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THE TEXTILE INDUSTRY AND ORGANIC CHEMISTRY.

By Dr. M. O. FORSTER, F.R.S.

I FEEL that I lay myself open to a charge of presumption in addressing The Textile Institute, because, apart from the fact that during the last two years I have been called upon to study certain problems connected with the cotton industry, my acquaintance with textiles is not much more intimate than that of an average member of the public ; but whether or not lookers-on see most of the game, it certainly does happen sometimes that a chance word from a sympathetic observer may influence the game in a useful direction. On that ground, coupled with the fact that I share with those actually engaged in this industry an earnest desire for its continued prosperity, I embrace this opportunity to plead for an infant branch of your activities, namely, the Research Department, which entered the world in response to the enlightened generosity of a Member of your present Council.

Among the numerous topics which the war, like a huge cauldron of boiling liquid, has brought to the surface of public discussion, is the proper relation between Science and Industry. It is not new, nor is it really more urgent than it has been at any time during the past thirty years, but present circumstances have combined to impress it so deeply upon the public mind that probably for the vast majority of our people its consideration came with an air of novelty. After a year of conflict, even those who never gave much thought to the subject are now agreed that a union, approaching in permanence and intimacy that of matrimony itself, must in future link these two forms of human activity if the commercial prosperity of the British Empire is to be maintained and the social welfare of its citizens augmented. The celebration of this union has been delayed and hampered by some confusion as to which is the bridegroom and which the bride. Another factor which, in my opinion, has operated more strongly, lies in the fact that Industry, bold, assertive and enterprising, has failed to recognise in the modest and retiring virtues of Science any of those qualities which are desirable and helpful in a life-partnership. In some cases Industry has been content to use Science as a handmaiden without admitting her to the privileges of complete union. An exception to this generalisation may be claimed for engineering, however, where, in most of its branches, full use has been made of the underlying scientific principles by its practitioners.

Possibly for this very reason the importance of chemical science has not obtruded itself upon the textile intelligence, because the foundation of the modern cotton and woollen industries was laid, I imagine, principally by the early skill in engineering displayed among our own countrymen. The engineering tradition, thus firmly established, has held somewhat autocratic sway, and the potentialities of chemistry have remained in the background. It is nevertheless a fact that the development of the textile industry during the past forty years owes quite as much to chemistry as to engineering, and the recognition of this fact by Germany, coupled with the failure to recognise it here, is responsible for the embarrassments in which our dyers are now involved.

So long as the range of colours applicable to the textile fibres was limited to the gifts of Nature, this country was able to hold its own in respect of these necessary adjuncts to textile manufacture, but with the introduction of artificial colours, dating from Perkin's discovery in 1856, a progressive alteration in the centre of gravity has taken place, the net result of which is to render the industry no longer self-contained so far as this country is concerned. Considering the justifiable pride we have taken in the principal industry of Lancashire and Yorkshire, and the huge population which depends for livelihood upon its success, the discovery of this vital flaw in the machinery is not merely humiliating, but alarming, and it has become an urgent national necessity to recover the position which we once occupied. The loss of that position is due to British neglect of chemical science, and it is difficult to understand how it has come about that the textile industry, which is as highly organised as any in the country, and which includes a large proportion of the best business brains in the country, should have been so deficient in strategy as to neglect this *point d'appui*, and thus allow its trenches to be enfiladed. It would have paid the textile industry, over and over again, to have begun the manufacture of its own artificial colours thirty or forty years ago, and by the encouragement of research to keep abreast of the Continental advances in chemical science. The bitter irony of the situation lies in the fact that not only could this have been done by a pecuniary outlay which would have been inconsiderable if calculated as a percentage of the annual turnover concerned in the textile industry, but artificial colour manufacture itself could have been made the source of substantial profits, as proved by the flourishing condition of this enterprise in Germany before the war. Furthermore, the textile industry would have been defended—in this connection I dare not say protected—from the depredations of its envious competitors. It is scarcely possible to imagine a more glaring illustration of "penny wise and pound foolish."

The point of these remarks may be emphasised by a brief survey of the manner in which organic chemistry has become indispensable to the textile industry. Although the discovery of mauve, in 1856, was the first step in the revolutionary course, it was not until about 1870 that the subsequent turn of affairs became clearly defined, for 1868 marked the discovery of a process for the synthesis of alizarin. This was followed immediately by the elaboration of a commercial method which has never been displaced, and which resulted not only in the complete elimination of madder, but offered the first extensive market for fuming sulphuric acid. The latter sequence is incomparably the more important of the two, for whilst alizarin could always have been produced from the natural source, a recognition of the advantages possessed by oleum would have been postponed. Continental chemists responded to the new stimulus with such vigour, however, that they rapidly placed themselves in a strongly fortified position regarding this material, which, if coal-tar colours represent the Cinderella of chemical industry, has fully earned the title of the Fairy Godmother. Moreover, the ramifications of this development may be traced still further, for it is to the concentration of thought and technical skill upon the manufacture of sulphuric acid by the contact process that there may be reasonably ascribed the application of catalytic processes to such vital problems as the synthesis of ammonia, and its oxidation to nitric acid, the possibilities of which were quickly recognised by the chemical engineers of Germany, and the benefits of which are now being reaped by that country. Incidentally, it may be mentioned that another recent application of the catalytic principle, also of great industrial importance, is the process known as fat-hardening, by which

enormous quantities of uninviting whale-oil are convertible into an amenable raw material for the manufacture of soap.

Returning now to the development of the synthetic colour industry, reference must be made to the far-reaching series of operations depending upon what is known to chemists as the diazo-reaction, which underlies a great number of valuable colouring matters still in common use. Although discovered by a German in Germany, its elaboration was conducted in Great Britain, and its early fruits were garnered here; but in this case also the wider developments have passed to Germany, owing to the discouragement of its exponents by the manufacturers of this country, and the quick recognition of its attractions by Continental industrialists.

By this time, England had become the spoiled child of the industrial family, and regarded the applications of chemical science as mere crumbs falling from the rich man's table. In consequence of the technical skill acquired by German chemists in working up these crumbs, and the prompt appreciation by State and Industry of their possibilities, applied chemistry in Germany has reached a pitch of excellence which cannot be attained in this country unless our manufacturers and Governments are prepared to bend their best endeavours to its rehabilitation. Mutual recriminations are futile, because we are all guilty. We must all, business men, scientific men and politicians, pure or applied, after a brief but salutary séance in sack-cloth and ashes, and after properly bewailing our past neglect, resolve that in future our conduct shall be sane and strenuous. It is fatuous nonsense to accuse Germany of having abducted chemistry; Germany has wooed and won her, and even if the recent abominable misuse of chemical science is justification for divorce, our only hope of succeeding Germany in her affection lies in employing the time-honoured methods of civilised courtship.

No better example of this principle could be adduced than the history of synthetic indigo. The experiments which opened the campaign began about 1865, and were directed at first towards elucidating the constitution of this colouring matter: it was only after fifteen years of patient enquiry that a process for its artificial production was patented, and another decade of incessant and elaborate research was necessary before there developed a method which was commercially profitable; even then, when the chemical difficulties had been overcome, the engineering obstacles were surmounted only by years of study, but the victory, when it came, was complete. Considering the importance of indigo to the Empire of India and to the cotton industry of this country, it is difficult to describe in restrained language the want of foresight, which not only so neglected the cultivation and standardisation of the natural product as to lay it open to the attack of its artificial rival, but also ignored the branch of scientific knowledge by which the secrets of its laboratory production could be revealed. A terrible Nemesis has punished this neglect, for it is the technical skill acquired by Germany in producing and transporting the liquid chlorine necessary to the indigo synthesis which has enabled her warriors to avail themselves of the dreaded "poison-gas."

Artificial indigo became a commercial reality in 1897, but it is not the latest contribution of German chemistry to the realm of colour. It has been the source of numerous indigo derivatives, and it is doubtless the study of these and of thioindigo which has given impetus to the whole domain of vat-dyes, culminating in the developments associated with the indanthrene group. Here, again, the manufacturers of Great Britain have allowed themselves to be hopelessly outpaced, and the consequences are now too well known to need any description.

Although these remarks have been directed towards the British neglect of colour chemistry, because that is the branch of science with which you are most closely connected, it should not be overlooked that drugs, perfumes, photographic materials and explosives have suffered in similar fashion, but the object-lesson is not so convincing to you because these products do not stand in the same vital relation to a huge industry as that occupied by colours towards textiles. In fact, it is only in the production of heavy chemicals that this country can claim to have held its own, which brings out very clearly the circumstance that it is the neglect of organic chemistry, the chemistry, that is, of carbon compounds, which has caused the trouble, because heavy chemicals are independent of that branch of science. It should not be beyond the collective wisdom of those responsible for the guidance and conduct of the textile industry to devise methods which, whilst the omissions of the past cannot ever be repaired, may limit the disastrous possibilities of future neglect.

My purpose in thus tracing, as briefly as possible, the manner in which organic chemistry has secured its grip on the textile industry, is to show that each stage has been reached only by patient research, and that when reached, it has offered a fresh vista of industrial enterprise capable of yielding new sources of profitable development. Among the reasons why this country has fallen so far behind in the application of chemistry to this branch of industry is the fact that it appears to be practically impossible to explain to the busy man of affairs just what chemical research involves, and what it is capable of yielding. The business genius of this country, drugged by the engineering tradition and by fat dividends, has been blinded to the fact that successful chemical enterprise not only yields fat dividends but is completely dependent upon engineering. Hence, even those business men whose horizon is limited by profits and machinery could have wallowed in profits and rioted in machinery during the conduct of a successful courtship of chemistry, either personally or by proxy.

There is, however, a much wider question involved, namely, the mental attitude of our whole people and the manner in which that depends upon our system of education. There is no longer any doubt in the minds of advanced thinkers that the curricula of our schools and universities have been dominated too long by the classical system, and the future offers no hope for this country unless the stifling effect of this obsession can be swept away. It is a direct inheritance of monkish days when Latin and Greek were the only avenues of knowledge, and has survived by persistently injecting the superstition that only by studying these tongues can orderly mental habits be acquired. Modern languages may serve the same purpose, however, and being by most people more rapidly assimilated, leave valuable time for the rudiments of natural science to be absorbed. One far-reaching evil of the system has been to render our business elements university-shy. It has been a common thing in the past to hear a successful business man declare that he will not employ a university graduate in his organisation, and he has sometimes sent his own son to the university by way of alienating the boy from business. This has been one of the intellectual tragedies of the Victorian era, because an enlightened university career should be the best equipment for a commercial one. Happily, the business community is awaking to this, as indicated by the rapid growth of the modern university, notably Birmingham, Leeds, Liverpool, Manchester, and Sheffield, one effect of which has been to galvanise Oxford and Cambridge into a healthy taste for modern study. It is to be hoped that there will come a time when every controller of a large business, whether manufacturing or distributing, will have been

fortified by a training of this character, for the management of such concerns depends quite as much upon knowledge of men as of things. The vital qualifications for success are loyalty to the organisation, capacity to weigh evidence, and human sympathy with colleagues; some happy natures may gain these attributes independently of collegiate life, but the great majority of us can achieve them only from some kind of corporate associations at the impressionable age.

When it has come about that a modern university training is recognised as a valuable qualification for a business career, it will not be possible to reach a position of real influence in the State or to become a power in commerce without having secured a grasp of the incalculable potentialities of applied science, including perhaps even a slight technical knowledge of at least one branch. If we were not at war, it would have been advantageous to indicate some of the colossal ineptitudes which have directly followed the disregard of scientific method in high places, but at the moment it is our common duty to make the best of existing conditions, and the first step will have been taken when the business brains of this country realise that there is scarcely a manufacturing industry of any magnitude which does not, at one point or another, and more or less intimately, depend upon chemistry. It will be necessary for these brains to make some endeavour to understand what chemistry is and what chemists do. Until the autumn of 1914 most people in England appeared to think that chemistry is intimately associated with the sale of tooth-brushes and sponges. The absence of clear differentiation between chemistry and pharmacy in the public mind is revealed whenever, in conversation, a chemist is called upon to explain to a layman the existing shortage of dyes in this country. The question is asked, "Oh, but surely we know how they are made?" In a general way we do know how they are made, but what the layman does not understand, unless he himself is some sort of craftsman, is that there is all the difference in the world between knowing how a thing is made and knowing how to make it. You may know how a dye is made, you may be able to go into the laboratory and make it—on a small scale—but if it is to be made in quantity, and for sale, there may be a dozen points, each of which will take a trained chemist a whole year to elucidate, before the conditions of manufacture can be so clearly determined as to secure a profitable yield. This is research, and it is because the few people who, from time to time, have been able to make dyes in this country, have been discouraged from employing chemists in conducting their researches, whilst such researches have been sedulously prosecuted in Germany, that we and the United States find ourselves where we are, namely, in the cart; happily, the cart has not yet reached the scaffold, although the guillotine is in sight.

Perhaps it may assist those who are not chemists to gain some idea of the extent to which research is practised in the German colour-factories if I mention that on visiting the experimental dye-house in one of these a few years ago, I was informed that on an average six new colouring matters were tested every day, although, amongst these, perhaps only six per annum would be proved commercially successful. I had no reason whatever to doubt that statement. The extent and appointments of the dye-house in question fully justified it, the equipment actually including a small paper-making machine, costing £5,000, so that promising colours might be tested in respect of their application to this particular material. Remember that these elaborate operations were regarded as necessary to the colour-factory, and were not part of a dyeing enterprise. Remember that they are merely ancillary to the far more elaborate and costly chemical operations which

had to be undertaken before the colours reached even this experimental dye-house. Furthermore, remember that in respect of new dyes, all these operations have to be completed satisfactorily before the question of plant arises and the services of the engineer requisitioned.

At the present moment it is not possible for our dye-factories to accomplish much in the direction of elaborating new dyes ; all they can hope to do with any approach to success is to attempt the production of those colours to which our consumers, spoon-fed with German produce, have grown accustomed. Even to achieve this restricted object, however, much of the experimental ground already traversed by the German producers must be investigated anew if the steps of our competitors are to be successfully traced, and owing to their superior technical skill, patiently acquired through decades of study, and their far more systematic manner of arranging and recording their experiments, this in itself will be the work of many years. I believe, however, that the colour-makers of this country are honestly and industriously attempting this undertaking, and it is of the utmost importance that they should receive the greatest possible encouragement from the consumers, who must rigidly deny themselves the expectation of miracles, for miracles are not on the list of experiments. The neglect of thirty years, with the moral and intellectual damage arising therefrom, are not to be repaired by the wave of a magician's wand. Instead of this or that company being condemned for not achieving the impossible, largely because the thoroughly well-meaning critics have incomplete knowledge of what the impossible involves, every British enterprise which is attempting to cope with the demand for colours has a right to expect the most liberal support, both sentimental and pecuniary, from consumers, the public and the Government. We are all in the dock together, and whilst it is perfectly excusable to hope that the sentence may be as light as possible, that sentence will not be mitigated if any one of us tries to escape by turning King's evidence.

In this brief review of existing circumstances, I have endeavoured to indicate in a few words the principal reasons for our present embarrassments. The remedy is at hand, but its adoption must be undertaken collectively by all earnest and thoughtful members of the community, and not left to politicians and educationists. That remedy, in my belief, is a drastic but good-tempered readjustment of the perspective which has allowed an ornamental study of the past fatally to obscure the realities of the present and future. A system by which all the State prizes are most easily attainable by classical study is dangerous and debilitating, because by its means most of the best and brightest brains of the country—other than those absorbed by commerce, the navy, the several great engineering industries, and medicine—are attracted into comparatively useless channels, thus acquiring an outlook on life which, although doubtless highly decorative, unfits them to deal with complex modern problems. For instance, when the question of dye-shortage first became urgent, it was quickly revealed, not merely that no single Minister was able to bring first-hand knowledge to the subject, but what is even more significant, that scarcely half-a-dozen among the elected representatives of the people possessed anything but a hazy idea of the real nature and origin of the difficulty. Yet these circumstances have been common knowledge for thirty years to the small band of saddened and discouraged chemists who have cried in the wilderness of their country's indifference.

The real trouble begins in the schools, whence the brighter boys are attracted by classical scholarships to the university, with the result that the principal masterpieces are perforce occupied by classics, otherwise the parti-

cular school falls behind in the race for public honours. The research minds among these boys then yearn for classical Fellowships, and, having achieved them, spend the rest of their days finding alternative explanations of obscure passages in Greek or Roman writings when they are not engaged in stimulating similar ambitions among fresh generations of students. The consequent misdirection and waste of intellectual effort is appalling, but it can be diminished by a strong parental demand for school instruction in French, German, Spanish and Experimental Science. By these studies a boy may learn to verify old facts and discover new ones, whilst classics teach him only other people's opinions about the old ones. We go to school in order to learn how to learn, and most of us have learned principally how to learn the less important things; in fact, the one indispensable thing which our public schools have taught in the past is quite independent of their study-courses, namely, team-work, *esprit de corps*, loyalty to the organisation. So long as this is preserved—and nobody can pretend that it has any connection with classical study—we might surely make our school system a real preparation for meeting the greatest needs of life, namely, the study and solution of problems. What is life, after all, but a continuous and splendid research into men and things, for which the most important equipment, next to a robust constitution, is a spirit of intelligent, patient and sympathetic enquiry?

Reverting, in conclusion, to the textile industry and organic chemistry, it may be worth while to point out that Americans are making a determined effort also to throw off the colour-yoke of Germany, and in certain respects they are situated more favourably than ourselves. In the first place, their business elements comprise many alumni of the modern university, and are therefore alive to the importance of employing graduates in their organisation. Secondly, they possess a flourishing heavy chemical industry, including the technical skill necessary to the production of oleum, the elixir of chemical life. Thirdly, they have great power of organisation, and lastly, when the time comes, they can rely upon whatever type of intelligent Government support may appear at the critical moment most potent in application. These factors are powerful enough when taken alone, but considered in the light of a recent Report to the Department of Commerce, showing that the coke industry of the United States alone can be rendered capable of supplying twenty times as much of the coal-tar products now required for the world's consumption of artificial colours, they become overwhelming. This being so, it is quite possible that if the war is of duration sufficient to give American manufacturers a fair prospect of success, they will put themselves in a position of independence regarding Germany. If in the meantime we have not done likewise, this country may become the dumping-ground of American as well as German dyes, and the last state of the British colour industry would be worse than the first. I am not dismayed by this possibility, however, cherishing sufficient faith in the courage and good sense of my countrymen to believe that they will recognise the facts in time, and by cheerful, loyal co-operation in confronting them, triumphantly mould their present misfortunes into the constituent elements of a happier destiny.

DISCUSSION.

Professor A. F. BARKER said that he was particularly interested in Dr. Forster's observations upon the question of education. In one school of which he knew, which was preparing for Oxford—perhaps *the* classical school of the country—he knew that the opinion of certain of the masters

was that classical education was a mistake. "But," they said, "we have to prepare for Eton and Oxford, and what can we do?" Really, the question was a very serious one, because unless they got at the fountain head the difficulties were almost insuperable. In another school, the headmaster told him that he had had a great task to get rid of the medieval traditions. Many of the medieval traditions were excellent, and he did not think there was the slightest need for them to be lost, but there was need for them to seriously consider the position developed by tending too closely on lines that were out of date. In connection with the Leeds University, they had developed there such a course as he thought Dr. Forster would approve of. They were very strongly advising their men to pay a great deal of attention to physics and chemistry, and, with the excellent equipment there was there, men could, while taking their bigger studies, take these others in addition.

Mr. J. A. BROOKE, M.A. (Chairman of Governors of the Technical College, Huddersfield), ventured to hope that while these subjects would be debated, and ought to be debated by the Textile Institute, it would not be allowed to go forth that the Institute had set its face against the classical education. He imbibed a little classics sixty years ago—he ought to have imbibed much more—and he would not be able to understand the language of science to-day if he were not able constantly to refer to his Greek and Latin dictionaries. He hoped it would not go forth that there was necessary opposition between classics and science, but he hoped that it would go forth that the two had to be co-ordinated one with the other.

The MAYOR OF HUDDERSFIELD declared that Dr. Forster was an acquisition to Huddersfield, and those present who had heard him that morning would no doubt have increased faith in the work he was attempting to do. He (the speaker) would like to appeal to manufacturers who were present who saw what meetings and papers of that sort meant to the textile industry to bring in other manufacturers, so that they might gain strength. He wanted the people of Huddersfield to have the fullest advantage of the brains that had come amongst them, because after all it was ideas that governed the world, and the textile industries had men of ideas. He hoped the textile people would back up the Institute to the fullest extent in their power. He, himself, never had any education, but when his daughter grew up and he sent her to Cambridge he told her to go on the modern side. He was sure in this matter, as in all other matters, the war was going to make them pull together, and if they could only express their ideas to one another it would be helpful in bringing about a better state of things than had existed in the past.

The PRESIDENT said the address Dr. Forster had given would be an inspiration to all who had heard it. He did not know whether he was right in saying that Dr. Forster was already a member of the Textile Institute. If he were not, he would take that opportunity of proposing him. (Laughter.) If Dr. Forster would attend their meetings occasionally and give them similar inspiring addresses, they would be all the better for having made his acquaintance, and he would be all the happier for having another opportunity for doing good. (Laughter.) The address he had just given was of incalculable importance. It went over the ground they themselves had trodden many times with far less ability to deal with the subject, and had given him something of a thrill of interest, and to some extent of belief in the aniline dye question.

The MAYOR said that the Chairman of British Dyes, Limited, was present, and might like to say something on this important subject.

Mr. J. FALCONER, M.P. (Chairman of British Dyes, Limited) said that in all their arrangements with regard to their effort to solve the dye problem in this country they had realised the importance of the technical and the scientific side of the work. It was only one side, but it was by far the most important side of the question with which they had to deal. For that reason a far more important personage than himself, who occupied the chairmanship of the company, was the gentleman who had undertaken the task of presiding over the Technical Committee of British Dyes, Limited. He (the speaker) wished to express the great sense of appreciation which he had of the spirit which had been shown in Dr. Forster's paper from beginning to end. Personally, he was perhaps an illustration of the kind of man who ought not to have anything to do with the management of an industry if the principles which Dr. Forster had so well expressed were really carried out to the full extent. He certainly was not pure in anything scientific, and he was very doubtful as to how far he might be useful however he might be "applied." (Laughter.) Therefore he did not profess that anything he might say on this subject was entitled to weigh with an Institute such as that composed of men whose daily work it had been to carry on their businesses successfully in connection with the manufacture of textiles, but he would venture to say this. He had given the best thought that he could to the difficulty which they had to solve and to the interests the dye manufacturing industry had to serve, and he was convinced that it would never be solved unless the general body of manufacturing people realised that they must yoke science to their industrial ability and to their engineering ability. He agreed entirely with what Dr. Forster had said. Unless they had as complete, as devoted, and as successful scientific assistance in connection with their industries they could not possibly hope to compete in the struggle with other nations—not merely Germany, but other nations abroad; and, therefore, he was very glad to be present, and particularly glad to note the reception given to Dr. Forster's paper by the Members of that Institute. At the beginning of their effort, and he dared say still, those actively associated with the direction of British Dyes, Limited, had had much encouragement from the enlightened men engaged in the textile industries. One was also aware that still there was a good deal to be done before everyone would fully realise the importance of encouraging scientific effort. It was a great satisfaction to him to see that in a meeting like that the principles which Dr. Forster had referred to, and the spirit in which he had spoken, were received with warm and cordial approval. He was certain that if Dr. Forster would go on preaching he would find a response at the present time in the minds of all enlightened business men engaged in industries of that kind, and he would certainly communicate encouragement to those of them who were concerned with putting the thing into practice.