latter always in the vat. Vat dyeing means that the indigo is reduced to the state of indigo white and then subsequently oxidized to indigo blue on the fibre. "Extract Blue" is dyed by means of a solution of indigo in sulphuric acid, formerly called "chemic," and in later years more carefully prepared by purifying the sulphuric acid solution of the indigo. A highly-refined dry indigo extract is sold as Indigotine,

but it is in reality only a disulphonic acid of indigotine—the real blue color of indigo in soluble form.

Madder is another of the natural dyewares that has been in use for centuries, being employed most commonly for the production of réds—the red which we are most familiar with being termed Turkey Red. Formerly, and up to the recovery in 1868 of artificial alizarine by Graebe & Lieberman, its cultivation and preparation for market was a most important and flourishing industry. When artificial alizarine became a commercial reality, the madder industry rapidly declined to very small proportions, and as a dyeware, it is no longer to be considered.

The several coloring matters to which I have directed your attention, occupying positions of first importance in the dyer's art, are mentioned for the purpose of preparing the way to the serious consideration of the dyes of artificial origin, and by which the great majority of the older dyes were completely displaced.

The first dyestuff of artificial origin is the well-known Perkins' Violet, and its discovery in 1856 paved the way for rapid strides in organic chemical research that has continued from that date to the present time, and the number of patents granted by various industrial countries attest the activity of chemists in the direction of dye production, although not every patent granted represents a dye that has attained commercial interest.

The more important artificial discoveries may be briefly summarized as follows:

Perkins' Violet or Mauvein.....	(Epoch) 1856
Fuchsine or Magenta	1858 (Hofmann)
Aniline Black	(Epoch) 1862 (Lightfoot)
Nicholson's Blue	1862
Methyl Violets	1866 (Poirrier)
Safranine	1868
Artificial Alizarine	1868 (Graebe and Lieberman)
and its manufacture in.....	1869
Indigo Blue from isatin	1870
Eosine	1874
Cachou de Laval (first sulphur color).....	1873
Triphenylmethane Dyes	1876
Methylene Blue	1877
Fast Red	1877
Azo Scarlets	1878
Propiolic Acid for Indigo	1880
Congo Red (first direct or substantive color) ..	1884

Tartrazine (first fast acid yellow for wool) ..	1885
Primuline and the "ingrain" colors	1887
Carbazol Yellow	1888
Diamine Fast Red F.....	1889
The Thioflavines	1889
Indigo from Phenylglyocol.....	1890 (Herman)
Cyanine	1891
The Rhodamines	1893
Vidal Black (first sulphur black).....	1895
Synthetic indigo, vat colors, etc.	

This list could be greatly augmented but it is sufficient to indicate the gradual extent of industrial and chemical research that has developed the great number of dyes that find use in some or all of the industries employing coloring matters.

The particular branch of dye research that includes the so-called azo colors, deriving its impetus by the discovery of Peter Greiss in 1862, has been most productive of results and for the time engrossed the attention of the great majority of dye chemists, with the result that there were innumerable products given to dyers that traced their origin to the Greiss reactions. This particular group of dyes—Azo dyes—is chemically subdivided into thirteen divisions, and in their extension and development there has been made necessary a vast amount of chemical research covering the production of those raw materials that are necessary for each particular dye. This phase of dye chemistry has been to a very great extent neglected in this country, but during the past three years it has been receiving a degree of attention never before attempted in private laboratories, works' laboratories and in colleges.

In the operation of dye making, certain raw materials are necessary. These raw materials are obtained in the first instance from certain distillation products obtained from coal tar; the most important for the purpose of illustration are benzol and naphthalene.

From benzol there are obtained a succession of secondary products each the result of a definite reaction, and each possessing certain properties.

From naphthalene there are also obtained by various reactions a number of products aggregating at least one hundred and seventy-five, and each of which possesses properties that make it useful for certain further reactions. If we study the chemistry

of several of these benzol or naphthalene derivatives, we will at once be impressed with the immense amount of painstaking research work that must have been done in order to ascertain the properties of each product, and the possibilities of combining each of them with other dissimilar bodies, for the purpose of obtaining a dye or coloring matter different from any other before produced. It is this constant investigation that has been at the bottom of the seemingly endless array of known dyes.

If the dye chemist has only to give his attention to combining various raw materials, his work is extremely simple, but where he has to work out the production of new raw materials, then his work becomes extremely complicated.

In studying the chemistry of the commercially useful derivatives of naphthalene, mostly sulphonic acids, we are at once impressed with the limited sphere of labor undertaken by the investigators, and a digest of the patents will show that the labors of these investigators have been quite active within these limits. Each investigator has concentrated upon some one, or possibly two, groups of colors, and their necessary raw materials, leaving to others similar work along diverging lines.

The group of azo dyes includes the greater number of dyestuffs that are available for cotton and wool, and for a long time after the classical discovery of Peter Greiss, occupied the attention of many chemists, with the result that a very extensive range of colors were produced with which the dyer was enabled to obtain shades of almost every conceivable hue.

One of the most important discoveries was the production of the so-called azo scarlets, which, in a short time, completely displaced cochineal. These original scarlets were later considerably improved upon, and brilliant shades were made possible possessing extreme fastness to light. Several of these scarlets are much employed in other industries, notably for the staining of paper.

The ultimate production of wool blacks marked the beginning of a revolution in dyeing certain textiles, which were formerly dependent upon logwood, and in time, the gradual decline of this latter dyeware became quite noticeable.

It is unnecessary for me to dwell upon the technical details for the production of these various products, since the outlines of the most important may be found in many treatises and in the patent literature.

After the discovery of Congo Red, in 1884, there was an immediate concentration of chemical endeavors upon the group of substantive dyes—dyes that colored cotton without a mordant—the result being a long line of products that at once gained recognition throughout the world. Some of these dyes are remarkable from the fact that they are capable of dyeing corresponding shades upon both cotton and wool, thereby opening the way for a valuable line of dyes, known as “union dyes,” with which both of these fibres may be dyed the same shade in the same bath. This is of great commercial importance, inasmuch as it permits the manufacture of cotton and wool mixed goods that were not theretofore possible, except with considerable trouble.

There are many wool dyes that partially stain cotton, and also many cotton dyes that only slightly stain wool. The dyer, therefore, has at his command the means, by a judicious admixture of these two classes of dyes, of producing a combination of dyes that will enable him to dye union goods with the greatest ease. Most of these combinations dye the cloth in a bath fortified only with a small amount of sulphate of soda.

One of the most important, far-reaching dye discoveries was that of an Englishman—Green—in 1887, who produced a series of dyes known as “ingrain colors,” and which at once gained a strong foothold in cotton mills on account of the then remarkable fastness of the shades produced. The most important dye of this group is known as primuline, and occupies a prominent position to this day as a source of red for cotton. It was the first dye to serve as a substitute for alizarine on certain classes of goods. Primuline is dyed upon cotton by the so-called “three-bath” process, which provides for the diazotization of the color on the fibre and its final development with a suitable developer, the most common being beta-naphthol, and produces the red above referred to. This group of colors was first limited to a few shades, possibly six, none being either a blue or a black. This disadvantage was at once apparent, and stimulated research, so that in due time diazotized blacks and blues came upon the market. The blacks appeared to offer particular advantages, especially as competitors of aniline black for hosiery dyeing. Indeed, a number of the best known brands of hosiery on the market are dyed with developed black.

The industry of the sulphur colors commenced by Croissant &

Bretonière in 1873 has been greatly extended, and from which has been given a great number of dyes of the utmost importance. Their field of usefulness is almost confined to the dyeing of cotton. The blacks of this group have, together with the diazotized blacks, been the active competitors of aniline black, while the sulphur blues have, in many instances, replaced indigo for certain lines of cotton manufacture. The sulphur color industry is actually the starting point of the now firmly established "vat color" industry, although but few of the vat colors are made by any of the processes used in producing sulphur colors. The extensive group of vat colors includes a considerable number of dyes that are remarkable for their extreme fastness, and it was the general use of these dyes that gradually educated the people as to what a really fast color is.

The so-called vat dyes are divided into two main groups designated respectively Indigoid dyestuffs and Anthrachinone. The chemistry of both of these two groups is rather complicated and it will serve no useful purpose by going into the details of the reactions. For convenience, however, the following classifications may be introduced:

(a) INDIGOID DYE STUFFS.

- (1) Indigo Group,
- (2) Ciba Violet Group,
- (3) Thioindigo Group,
- (4) Indi Rubin Group,
- (5) Thioindigo Scarlet Group,
- (6) Ciba Scarlet Group.

(b) ANTHRACHINONE DYE STUFFS.

- (1) Indanthrene Group,
- (2) Flavanthranone Group,
- (3) Benzanthranone Group,
- (4) Anthrachinonimide Group,
- (5) Acylaminochinone Group,
- (6) Anthrachinonacridone Group,
- (7) Vat dyestuffs of unknown composition.

(c) VAT COLORS CONTAINING SULPHUR.

- (1) Anthrachinone Bodies,
- (2) Carbazol Bodies.

This particular group of dyestuffs has excited remarkable interest ever since they were put upon the market; not alone from the chemical standpoint, but also from the fact that the practical

results obtained from their use enabled manufacturers of cotton goods to greatly extend their line of woven and printed novelties, carrying at the same time a guarantee as to fastness and durability of shades that startled the industrial world in those lines of cotton manufacture known particularly as wash goods, ladies' and children's summer garments, men's shirtings, madras cloth and similar fabrics, carrying shades of blue, red, pink and combinations that emerged from the laundry quite intact. The study of the vat colors is most interesting. It should be borne in mind that the great majority of the patents granted for these particular colors are still in force and this fact alone is likely to mitigate against the possibility of the more important of the dyes so protected being manufactured in this country, even after the present war is terminated. There is every reason to believe that the German holders of patents for these valuable dyes will exert every effort to retain the manufacture of these dyes for and in Germany, and that it is hardly likely that licenses will be granted to American dye manufacturing plants permitting of the manufacture of even some of the most wanted of this group of colors. This condition, however, should not prevent a special effort being made on the part of dye chemists, professors of organic chemistry and advanced students of that particular branch of organic chemical work from devoting their undivided time and attention to the investigation of problems aiming to the production of further additions of dyes to this important group of colors. This is a most prolific field and one worthy of very serious thought on the part of chemists.

In this particular connection and relating very closely to this same group of coloring matters may be mentioned work done within very recent years. I take the liberty of making reference to a particular blue that requires as one of its chief raw materials a substance that has heretofore been regarded as an industrial nuisance, but which, due to the painstaking care of the investigating chemists, has been made available for the production of a coloring matter that possesses a shade equal to, and properties excelling in fastness those of indigo. I refer to carbazol, which, prior to this time, had been of no commercial or industrial value whatever, which has been found closely associated with anthracene as an impurity and from which latter it has to be separated by a process fraught with some difficulties. Carbazol has been

made available for textile purposes by being converted into the blue dye applied in a manner similar to indigo in the "vat," and which produces indigo shades from the lightest to the darkest with great facility. For its production it is simply a matter of obtaining carbazol and when this product is secured in sufficient quantities there is no doubt but that the dye industry and that portion of the textile industry most interested will receive a great impetus.

In mentioning carbazol as a prolific field for chemical investigation, I might also include a number of equally well known and troublesome organic impurities found in other coal-tar distillates, which only await the attacks of the painstaking industrial chemists to find ways for their commercial utilization.

At this point the lecturer directed attention to a number of illustrations, several of which are printed herewith. The first was a diagram of a coal tar tree showing the general relationship that the finished dyestuffs have towards coal tar. By this tree we immediately grasp the idea that upon the destructive distillation of tar, certain prime raw materials are obtained, which, when subjected to further chemical treatment, are converted into the so-called intermediates that the dye maker employs for the production of the finished dyestuff. Coal tar itself is a by-product of the destructive distillation of coal either from the illuminating gas making process or from other operations where tar is recovered. During the process of distilling coal, illuminating gas is obtained, and during the operation of washing this gas ammonia is recovered. The residue remaining in the gas retorts is coke. When coal tar itself is subjected to destructive distillation it breaks up into a large number of raw materials, including Benzol, Carbolic Acid, Cresoles, Naphthalene, Anthracene, heavy oils, and leaves a large residue of pitch, the exact composition of which is known to vary, but which is still a subject of fruitful investigation by chemists.

The next diagram herewith reproduced (Fig. 1) shows graphically the average percentage composition of coal tar. Each square represents one per cent. The small amount of phenol or carbolic acid actually present in tar is indicated as well as the small amount of anthracene. It is this small amount of anthracene that carries a small, though available, amount of carbazol, to which I have previously alluded.

Figure 2, herewith, is a diagram showing the average

quantity of distillates obtained from 2000 pounds of coal, together with the quantities of a few of the important dyestuffs which some of these distillates produce.

Figure 3 shows the sequence of events for the conversion of Benzol and Toluol into the well-known dyestuff magenta or fuchsine.

FIG. 1.

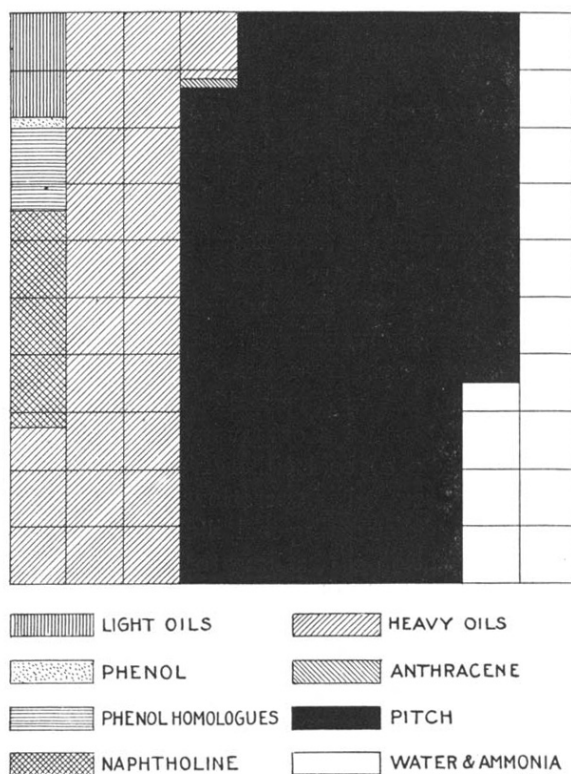


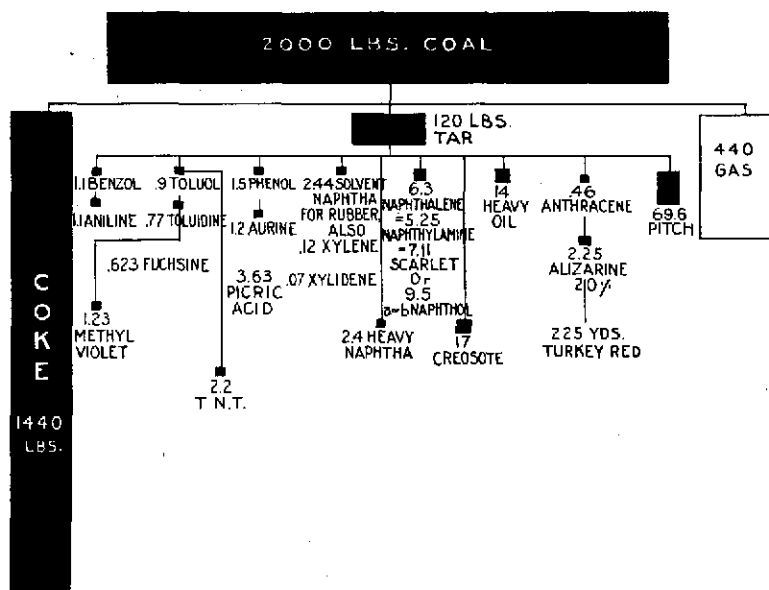
Figure 4 represents the chain of operations necessary for the conversion of the primary raw material—naphthalene—into Naphthol Yellow.

Figure 5 is of particular interest and shows graphically the so-called aniline process for the manufacture of synthetic indigo, from which we see that there are three primary methods having this object in view, all of which, however, aim to produce Phenol-

glycene, which is then subjected by one of three processes, according to patent limitations, into Indoxyl, and this latter product is then, by the oxidizing influence of the air, converted into indigo.

The so-called naphthalene process is shown in Fig. 6. This process has for its object the conversion of naphthalene into indigo and is known as phthalic acid process. The main product obtained is phenylglycine-o-carboxylic acid, which is fused with caustic soda producing indoxyl, and this latter by oxidation is changed into indigo.

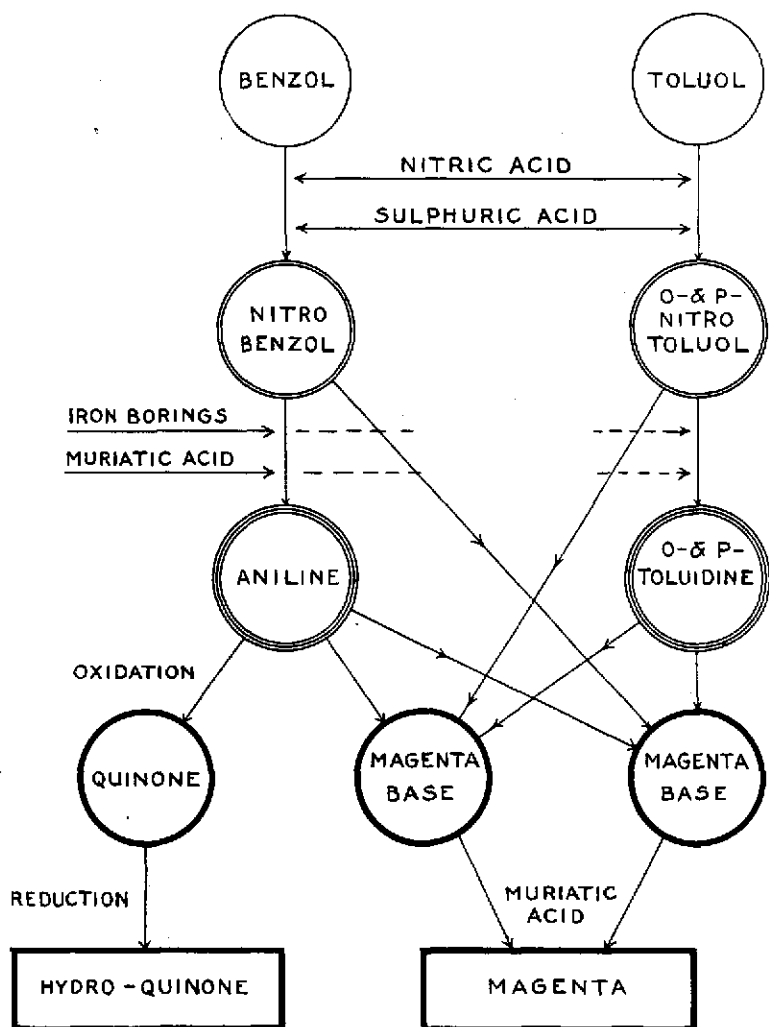
FIG. 2.



These several Indigo processes which I have shown are rather complex, but this complexity need not stand in the way of well-directed students in our organic chemical laboratories for undertaking the work under competent directors. There is not the slightest doubt but that investigating students equipped with personal laboratory manipulating ability and supplied with the necessary patent literature, should be able to carry out, first upon a laboratory and second, on a semi-factory scale, every operation involved in the production of this most important coloring matter, and the practical technical information thereby gained would be of the greatest value for further industrial research.

There were also shown a succession of diagrams illustrating graphically the manufacture of naphthol black, which includes the manufacture of beta naphthol, the conversion of beta naph-

FIG. 3.

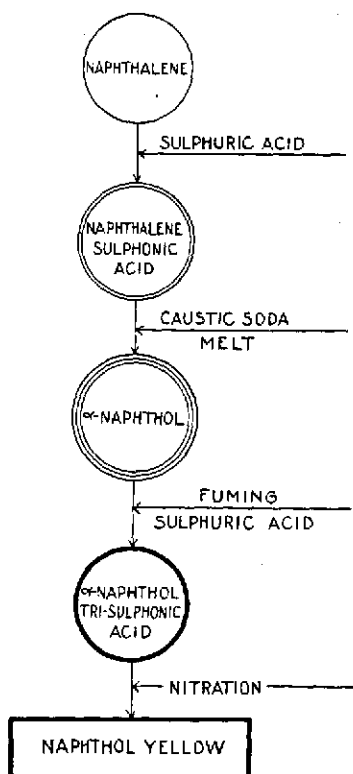


thol into R-salt and G-salt, which are formed simultaneously and separated finally as shown in Fig. 7, and the conversion of the R-salt into the complete dye.

The manufacture of cyanol was illustrated by a succession of slides showing the production of crude benzaldehyde, the conversion of that substance successively into nitro-benzaldehyde, amido-benzaldehyde and oxy-benzaldehyde.

There were also shown illustrations of the process for the production of ortho-nitro-toluol, its conversion into ortho-tolui-

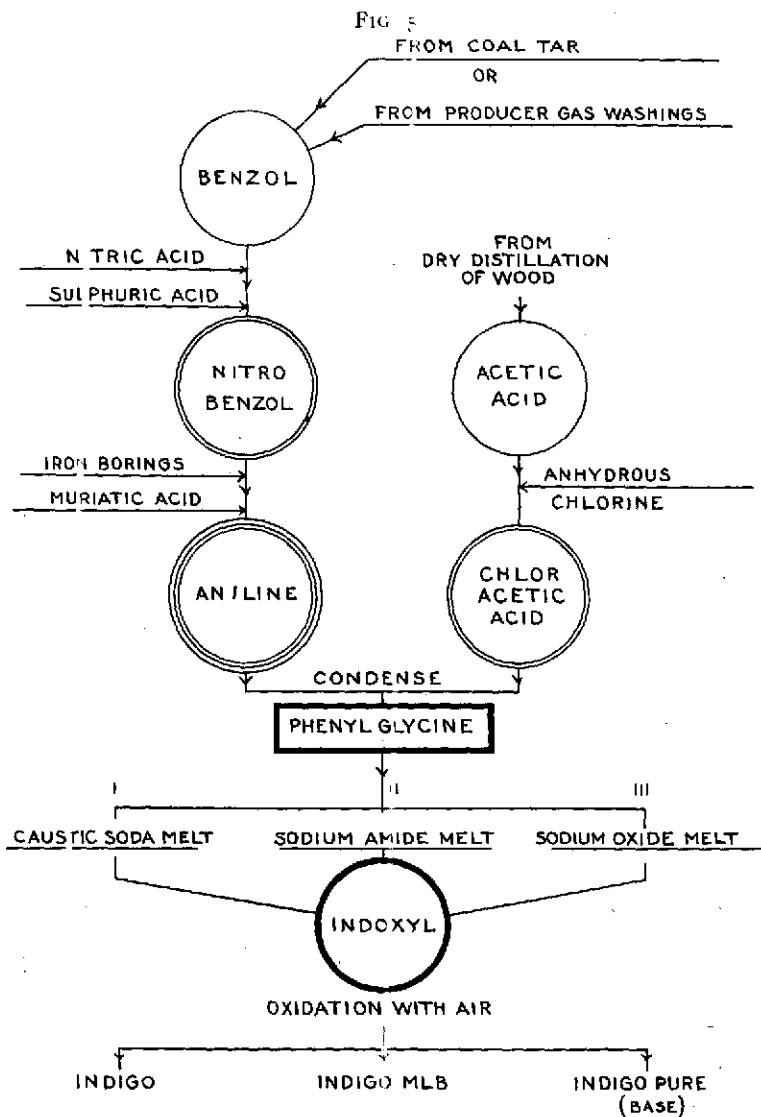
FIG. 4.



dine and the ethylating of the same, and finally as shown in Fig. 8, the condensing operation and finishing of the completed dyestuff.

From an inspection of the several figures, we are impressed with the fact that dye manufacturing is not entirely chemistry, but is an industry that depends very largely upon the ability of the chemical engineer specially trained in dye making and dye-works equipment. After the preliminary outline of the process

has been worked out, the results of his labor are taken up by others in the plant and gradually brought to manufacturing per-

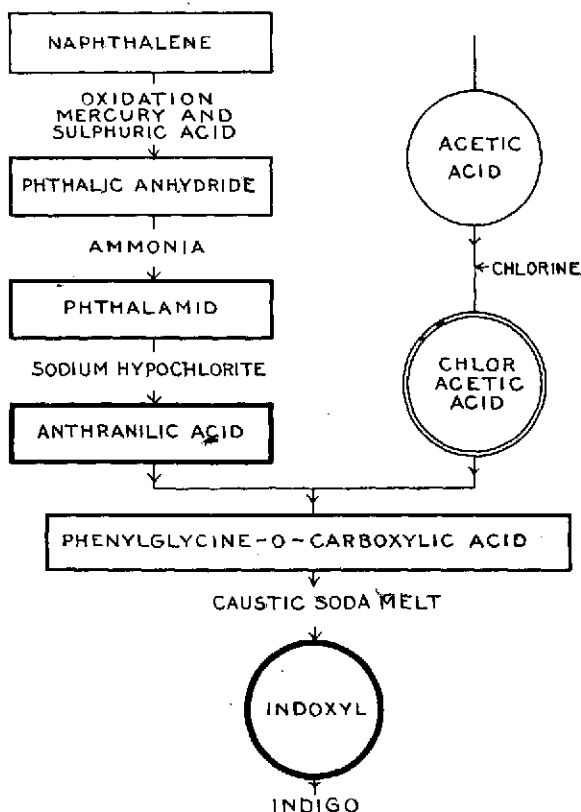


fection, and it depends in a great measure upon the commercial importance of the dye in comparison with dyes known prior to

this discovery. If it possesses properties of fastness not assured by the older dyes, its field of usefulness is thereby enhanced.

In the ordinary course of dye manufacturing as carried out in the large color works abroad or in the more important dye manufacturing plants in this country, the work is divided about as follows:

FIG. 6.



First, *Research Chemists*.—These are men with university training. As a rule they enter the dye works under rather humble conditions until they "find" themselves. Generally they specialize in one and sometimes in two groups of colors and it is seldom that they depart from the confines of their chosen specialty. It is they who experiment and work out what may ultimately appear

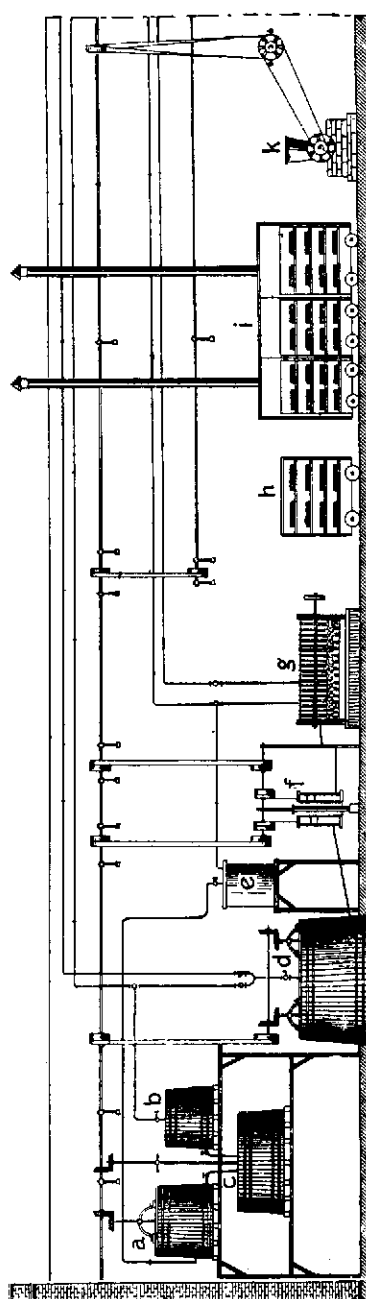
on the market as a new dye. Their compensation is rather low; lower than men holding corresponding degrees from American universities. Their ambition is to make discoveries that will yield them royalties on account of their discoveries being good sellers. When a man has made a few discoveries and his dyes are on the market his income in the form of salary and royalties gradually increases and he becomes more or less a fixture in the research department. Ample evidence of this is to be found by carefully inspecting the names of patentees of dyes during the last three years, when we find that the same name occurs at various intervals, and, except in a few instances, is connected always with the same firm.

Second, *Factory Chemists*.—These men are also university graduates, but for one reason or another are less adapted to research work, or do not care for the restraint incident to chemical research. It is they who take up the work where the research chemists leave off. They adapt the chemical discoveries and reactions to factory conditions, and in most instances are the dye production supervisors; they are not foremen. Some of them may have under them two or three departments, for which they are responsible. As a rule it is from the ranks of these chemists that the superintendents or technical directors are obtained.

Third, *Chemical Engineers*.—Owing to their particular training and abilities, these men are responsible for the particular design and installation of the necessary machinery required for manufacturing the various dyes as the results are obtained from both the research chemists and the factory chemists. As a general rule, after the identity of the dye has been proven by the research chemist and after the factory chemist has worked out satisfactorily the sequence of the several operations necessary, even to the production of batches of fifty to one hundred pounds, or even more, and the dye has been demonstrated to be a promising one, it is then that the chemical engineer steps in and designs the plant for its commercial production upon a full factory scale.

Fourth, *The Engineers*.—The engineer department of a dye manufacturing plant goes beyond the corps of chemical engineers, although in some instances these departments may overlap. The engineers, of necessity, are more familiar with the construction of the individual units comprising the plant than the chemical

FIG. 7.



NAPHTHOL BLACK MANUFACTURE.

a, Vat for diazotizing the b-naphthylaminedisulpho acid; *b*, vat for dissolving the a-naphthylamine; *c*, vat for producing the amidoazonaphthalenedisulpho acid, and for diazotizing the same; *d*, vat for combining the diazo body with R salt; *e*, vat for producing R salt solution; *f*, duplex pump; *g*, filter press for the finished naphthol black B.; *h*, truck for the moist dye; *i*, drier; *j*, grinding mill.

engineers. It is the engineer department that takes care of the construction of the elements of the plant called for by the chemical engineer and factory chemist and whose advice and assistance is at all times encouraged when necessity requires.

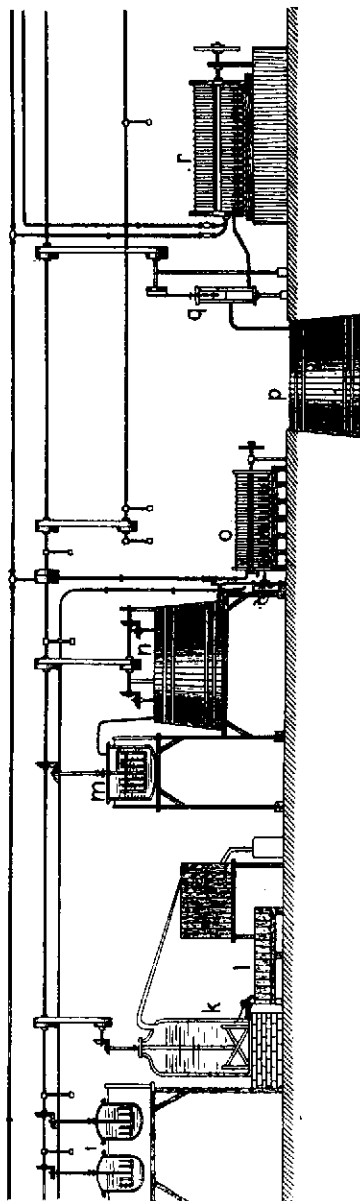
One thing is to be constantly kept in mind, however, regarding the so-called efficiency of German dye plants and that is the utmost care taken by the management to prevent undue intercourse and familiarity between those who comprise the several main departments. There seems to be, in fact there is, a sharp line of demarcation which keeps the various professional groups sharply separated. Unlike the prevailing custom in well-managed American plants, there are seldom, if any, general conferences that have to do with increasing the proficiency of the various departments. In most of the larger German color works there is rather a dense atmosphere of association difficult to penetrate and the existence of which only tends to retard rather than advance the particularly high degree of professionalism. This may be contrary to many pre-conceived notions gained by the American public, but it is a fact, nevertheless.

In dye establishments, distributing plants and similar commercial enterprises, the technical staff may be conveniently divided into two broad groups as follows:

(1) *Textile Chemists*, who specialize more or less in wool, cotton, silk, union goods, etc.—In some of the larger establishments men to fill these positions have been selected from the ranks of the salesmen who may have had previous mill experience, or from graduates of the various textile schools.

(2) *Dye Laboratory Chemists*.—These are usually boys or young men who entertain the idea that they are chemists, but whose preliminary education combined with lack of chemical training, enables them to discharge the duties only of dyer on a miniature scale and consequently they become standardizers or simply shade matchers. These young men become very expert in compounding the dyes of the firm for which they worked and in matching the colors of the firm's competitors. Generally it may be regarded as a mistake for a young man with chemical ambition to lose himself in a standardizing or shade-matching laboratory of a dyestuff house. There is little or no chemical work to be performed, and any knowledge that he may have upon this sub-

FIG. 8.



i, Kettles for condensing oxybenzaldehyde with mono-ethyl-o-toluidine; *k*, still for recovery of unconverted ethyltoluidin; *l*, filter for the condensation product; *m*, sulphonation kettle; *n*, vat for diluting and oxidizing the sulphonation; *o*, filter press for lead sulphate; *p*, neutralizing, and salting-out the dyestuff; *q*, filter press for the finished dyestuff (cyanol).

ject will certainly become stale, since no opportunity is afforded for him to exercise his chemical skill. Except in very few instances have such men ever become valuable technical men in the broad sense of the word, that is, men who are competent to go out into the dye houses of the firm's customers and solve difficult problems in the practical application of dyes or to seek the cause of the trouble, when, through one fault or another, the dyestuffs failed to do their work properly.

It is here that I believe many of our textile schools make the mistake of not suggesting to their dyeing students that they should take up the study of dyeing along some one restricted line and specialize in that. For example, wool. It is manifestly impossible for a man who is a wool dyer to be at the same time a skilled cotton dyer or a skilled silk dyer. I mention these points in order to direct your attention to the circumstances surrounding the employment of chemists in the dyestuff industry. It is an industry that offers remarkable opportunity for experimental work for young men to take up this particular field, but in order to do it to their own satisfaction and that of their employer, it is necessary that they should give serious consideration to the labors required of them and the amount of knowledge necessary for them to discharge their duties satisfactorily.

I have made mention of the employment of chemical engineers in the dye-manufacturing plants, but the satisfactory employment of a chemical engineer in the above organic chemical industry resolves itself again into some special branch of chemical work that the engineer has particularly studied.

Broadly, the color industry is divided into the production of: Raw materials, intermediates, dye making. Any one of these sub-divisions is likely to include one or more of the following operations, each of which is generally complex and which should have the undivided attention of the engineer.

I refer particularly to alkali fusions which are generally preliminary operations.

Sulphonation, which involves the use of either artificial or fuming acids.

Nitration and Lining.—These are operations in which sulphonations are generally decomposed.

Filtration.—Where solids are separated from liquids or *vice*

versa. This is an art. It seems simple at first glance to have a solution with insoluble matter suspended in it or a sludge of greater or lesser density requiring filtration, but it is at its best a problem requiring a great deal of thought, time and attention to be able to successfully filter a given liquid from a solid or a solid from a liquid. There are so many conditions of density, that only long experience can point the way successfully.

It is to be regretted that more young men in our chemical engineering courses have not devoted more time and attention to this particular branch of chemical engineering. Little has been published upon it and the information that has been gained by those who have worked upon filtering problems is generally not divulged.

Drying is another chemical engineering subject that is of the utmost importance, since it occurs so frequently in many phases of dye making, from raw materials to finished dyes. I may mention particularly the production of certain of the Amidonaphthol sulphonic acids and disulphonic acids where both the filtering and the drying determine almost exclusively the value of the finished product. Some of those products depend more upon the skill of the engineer than upon the skill of the chemist.

I could name in succession a number of other important operations, all of which contribute to the successful production of the finished article, and each of which requires that the man in charge—the directing genius—if I may use that term, should be equipped and trained to take care of that particular phase of the work.

Referring again to the amidonaphthol sulphonic acids, I may mention that with the exception of one plant—and that one located in France—no single chemist has been able to successfully carry out every single operation from the conversion of the naphthalene in the first instance to the grinding and sieving of the finished product. This may appear to be a strong statement, but if we consider that to produce these finished products almost every operation previously referred to is involved, it is safe to say that no one industrial chemist or chemical engineer is sufficiently familiar with the innermost details to permit him to successfully direct the work upon every stage in the chain of processes.