for chemical analysis at the trial, we did only enough work to give us an insight into the character and amounts of dissolved substances in the water. The sanitary chemical analyses, Table II, and the mineral analyses, Table III, indicate that the water being delivered through the Aqueduct is softer and contains less solids than the water from the present Los Angeles River supply. Also, it is to be expected that when the more soluble salts are leached from the reservoir beds and the concrete, and the water is not run through San Francisco Canyon, the water will contain less solids than at present.

BIOLOGICAL EXAMINATION

To conclude this paper without reference to this subject would leave it incomplete. Yet there has been no systematic work done to date which will warrant a public statement. It is to be expected that algae will flourish in the reservoir water during the summer months. The system does not provide for filtering the water, but chemical treatment of the stored water is contemplated. Aeration is provided at present with the "Cascades" near San Fernando.

CONCLUSION

A conclusion of this subject can best be made by stating the quality of water delivered through the Aqueduct to the consumer. A portion of the decision of Judge Lewis R. Works, rendered after hearing expert testimony for forty actual trial

mont, Dry Canyon and Franklin Reservoirs, three other basins having some value for storage purposes.

"A large portion of the testimony during the trial has been directed to the question of the efficacy of the entire system mentioned, and especially of Haiwee Reservoir, as a purifying agency, and many experiments have been conducted in the waters of the reservoir in order to determine the problem. It is not necessary now to state the nature of these experiments, nor to analyze the theories and arguments advanced by the various expert witnesses who have testified concerning them. It is sufficient to say that the great weight of the evidence demonstrates that Haiwee Reservoir is remarkably efficient as a great purifying unit in the Aqueduct system. This immense basin is over seven miles in length, with that distance between its inlet and outlet, and impounds, for a long period of time, certainly not less than thirty days, all waters which enter it. The reservoir is peculiarly adapted to the use for which it was principally designed. One of the leading expert witnesses in the case characterizes it as unique among the storage reservoirs of the world. Being in a region in which there is a rainfall of not to exceed five inches per annum, a region of porous, sandy soil, and entirely uninhabited, it is the recipient of no run-off from its own water-shed and it is therefore free from the contamination of such a run-off. The only influent of the reservoir is the Los Angeles Aqueduct, containing waters brought from the Owens River. The intake gates on the river may be closed

TABLE IV—TIME FACTOR IN SELF-PURIFICATION OF AQUEDUCT WATER
Rates of Forward Travel of Water Estimated with Haiwee Reservoir $\frac{1}{2}$ full and Other Reservoirs $\frac{2}{3}$ Full

FROM	TO STATION AT	TIME IN TRANSIT OR STORAGE IN DAYS			
		With maxi- mum flow	272 m. g. d. draft	136 m. g. d. draft	With pres- ent flow
Intake of Aqueduct	Cottonwood Creek	0.907	1.242	1.565	2.930
Cottonwood Creek	Intake, Haiwee Reservoir	0.279	0.362	0.465	0.798
Intake, Haiwee Reservoir	Outlet, Haiwee Reservoir	38.300	38.300	76.600	402.500
Outlet, Haiwee Reservoir	Inlet, Fairmont Reservoir	1.549	1.549	1.888	3.098
Inlet, Fairmont Reservoir	Outlet, Fairmont Reservoir	4.750	4.750	9.500	47.900
Outlet, Fairmont Reservoir	Inlet, Dry Canyon Reservoir	0.113	0.113	0.138	0.226
Inlet, Dry Canyon Reservoir	Outlet, Dry Canyon Reservoir	1.050	1.050	2.100	10.600
Outlet, Dry Canyon Reservoir	Inlet, San Fernando Reservoir	0.139	0.139	0.169	0.278
Inlet, San Fernando Reservoir No. 1	Outlet, San Fernando Reservoir No. 1	11.992	11.992	23.975	0.055(a)
Outlet, San Fernando Reservoir No. 1	Inlet Upper Franklin Reservoir	0.106	0.106	0.106	0.775
Inlet, Upper Franklin Reservoir	Outlet, Upper Franklin Reservoir	0.718	0.718	0.718	2.154
Outlet, Upper Franklin Reservoir	Inlet, Lower Franklin Reservoir	0.008	0.008	0.008	
Inlet, Lower Franklin Reservoir	Outlet, Lower Franklin Reservoir	6.180	6.180	6.180	0.174(a)
Outlet, Lower Franklin Reservoir	Third St. & Western Ave., Los Angeles City	0.080	0.080	0.080	
Total		66.171	66.589	123.492	471.488

(a) Reservoirs by-passed at present.

days in the above cases, states this ably and concisely, as follows:

"The scientific principles governing the selection and operation of a water system intended to furnish a domestic supply from surface streams requires a treatment of the water in order to rid it of the contamination which is inevitably incident to such a source of supply. This treatment consists in either the use of chemicals, the installation of infiltration plants, or in the storage of the water in reservoirs for a period of time requisite to its purification.

"If it be granted that the waters of Owens Valley are contaminated like all other surface waters, the density of population of its drainage area being the true index of contamination, and if it be granted that, for that reason, those waters would not be proper for domestic use at the intake of the Los Angeles Aqueduct, in the valley, does it follow that the water has not been purified when it reaches the point of delivery in Los Angeles, two hundred and eighty-six miles from the intake? In other words, is the water, during its transmission from the intake to the city, subjected to either of the methods of treatment above mentioned as requisite to the purification of a surface water supply?

"Ninety miles from the Aqueduct intake is located Haiwee Reservoir. From the outlet of that reservoir to Los Angeles is one hundred and ninety miles. During this progress over that distance, the water supply is halted, even if briefly, in Fair-

mont, Dry Canyon and Franklin Reservoirs, three other basins having some value for storage purposes.

"This peculiarly advantageous location of Haiwee is mentioned in passing, only, as the period of storage, which is allowed by its size and shape, is alone sufficient to guarantee to the people of Los Angeles a positive immunity from dangers residing in the waters before they leave Owens Valley, conceding that such dangers are there present, and without regard to the use of the waste gates mentioned, which furnish but an added factor of safety to a system safe enough without them."

THE REVIVAL OF THE USE OF NATURAL DYESTUFFS¹

By EDWARD S. CHAPIN

Imagine, if you can, the following situation: The supplies of artificial dyestuffs have become exhausted. The European blockade of embargo, call it what you will, has continued in uninterrupted force. Capital has been too timid to manufacture artificial dyestuffs in this country. This situation we will

¹ Address before the 98th Meeting of the National Association of Cotton Manufacturers, Boston, April 28 and 29, 1915.

now consider. "Nothing but black and white," says one; "The country will have to wear white," cries another; a third asserts: "The mills of the country will have to shut down!" What is the truth? The truth is that natural dyestuffs can keep the mills of the Nation in operation, producing a diversification of shades and giving fast colors.

This paper does not propose to consider the question of the relative merits of natural dyestuffs *versus* artificial dyestuffs. The present is no time for controversy. It demands coöperation and construction. We must remember that before the days of the modern artificial dyes people wore colored garments. Ladies were gay and gallants tried to please long before Perkin discovered mauve. A careful reading of any of the works of the masters of detailed description of the past century—of Dickens, Thackeray, Victor Hugo, or Goethe—will reveal interesting evidence of color and colored fabrics. Even more so the standard text-books on dyeing, of fifty or seventy-five years ago, consider the whole range of the spectrum. It is truly remarkable the multi-colored and fast effects that the dyers of the old school achieved with limited means and facilities. It is quiet within the memory of many of this audience, when the earlier aniline colors were distrusted by the general public because of their comparative fugitiveness, and it took much industrious advertising and scientific development of new and better products to overcome this prejudice.

The dyers and chemists of today are in a position to secure with natural dyestuffs better results than the dyers of former days. The forms of natural dyestuffs were not so perfect formerly as today. Then the dyer was forced to use the dyestuffs in the form of chips or ground bark or ground leaves; today he has ready at hand the essential coloring matter of the natural dyestuffs in the form of extracts, pastes, or powders, and in many instances the coloring matters have been worked up by chemical treatment so that they dye more readily and give brighter and faster results. The march of chemical and mechanical science contributes to the solution of the task. Chemical science in recent years has found the exact chemical composition and nature of the natural dyestuffs, so that they can now be dyed most intelligently and in accordance with the highest development of the theory and the practice of dyeing. New and improved chemicals and dyeing assistants are at the disposal of the dyer. New forms of dyeing apparatus and improved mechanical devices help further. Improved dyeings are to be expected in response to persistent and intelligent work, and during the past months such results have been secured in many instances.

AVAILABLE NATURAL DYESTUFFS

For the dyeing of cotton the following natural dyestuffs are available: logwood, fustic, bark or quercitron, flavine, hypernic and the various redwoods, catechu or cutch, gambier, sumac, madder, Persian berries, and indigo. Of these dyestuffs all except madder, Persian berries, and indigo are available in large quantities.

Logwood is the product of a large tree known botanically as *Hematoxylon campechianum*, which grows abundantly in the West Indies and Mexico. The supply of logwood is not petering out as some have erroneously imagined; the logwood forests have not all been cut off. There are well-nigh limitless virgin forests of logwood in Haiti, Jamaica and Mexico. Reforestation and cultivation are the simplest of operations. The logwood tree is a veritable weed—it spreads itself; twelve years alone elapses between the seed and the tree ready for cutting for commercial purposes. Cultivation consists in keeping the forests thinned out, so that the luxuriant tropical growth will not form an impenetrable jungle. It may fairly be said that never before has there been available more logwood than today.

Fustic, also known as old fustic, Cuba wood and yellow wood,

comes from a tree known botanically as *Morus tinctoria* or *Maclura tinctoria*. It is a native of Brazil, Mexico, and several of the West Indian Islands. Quercitron bark is the inner bark of a species of oak, the *Quercus nigra* or *Quercus tinctoria*, a native of America. It grows abundantly in Pennsylvania, Georgia, and the Carolinas. Flavine is the name given to a preparation of quercitron bark. It contains the principal coloring matter of quercitron bark, quercetin, in nearly chemically pure state. Hypernic is the name given to the color extracted from the various soluble redwoods. These are principally Brazil wood, peach wood, sapan wood, and lima wood. Brazil wood grows in the forests of Brazil. Peach wood is a native of Mexico. Sapan wood grows in Siam, Japan, and the East Indies. Lima wood is imported from Peru. Catechu or cutch and gambier closely resemble each other in properties. They are obtained from various species of acacia, areca, and uncaria, growing in India. Sumac consists of the leaves, leaf-stalks and small twigs of several species of *Rhus*. This shrub is remarkably common and widely spread, growing in Sicily, Tuscany, France, Spain, Algeria, Canada, and the United States, particularly in Virginia.

The various regions from which these natural dyewoods come are with unimportant exceptions outside the inhibiting influence of the war. Accordingly, they are all available. Even prior to the war these dyestuffs were in large general use—much more extensively than is generally realized—so that the present additional demands from the textile mills find an industry well fitted to take on extra burdens and to perform needed services.

BLACK DYEING OF COTTON

Black is the color most widely demanded by the trade, and will accordingly first engage our attention. For black dyeing logwood has been and still is the most generally all-round useful black dyestuff. It can be used not only for the coloring of cotton but also of wool and silk and a great variety of fibers. There are three methods of applying logwood on cotton: (1) the stuffing and saddening; (2) the bluestone soda ash; (3) the mordanting methods.

THE STUFFING AND SADDENING METHOD

In this method of dyeing, the cotton, as piece goods, yarn, or raw stock, is first impregnated with the logwood by passing it through or boiling it in a concentrated logwood extract solution; it is then dried or whizzed to fix the logwood or remove an excess not taken up by the fiber; finally it is passed through a bath of chemicals, usually chrome, or chrome and bluestone, or copperas, to develop the black. Two illustrations of this process will be given: one on piece goods, and the other on raw stock.

LOGWOOD BLACK ON PIECE GOODS—This process makes use of two boxes and has been in constant successful use for the past four years in the dyehouse of a large producer of black dyed cotton piece goods.

The apparatus consists of a stock tank for the logwood liquor and a logwood dye-bath, three sets of drying cans, a stock tank for the chrome liquor and a chrome bath, a steam box, a wash mangle, and a washer. The logwood box and the chrome box are provided with guide rolls, and above the center of each box are three squeeze rolls. The guide rolls and the squeeze rolls are so related that the cloth in its passage through both the logwood and the chrome baths is twice immersed and twice squeezed.

The dry bleached pieces are run into the dye-bath and over the first four rolls, squeezed and given a second run in the dye-bath over the second four rolls, followed by another squeeze. From the dye-bath the pieces are dried over three sets of drying cans. The passage through the chrome bath follows imme-

diately and here, as in the dyeing, there are two immersions and two squeezes. After the chroming, the goods are steamed, and then washed. The washing is very thorough, first by passage through a wash mangle, and then through a washing machine. After washing, the goods are again dried and then finished.

STOCK LIQUOR	CHROME LIQUOR
125 gallons water	125 gallons water
110 lbs. logwood extract, 51° Tw.	49 lbs. bichromate soda
5 gallons acetic acid No. 8	3 lbs. soda ash, 58°
Temperature of dye-bath—near boil	Time of immersion—about 2 sec- onds
Time of immersion—10 seconds	Time of steaming—about 10 seconds

The speed of the machine, 45 to 50 yards a minute, corresponds to a production of about 3,000 yards an hour; but a speed of 75 yards to the minute (4,500 yards an hour) is possible.

The goods are used as linings for suitings, overcoats, and the like, where a black is needed that will not stain white when wet hot-pressed. The logwood process is preferred because of the low cost of production, and the excellent fastness of the result.

LOGWOOD BLACK ON RAW STOCK—The following method is being employed in a Klauder-Weldon dyeing machine, coloring 1,000 pounds of cotton to a batch.

Run for one hour at a boil in a 10 per cent solution of logwood extract, prepared by dissolving 10 pounds logwood extract 51° Tw. to every 12 gallons of water. This solution will stand 4° Tw. at 70°. Take out of machine and whizz. Repack in machine, and strike with 4.5 per cent bluestone and 1.5 per cent soda chrome. Run in striking bath 1 1/4 hours; wash well. Soap in a 0.5 per cent solution of soap; wash and dry. The logwood bath is saved and brought up to 4° Tw. for further dyeings. This method gives a remarkably full and rich black on stock of excellent fastness to fulling and of moderate fastness to light.

THE BLUESTONE SODA ASH METHOD

The bluestone soda ash method of dyeing cotton, or the ash black as it is commonly called, is a favorite method because of its simplicity.

The following recipe is a slight modification of a bluestone soda ash logwood black formula used in a large mill for the coloring of raw cotton, and illustrates well the general principles and practice that are obtained in the successful dyeing of cotton with logwood in the single bath:

DYE-BATHS FOR 100 LBS. RAW COTTON	Starting bath Lbs.	Second bath Lbs.	3rd or standing bath Lbs.
Logwood extract, 51°.....	60	40	20
Soda ash, 58°.....	6	4	3
Bluestone.....	3	2	1.5

Boil 1 1/2 hours. Throw out the stock and allow to drain. Oxidize for two hours, or until the full shade is developed, turning occasionally.

After the standing bath is obtained, enter the first lot for a second dip in the standing bath. After this, one immersion is usually sufficient. If extra heavy shades of black are required, give two immersions or increase the amount of dyestuff and chemicals in the standing bath. If a jetter shade of black is desired, use an ounce of cutch extract for every pound of logwood extract. Some dyers find it advantageous to use also an ounce of sumac extract for every pound of logwood extract.

The bluestone soda ash logwood black can be utilized for the dyeing of other forms of cotton, as cotton yarn, cotton warps and the like; and for the dyeing of a wide variety of cotton fabrics. The following series of formulae are taken from practice:

DYEING COTTON YARN—For dyeing cotton yarn, black dye is usually preferred. Black dye is a logwood extract, which contains a proportion of tannin-bearing material, such as chestnut extract. It gives a very good deep black at an exceedingly low cost.

DYE-BATHS FOR 100 LBS. COTTON YARN	Starting bath Lbs.	Second bath Lbs.	Third or standing bath Lbs.
Black dye.....	50	25	20
Soda ash.....	20	8	3
Blue vitriol.....	10	4	1.5

Boil 1 1/2 to 2 hours, lift and oxidize 2 or 3 hours. By after-treating with 1 per cent chrome at 150° to 160° for 20 minutes, the fastness to washing is made excellent.

DYEING COTTON WARPS—For 650 pounds warp, prepare a bath containing:

130 lbs. logwood extract, 51°	18 lbs. soda ash	12 lbs. blue vitriol
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Give four runs, boiling. Sadden in another tub with 6 lbs. copperas, at 120° F.; finish. This gives a very good black.

The following recipe is an example of a successful application of the use of salt in the bluestone soda ash logwood black. A Klauder-Weldon machine was used in dyeing.

For 800 pounds raw cotton prepare a starting bath containing:

370 lbs. logwood extract, 51°	18 lbs. soda ash
18 lbs. blue vitriol	10 lbs. common salt

Boil the cotton for 2 hours. Oxidize for 2 hours. Afterwards wash in:

8 lbs. soap	15 lbs. sal soda
5 lbs. common salt	1 qt. ammonia

Dissolve the chemicals for the washing in about three-quarters of a barrel of water, and feed onto the cotton at 120°. Continue washing one-half hour.

For a standing bath, gradually reduce the amount of dyestuff and chemicals above given during four or five baths to one-half the quantities.

The bluestone soda ash logwood black can be used for all purposes where fastness to fulling is not required. It is faster to light than the stuffing and saddening black.

THE MORDANT METHODS

By mordant methods is meant those methods in which the mordant is fixed on the cotton previous to the logwood treatment. Two of these methods will engage attention: (1) the iron; (2) the chrome.

1. THE IRON MORDANT BLACK—The iron mordant logwood black has always been employed when a black of special fastness to fulling and light is required. The following recipe is for coloring warps in a four-box machine:

LOGWOOD BLACK ON WARPS—Boil up 25 per cent extract of sumac in the boxes, run in the yarn, and leave over 1 day (36 hours, or more). Treat to two runs in clear lime-water, followed by two runs in pyrolignite of iron, 3° Tw.

In practice the volume of liquor in the iron liquor machine is so small that the readings of the hydrometer are not of much value. It is best to add between 20 per cent and 25 per cent iron liquor, one-half before each run, and to squeeze the warps lightly. Much of the liquid is removed from the bath, and it is generally necessary to add some water on every set. Wait twenty to thirty minutes before washing. Then treat to 1 run in clear lime-water and wash again.

15 per cent conc. extract logwood;	3 per cent conc. extract fustic;
1 per cent copper sulfate	

Add one-half the logwood and one-half the fustic, bring the temperature of the bath to 140° F., and make one run. Add the remainder of the logwood and fustic, raise the temperature to 170° F., and make one run. Raise the temperature to a boil and make six runs. Add the copper sulfate in solution, half on the fifth and half on the sixth run, there being eight runs in all. Then wash with 1 run.

One per cent potassium bichromate

Add one-half the bichromate to make one run at 180° F. Add the remainder and make one run at the same tempera-

ture. Wash with 2 runs. Finish with 3 per cent lard oil and 3 per cent soft soap (one run).

The above process can be shortened considerably with equally satisfactory results, by the use of the machinery constructed for the dyeing of sulfur colors. These machines give longer immersions than the old Scotch tubs, and have heavier nips.

FOUR-BOX MACHINE	
First run	First box: 50 per cent sumac extract, 180° F.; nip
	Second box: 30 per cent nitrate of iron; cold; nip
	Third box: Lime solution; cold; nip
	Fourth box: Water
Second run	Three boxes of logwood
	30-40 per cent to each box, boiling
	Fourth box: Wash

Practically the same processes may be used for pieces.

2. THE CHROME MORDANT BLACK—The chrome mordant black came into being in response to the request to dye logwood blacks on raw stock in a vacuum dyeing machine. In this machine the methods above described, except the iron mordant method, do not give any results at all.

The use of a chrome mordant to develop and to fix logwood on wool is a well-known dyeing process. It yields blacks of excellent fastness to fulling, light, and various other agencies, and of exceptional beauty. The idea to adapt this method of dyeing wool to obtain equally fast and handsome results on cotton has long been alluring. Various methods of mordanting the cotton with chrome that have been tried in the past have not met with wide or permanent success.

The trouble has always been either that the chrome would not go on the cotton fiber or was deposited so loosely that in washing it nearly all came off.

These difficulties have recently been overcome by the use with the chrome of a compound (invented by a well known chemist) which causes the chrome to exhaust onto the cotton and to be deposited so firmly that even severe washing will not strip it off.

The preliminary studies for the practical use of this new method of mordanting cotton were made in the model laboratory of the American Dyewood Company. This laboratory is fully equipped with small size dyeing machines of latest invention. Through the courtesy of Mr. W. A. Mitchell the work has passed beyond the laboratory stage. Mr. Mitchell generously offered the use of the dyehouse of the Massachusetts Cotton Mills for trials on a practical scale; and the results obtained in the laboratory of the American Dyewood Company have thus had the benefit and the test of the splendid personnel and equipment of Mr. Mitchell's plant.

The following recipe was employed in the coloring of 150 pounds of raw cotton in a vacuum dyeing machine:

BLACK ON RAW COTTON—After loading the machine, fill with water and bring to a boil. Boil ten minutes to ensure thorough wetting out of the cotton. Add 6 lbs. of soda chrome dissolved in three pails of water, and after the chrome liquor has well circulated, add slowly 3 lbs. of chrome assistant dissolved in 2 pails of cold water. Boil one hour; wash. Fill the machine with water and bring to a boil. Prepare a half barrel of logwood extract liquor 15° Tw. containing 10 per cent fustic, and six pails of clear lime-water. Boil the logwood liquor well. Add slowly to the machine, and boil one hour. Wash. Strike cold with 1 lb. of bluestone and 8 oz. of chrome. Wash and finish as usual. Soaping improves the beauty of the shade, but is not essential.

The more concentrated the chrome liquor the more quickly the cotton takes up the chrome and the less the time required for boiling. From two-thirds to five-sixths of the chrome is exhausted on the fiber. The logwood liquor is not exhausted, but should be run off and kept for use in subsequent baths. The heavier the black required, the more concentrated should be the logwood liquor.

This process gives a black of excellent fastness to fulling and to light. The stock cards readily and the feel is especially satisfactory.

The process has been tried practically only on raw cotton. It has given good results in the laboratory on yarn and pieces. As the coloring of raw cotton in a vacuum dyeing machine is the hardest test of a process, there is good reason to believe that the new chrome mordant method can be adapted in practice to the coloring of the other forms of cotton and in the various other dyeing apparatus.

3. FASHION SHADES ON COTTON—Next in importance to black come the fashion shades. Many artificial colors are so brilliant that the great fear of many people has been that without these the consuming public could not be satisfied. A few illustrations will show that besides blacks the natural dyewoods can be made to yield a wide variety of fashion shades.

In dyeing the fashion shades, the stuffing and saddening method and the mordant method are applicable.

CATECHU OR CUTCH AND GAMBIER BROWNS—These valuable dyestuffs yield browns of specially pleasing tone and satisfactory fastness. The following recipe represents the method of dyeing a medium shade of cutch brown on pieces in a jigger:

For 100 lbs. of goods use 50 lbs. of good extract cutch. Enter goods nearly at a boil. Add the color in two ends. Then add 5 lbs. of bluestone. Bring to a boil, and boil one hour; shut off steam and allow to run from one-half to three-quarters of an hour. Draw off liquid and run in 2 lbs. of chrome. Run twenty minutes at 140° F. Rinse and dry. For a standing bath the amount may be reduced one-third. Gambier may be used in place of cutch and acts similarly.

For the toning of browns, fustic, bark and flavine are available as yellows, and hypernic as a red. Logwood, sumac, and copperas can be used for darkening.

Two illustrations follow: a light, bright brown dyed in a four-box machine, and a dark brown dyed in a jigger.

LIGHT SHADE OF BRIGHT BROWN—Prepare gambier, bark, and chrome solutions at 10° Tw. The gambier and the bark are divided between the first two boxes. Use fifteen pails of gambier and nine pails bark. The third box contains cold water, and the fourth box the chrome. Use eight quarts of chrome liquor. After leaving the chrome bath the goods are well washed in a water mangle. Repeat the process. Dry and size.

DARK BROWN—Prepare a solution in the jigger containing for 100 lbs. of goods: 10 lbs. hypernic crystals; 5 lbs. logwood extract, 51° Tw.; 15 lbs. extract of fustic, 51° Tw.; and 15 lbs. extract of bark, 51° Tw. Add the color in two ends. Boil one-half hour; shut off steam. Add 1 lb. of bluestone. Run fifteen minutes. Add 2 lbs. chrome. Run fifteen minutes. Wash.

The use of logwood for blacks has so overshadowed the other natural dyestuffs that the thought of violets, oranges, reds, bright yellows and blues does not come easily to mind when natural dyestuffs are mentioned. For this particular purpose, the new mordant process is especially adapted. On the table, in addition to sample dyeings of the other processes described, are a range of bright fashion shades colored by the new mordant process from natural dyestuffs.

In discussing this process earlier in the paper, mention was made only of the ability of the new assistant to exhaust chrome on the fiber. This chemical is also able to fix other mordants—aluminum sulfate, tin crystals, copperas, and blue vitriol, on cotton, and so firmly that washing will not strip the mordants. These mordants then react with the natural dyestuffs to produce a diversification of shades. Thus fustic on a tin or aluminum mordant produces brighter yellows than on a chrome mordant. Logwood on a tin mordant gives violet to bordeaux shades of excellent brightness.