JOURNAL

OF THE

OIL AND COLOUR CHEMISTS' ASSOCIATION

Vol. 54 No. 1 **January 1971**

First list of exhibitors at OCCA 23

OIL & COLOUR CHEMISTS' ASSOCIATION
WAX CHANDLERS' HALL,
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introduction to paint technology

second edition with additional chapter

The sales of this Association publication now exceed 13,000, and because of continuing high sales of the second edition, and the need for a work of reference to be constantly abreast of the latest developments in its field, the Council of the Oil and Colour Chemists' Association has authorised the addition of an eleventh chapter to the 'Introduction to Paint Technology.' Entitled 'Recent Developments,' the Chapter incorporates up-to-date information on the latest advances in the technology of the paint and allied industries.

This addition will help the 'Introduction to Paint Technology' to maintain its position as an invaluable aid to young entrants into the industries and to marketing and other personnel requiring a basic knowledge of the principles and techniques of surface coating production and application.

new chapter

The new chapter is subdivided to three sections

resins and media

Including polyester, epoxy, polyurethane resins and developments in water based paints, vinylics, etc.

application techniques

Including electrodeposition, powder coatings, strip-coating, aerosol spraying.

instrumental testing and control methods

Including colour measurement, viscometers, brushability, hardness, film thickness, weatherometers, and use of computers.

The book contains 204 pages including 11 line diagrams, 8 photographs of common paint defects, and comprehensive index. Copies can be obtained from the Oil and Colour Chemists' Association, Wax Chandlers' Hall, Gresham Street, London E.C.2, price 20s. (post free).

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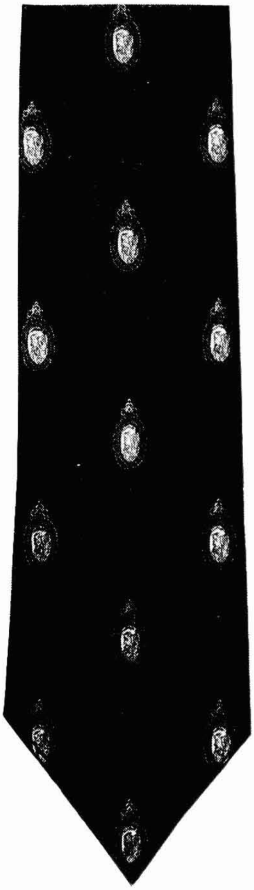

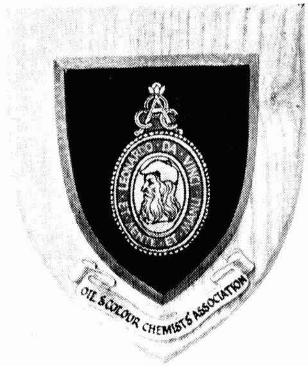

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The plaque has the insignia hand-painted in red and gold on a blue ground.

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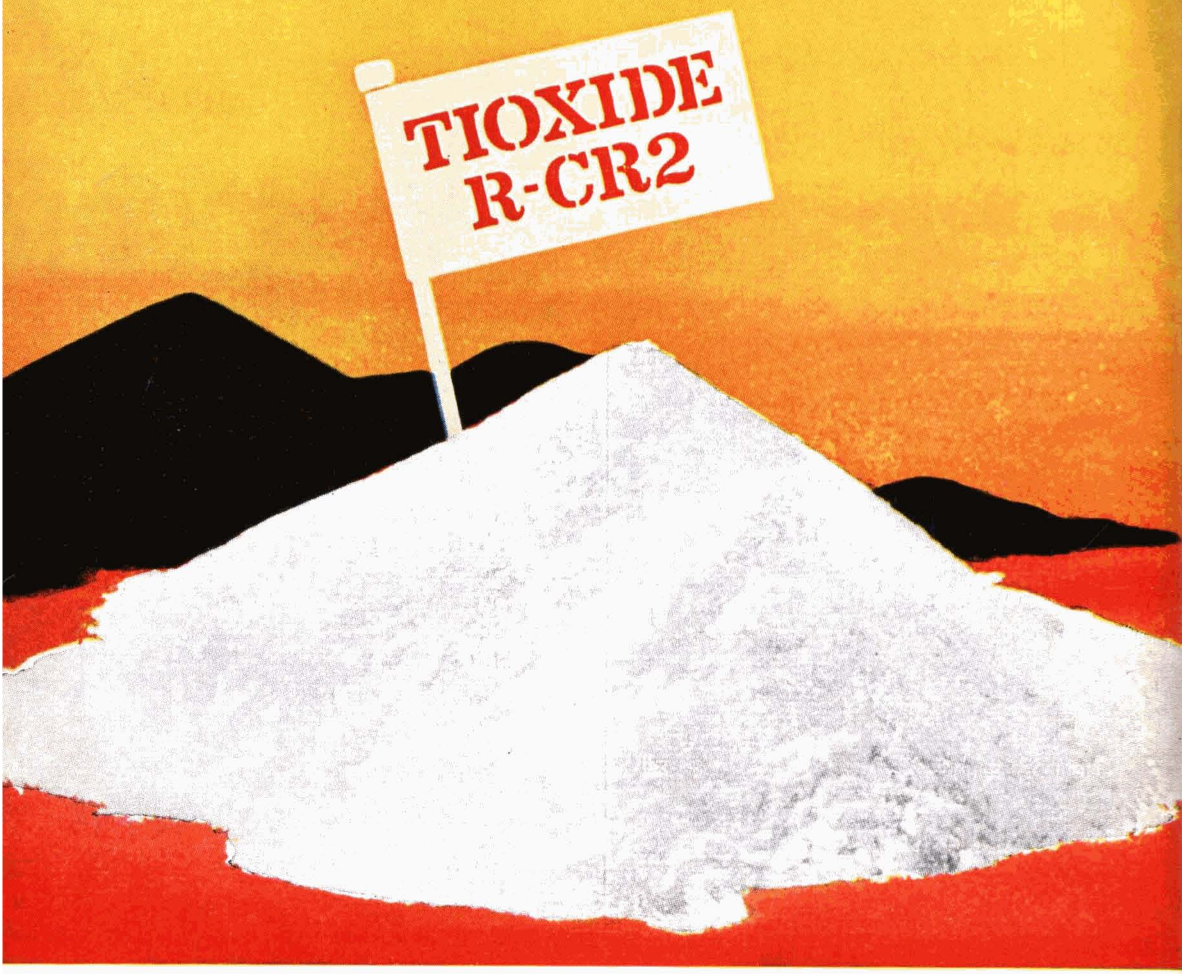

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Foundation Lecture

Human relations and communications in industry*

By Sir Paul Chambers

President of the Advertising Association, Chairman of the Royal Insurance Co., Ltd.

We are all aware of the great contributions that have been made to productivity in industry by technological advances since the war, but we are equally aware that much of the potential progress is being frustrated by disharmony, disaffection and bad human relations.

In this lecture I shall not be concerned with technical matters but solely with human relations and the nature of communications between persons or groups of persons within a single industrial enterprise. Communications, of course, can be between equals with different jobs or functions within the organisation, from somebody in authority to a person or group of persons over whom he has authority, or in the opposite direction, i.e. upwards to those in authority.

A communication can be an order, a request, a suggestion, information or the response to a communication in the form of a comment upon a suggestion. It is an elementary rule, not uncommonly overlooked, that the originator of a communication should be quite clear as to which of these types his communication is intended to be, and what he expects to be the result of making it.

The nature and the basic form of these different kinds of communication are of the greatest importance, both to the happiness of the persons concerned and to the efficiency, and, therefore, to the productivity and profitability of the enterprise. Good human relationships and good personal communications do not just happen in *any* organisation, and are very difficult to achieve in any *large* organisation without some hard thinking and planning.

The first and most elementary condition for good relationships and communications is that those in control of the enterprise have clear objectives and clearly expressed policies for the achievement of those objectives. Without this condition different persons within the organisation can get seriously at cross purposes. An atmosphere in which nobody knows the reasons for the work they are doing or where it is all leading, or in which there is a feeling that the objectives are anti-social, can lead to poor work done in a perfunctory manner, and to a "couldn't care less" attitude of mind.

In competitive private enterprise more harm than good is done by being sentimental, or hypocritical, about basic objectives and policies.

To maximise *long-term* profitability by fair, competitive production and marketing is, in my view, the natural and right objective of an industrial undertaking owned by shareholders in a society which recognises individual freedom

*Presented to the Association on 8 October 1970

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of choice, and this objective is more likely to be in the interests of society as a whole than any woolly objective such as "operating in the national interest." The inclusion of the words "long-term" and "competitive" is essential in this definition of the objective; the making of large profits by the maintenance of monopoly conditions, and the making of quick short-term profits at the expense of the future, are objectives of a different character altogether and much more difficult to defend.

Given the qualification of "long-term" to the word "profitability" and of "competitive" to "production and marketing," the interests of employees and customers are assured, as far as this is practicable in the circumstances of the business, because unless employees at all levels have good pay and conditions the right kind of men and women will not be recruited and kept in the business and, similarly, without products which are competitive in price and quality customers will turn to other suppliers.

Some of you may feel that this statement of objectives in private enterprise is so obvious that it is unnecessary to spell it out in this way. I do not agree. There are still some enterprises in British industry in which the directors have no clear understanding of their objectives and policies, and who rather vaguely feel that if they are technically competent, somehow or other the profits will follow. Some directors feel that they should work "in the national interest" or "to expand exports at all costs" and they end up working *against* the national interest by making losses (which means the loss of valuable resources to the nation) and by losing exports by being uncompetitive. Such directors need to sharpen up their ideas about their objectives and their policies or be replaced by others.

Secondly, however difficult it may be, there is a great need to explain the objectives, and the policies being followed to achieve these objectives, to all employees. Whether all of them will accept the explanations is another matter, but my experience is that, except for those whose minds are closed and who have in advance determined not to accept the explanations given, the extent of recognition of the arguments and their acceptance can be very high. Incidentally, the tentative adoption in certain communist countries of profitability in place of output as the criterion for bonuses for factory production must be giving second thoughts to some of those to whom "profits" has always been a bad word. I should add that personally I have reservations about this new practice in countries where the other conditions of private competitive enterprise are absent.

It is essential, however, that in any explanation "profits" and "profitability" should be qualified as I have indicated, so that the vital importance of serving the customers (and through them society as a whole) is recognised and the key importance of pay and conditions of employees is also apparent. In any explanation to employees, no excuse should be made for aiming for good profits—or achieving such an aim; it is a loss that we should be ashamed of, unless we can explain it away as a passing phenomenon due to external causes.

On the other hand, recognition that, given the condition of competition, particularly international competition, the achievement of good profits is the result of good team work is also essential to good human relations within an enterprise. It is easy to forget that productivity on the shop floor is only one element in profitability; the work of many others in the organisation is just as important. Incidentally, it is for this reason that I am in favour of profit-sharing in a form suitable for employees as a whole; I shall be referring again to profit-sharing in another context a little later.

The recognition that the final results in terms of profits is the achievement of the whole team does not end with profit-sharing; the consideration of the part played by *individual* members of the team is also involved.

In any large-scale enterprise, management consists in the main of making decisions based upon the consideration of the available evidence. There are, of course, other functions of management such as verifying that the policies are being carried out and the drawing up of evidence for others to make decisions; but it is now generally recognised that decision-making is the heart of the work of those engaged in management.

One of the arts of management in a good organisation is to ensure that each decision is taken at the level which, and at the place where, given both the expertise and the knowledge of the facts, it is likely to be the best decision. This will sometimes be at the top i.e. at the level of the main board of directors, and at other times anywhere between that board and the shop floor or the sales office. The responsibility of making decisions is the essence of some jobs in the organisation, and a good man appreciates not only the work involved, but the satisfaction of making important decisions. Human beings, particularly very intelligent human beings, do not like being treated as cogs in an elaborate management machine; they wish to have the power to do the job assigned to them to the best of their ability and with the minimum of supervision and instruction. In some rather bad organisations instructions are given by people in higher authority to those in lower positions to do things which the receivers of the instructions understand better than those giving the instructions.

Moreover, a competent and intelligent member of the staff does not take kindly to extensive supervision and checking by a "superior"; he prefers to take the full responsibility for his work, seeking guidance if he needs it in any special situation. A man's attitude to his job, and his enthusiasm and sense of responsibility, depend to a surprising degree on the amount of independent authority he is given. I knew of one industrial concern, long since defunct and therefore unidentifiable, which took on first-class scientists and other graduates and then treated them as trainees for so long that many, perhaps most, of them became incapable of any independent decisions or action. From this concern many of the best men left to go to enterprises where, as they expressed it, they had a real job to do and more independence. In some large undertakings there is a need to get away from the idea that instructions have to be given covering nearly every aspect of the work. Instead there should be communication of the basic objectives and policies, and a general plan for carrying out these policies coupled with the maximum possible independence to those who, at different levels, have to carry out the policies and help to achieve the objectives. Ideally, there should be *no* operational instructions, except where new technologies or special conditions are involved and where, therefore, the word "instructions" has its natural meaning of conveying new information.

There must, of course, be accountability and some means of monitoring performance. Here again, as all decisions involve risks, some mistakes will be made and the worst feature of some organisations is the tendency to have inquests on what has gone wrong with little or no recognition of what has gone right. Such a feature in an organisation leads to a reluctance to make decisions and a growing sense of frustration.

Part of the great task of top level management is to find out what goes on in the minds of employees of all ranks from the top to the bottom. The desire to do a job well is much more widespread than some people imagine and extends to branch managers, works managers, craftsmen and operatives, as well as to those at or near the top of an enterprise to whom the success or failure is of very direct concern.

The incentives or driving forces in an individual are, however, complex. To do his job well is one. Another is to earn good pay for himself and his family; yet another is to gain promotion. Another is to stand well in the eyes of other people, whether at his place of work, in his home or his social circle. It is wrong to assume that one person has one motivating force, e.g. to do his job well, and another, a different one, e.g. to make money; in fact, every human being has many motivating forces, but hardly any two have them in the same proportion. For example, the humiliation of a conscientious man who loses his job can be very cruel and of greater importance than the loss of income. He stands condemned as incompetent by his colleagues and may lose face in his own home. Sometimes, when a man is given notice because he is not thought to be good enough for his job, generous financial compensation for loss of office may even aggravate the sense of personal humiliation; he may infer that the greater the compensation, the greater the desire to get rid of him—and he may be right.

None of the incentives which spur a man to give of his best in his job is unworthy and none should be neglected. An employer who expects an employee to be utterly devoted to his work to the neglect of his family or social life—to be "dedicated" to the work—is not only unreasonable, but is lacking in understanding of human beings and a bad employer; the chances are that he is also a hypocrite.

I have said that it is necessary to explain the objectives and policies of an industrial organisation all down the line, and to get a sense of involvement in these objectives and policies, so that none of the work is done in a careless or perfunctory way. Inevitably the question of joint consultation arises, and here there is a good deal of misunderstanding and over-statement of what is possible.

There is a need, for example, to explain why it is necessary to close a plant or factory. Such explanations should be given honestly and as long in advance of closure as possible, so that preparation can be made both organisationally and personally. Some employees may prefer to start looking for other jobs as soon as possible, others might prefer early retirement; others might be fitted elsewhere in the organisation.

Explanations of what is happening in the concern as a whole, where progress is being made, where there are disappointments, at home and overseas, are given to all employees in some of the best businesses, not only in Britain and the United States but also in Japan and industrial countries on the Continent.

I have been present at meetings, including one in Japan, where the president of the company had gone to great trouble, with the use of modern visual aids, to get the facts across.

It is surprising how significant a profit-sharing scheme can be as an aid to the communication, to employees of all ranks, of the facts of the business of the enterprise as a whole. When ICI introduced a profit-sharing scheme, which took the form of giving ordinary shares on a basis related to a percentage of each employee's total remuneration for the year, the proportion being determined by reference to a number of factors of which the total profit for the year was only one, it was thought desirable to issue a leaflet putting the figures of profit and the main balance sheet items in a simplified or popular form with coloured diagrams. A year later at the central council meeting of workers and management, it was suggested by workers members that this leaflet was unnecessary and a waste of money; workers preferred to get the information from the company's published report and accounts, which as stockholders they received individually. It is fair to say that the finance director had at a series of central council meetings given talks explaining the figures, but it is significant that once there is a direct personal financial interest in a subject, those concerned settle down very quickly to the task of understanding the figures. This we found to be just as true of profit-sharing as, for example, of football pools and other matters which may look complicated to those who do not bother to examine the facts and figures carefully because they have no financial interest.

My belief is that such schemes have a merit which goes beyond giving a financial spur to employees to work well; it makes it far easier for them to be receptive to explanations and information about the company's operations as a whole. It also helps towards a better understanding of the objectives and methods of private enterprise.

"Co-partnership"—profit-sharing and similar schemes—undoubtedly go a long way to the improvement of understanding throughout an organisation and achieving that intelligent application to work which makes so much difference to the results as a whole.

There is a danger, however, of becoming too enthusiastic and expecting co-partnership to achieve more than is practicable. In this matter there is a wide difference between a small or medium-sized business and a large international business. It may well be possible in a small single-product business to discuss with the workers as a whole decisions which will have to be taken, so that it may be said that they are in a sense party to such decisions. This is not true of large concerns where, in general, no effective contribution towards decisions involving difficult technical, commercial, financial or international factors can be expected, except from those who are expert or experienced in these matters.

For example, the problems that have to be considered when licensing patent rights and selling know-how in respect of processes involving large highly technical plants are very complex; if the potential buyer is a foreign government, perhaps the government of a communist country, the reasons for fixing terms in one way rather than another are too complicated and involve too many factors for general discussion with people who are unfamiliar with the factors involved. The same is true when decisions have to be taken to erect, or not to erect, large plants costing millions of pounds in countries overseas. What can be done is to explain to employees the effects, in due course, of production from these plants on the marketing of corresponding products from plants in Britain, but in reaching a decision to go ahead or not to go ahead with such a project, the factors to be taken into account include not only marketing factors and questions of financing and long term profitability, but also the economic or political stability—or lack of it—of the country or countries concerned. The reasons for going ahead in one country and not in another are sometimes best not spelt out in detail in a large meeting.

My personal experience has been that many very intelligent trade union leaders and shop stewards who have looked at this subject come fairly firmly to the view that decisions on complex matters of this kind are decisions which should be left to management or directors. On the other hand, they are most anxious to see a general explanation given of what is being done, together with an account of the effect this will have on the work and conditions of employees. In ICI, discussions of local matters of personal concern to employees at regular works councils, and the wider discussions of more general importance at the divisional and central council, give valuable opportunities of explaining the company's objectives and policies and of showing what progress is being made and how employees' interests are being safeguarded.

Any attempt, however, to involve the workers as a whole with major decisions of a difficult nature would not only be rather a waste of time, but would cut across the principle, which I have already explained, that in any large organisation a decision should be taken by the person at the level and at the point where it is likely to be the best decision. This means that management higher up may take no part in many of these decisions and may have no detailed facts about them, because to attempt to do so would involve breaking two principles (a) leaving the decision to be made at the right point and (b) not asking for detailed reports in a way which takes away from the persons concerned their full power to make effective decisions within their sphere of control. Discussions of many matters with groups of workers before decisions are taken would cut across the general principles of decision-making and would lead to delay, inefficiency and sometimes to chaos.

I have said that an important function of higher management is to explain the company's objectives and policies to those who in the management structure are on the next lower level and ensure that the message gets all down the line. This is much better than giving detailed instructions telling people how to do their jobs, and limiting their powers of decision by requiring too many matters to be referred upwards for decision or confirmation at a higher level.

What is difficult to get across to some men, to whom responsibility for certain decisions is delegated, is the need to treat those under their control as human beings whose feelings and reactions to decisions should be taken into account. Good relationships can so easily be wrecked by this weakness. I can think of two cases, in quite different organisations, one Government and another in private industry, when, just after the war, a man of German origin was put in charge of British ex-soldiers who deeply resented taking orders from somebody whom they regarded as a recent ex-enemy. In both cases, it may be that the man appointed was technically competent, but acceptability to his colleagues on other grounds is a factor which has to be taken into account if full co-operation is to be expected. In both cases, a little thought would have showed that making the appointment was bound to put a spanner into the works.

Another type of case is the promotion of somebody above the heads of others when it is far from clear that he will do the higher job better than those who have been passed over. That there should be promotion on merit to all jobs of any importance must be a general principle in any sound organisation, but where a whole range of jobs constitute a "service" with long-term careers and reasonable expectations, one has to be fairly certain that a promotion out of turn will be recognised as having been made on merit and not the promotion of a favourite or, worse still, the promotion of a "yes" man. On the other hand, failure to remove somebody who has been over-promoted and is manifestly not up to the job can be just as disastrous for good human relationships. Provided that generous and fair treatment is given in these cases of casualties, firm action leading to greater efficiency will earn respect.

I have mentioned that there are major differences in the application of general principles to large, medium and small businesses. What is appropriate and possible by way of communication in a very small concern is sometimes impracticable in a larger one. I remember one small and profitable business in which all communications internally were verbal and personal. This business, which let me hasten to add was not a chemical business, had less than 100 employees and was owned and managed by a man who earlier in his life had worked as a skilled craftsman in the industry and knew the business thoroughly. He knew the strengths and weaknesses of each employee and his personal relationships were excellent. The net result was that communications were ideal, i.e. prompt, verbal, personal and completely frank. There was a genuine loyalty which meant good, intelligent co-operation and good profits when other firms in the same line of business were making losses.

This ideal system of communication is quite impossible in a large organisation, and when it is sometimes said impatiently by people who have no understanding of communication problems in large businesses, that the managing director, or whoever is the chief executive, should get to know all his people better, they fail to recognise the complete impossibility of doing this effectively. A business with several thousands of employees and with perhaps twenty or more factories in different parts of the country as well as factories overseas can only have brief local visits by the chief executive and in a way which would make it impossible for personal relationships to be established, even if he spent all his time visiting factories, which would mean that he would completely fail to do his job properly. In fact, attempts of this kind by some very energetic managing directors do more harm than good. I know of at least two businesses which suffer from a traditional system under which the chief executive feels obliged to spend a great part of his life making such rather ineffective visits.

I have explained how important it is to delegate decisions to lower levels, leaving those to whom decision-making of different kinds has been delegated to get on with the work without interference and with the minimum supervision, if any. The danger of trying to establish strong personal links direct from the top to the bottom, by-passing several layers of management, is that the authority at intermediate levels is weakened, particularly if there is any feeling that there is always some kind of right of appeal to the man at the top, by-passing the man in direct charge.

This does not mean that there should be *no* contact between those at the top, or near the top, of an organisation and those further down the line, but these contacts have to be for the purpose of getting a better appreciation of what is happening and must be made skillfully to avoid the dangers to which I have referred. There can be no clear rules as, of course, different conditions will require different kinds of personal communication. I cannot too strongly emphasise the utterly demoralising effect that the overruling by a higher authority of somebody who has been given powers of decision can have, not only upon the man directly affected, but on the organisation as a whole. I have seen instances of this not only in industrial organisations, but in Government matters as well.

Some failures of communication and bad relationships arise from defective organisation, where there is no clear distinction between line management and specialist advice or instruction. In a very large organisation where operations are under the control of separate divisions or subsidiary companies and the parent company has specialists in technical, finance, marketing and other matters, it will normally be found that, for efficient operation, the effective control of everything relating to the production and marketing of a product or product group has to be vested firmly in the manager of the division or the managing director of the subsidiary company concerned. As you know, decisions on manufacture and marketing cannot be made in isolation; they have to be co-ordinated at an operational level where, on a consideration of all factors (production, distribution, marketing, finance etc.) decisions can be made promptly to meet changing conditions. For this reason, orders from the head office or parent company should not normally be orders of a narrow specialist type, e.g. related to one function only—methods of production, pricing or products or finance; such orders can only cause confusion and, if they are sent direct to the corresponding specialists in the division or subsidiary company, may be in conflict with the orders from the division's manager or the subsidiary company's managing director who has taken all factors into account. This kind of thing can, and does happen when energetic specialists at a higher level want to give *orders* instead of being available to give specialist advice, and the result can be confusion, a serious failure in personal relationships and morale, with a corresponding loss of efficiency. Restraint and self-discipline in communication to those down the line are more important the higher up you are in such an organisation.

I have explained that one of the most difficult aspects of communication arises when there have been failures at a lower level. At the higher levels in any industrial or commercial enterprise, there is an element of risk with every important decision taken. This is true whether, for example, the decision is to embark on the production of a new product, put up a new factory, to change the marketing policy on a product or to appoint somebody to an important management post.

Everybody who makes decisions, therefore, runs the risk of being wrong and, of course, the only people who never make mistakes are those who never make decisions. A good man will therefore sometimes make mistakes and sometimes these might be quite big mistakes. If, as a consequence, there is *hasty* action from those in authority to condemn or censure him, the net result is likely to be timidity in making decisions in future.

Another serious error when mistakes have been made is to bring back to a higher level the power to make decisions which were properly delegated. This may not only weaken the organisation by taking away the power of decision from its natural point, but may cause a fall in morale and in enthusiasm.

In these matters there has to be a careful assessment at the higher levels of management as to whether, if there are continuing mistakes, this is due to personal inefficiency or to some organisational defect. Where the mistakes are due to poor judgment or some other weakness, unpleasant action may have to be taken and there should be no flinching from it.

It is here that some of the more difficult decisions have to be made at a higher level. Somebody may have to be moved, retired, asked to resign or dismissed with, or without, compensation. Hardly anything is worse in an organisation than failure to make decisions of this difficult personal character but, if the system of communication is good, it should be possible to explain matters to the man, or men, concerned and to give adequate and suitable compensation where it is appropriate. When such firm action is taken the morale of the organisation is generally likely to be maintained if communications and personal relationships are good. My experience is that, where communications are bad, there is frequently the retention of weak members of a team for far too long and there is a great reluctance to take the firm action that is necessary. The effect of weakness in personnel matters upon other and better members of the team is, of course, intangible, but there is no doubt that weakness or indecision in these matters is just as damaging as impetuous, harsh or ill-judged dismissal.

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Transactions and Communications

The dispersion of carbon blacks in paint and ink systems*

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Summary

The Quantimet Image Analysing Computer (QTM) was successfully applied in automated carbon black dispersion analyses of a variety of paint and ink systems. Dispersion functions were developed in terms of agglomeration frequency (agglomeration index), the weight mean agglomerate size, and the product of these two functions: dispersion quality index. Light micrographs of thin drawdowns of paint films were analysed by this method, each analysis of 25 or more fields requiring less than five minutes for data storage on punched tape. Final results were based on programming of the paper tape output in a larger computer system.

A modified version of the Daniel Flow Point Method was used in evaluating a wide variety of carbon blacks in medium oil alkyd, thermosetting acrylic and polyurethane vehicle systems. To derive the most benefit from a pigment, it is necessary to compound it in a polymer system with a critical balance of all ingredients. For this purpose the modified flow point technique was generally successful in yielding agglomeration index and agglomerate size values equivalent to or lower than those obtainable by other methods, thus providing optimum dispersion quality at the highest pigment concentration.

A variety of factors related to the dispersibility of carbon blacks was evaluated. Large particle size and high structure were shown to be the most important properties of carbon pigments for ease of dispersibility. Significant improvements in dispersibility, obtained by modification of the carbon black surface chemistry (e.g., increased oxygen volatile) were observed in both a medium oil alkyd and a heatset ink system, the latter showing the most important effects.

In the end use of paint and ink systems, the most significant correlations with dispersion were related to appearance, notably gloss: the better the dispersion, the higher the gloss. However, gloss development as a function of dispersion quality varied appreciably between different carbon and vehicle types, with the coarser carbons tending to give higher gloss ratings at specific dispersion levels. On the other hand, gloss retention (in accelerated weathering tests) was predominantly a function of particle size, with dispersion a very minor factor, except in achieving the initial rating: the finer the carbon the better the gloss retention. The relationship of dispersion to blackness development was also found to be relatively insignificant.

Keywords

Prime pigments and dyes
carbon black

Equipment primarily associated with analysis, measurement and testing
computer

Properties, characteristics and conditions primarily associated with dried or cured coatings
dispersion
gloss

Process and methods primarily associated with analysis measurement and testing
Daniel flow technique
microscopy

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L' état de dispersion des noirs de carbone en peintures et encres d'imprimerie

Résumé

Le QTM (Quantimet Image Analysing Computer) était utilisé avec succès pour les analyses automatisées des dispersions de noir de carbone dans une gamme de systèmes de peintures et d'encres d'imprimerie. Des fonctions de dispersions ont été établies sous termes de la fréquence d'agglomération (indice d'agglomération), de la grandeur de l'agglomération en poids moyen, et le produit de ces deux fonctions, DISPERSION QUALITY INDEX (l'indice de la qualité de dispersion). Des photomicrographies de feuils minces de peintures ont été analysées par cette méthode. Chaque analyse, comprenant de 25 champs au moins, exigeait pas plus de 5 minutes pour l'enregistrement des données sur ruban perforé. Les résultats ultimes étaient basés sur le programming de la sortie du ruban dans un plus grand ordinateur.

On a utilisé une version modifiée de la Daniel Flow Point Méthode pour évaluer une gamme étendue de noirs de carbone dans des systèmes de liants à base des résines alkydes en longueur d'huile moyenne, des acryliques thermodurcissables et des polyuréthannes. Afin d'obtenir le rendement pigmentaire le plus important, il est nécessaire d'incorporer le pigment dans un système polaire ou tous les constituants sont en équilibre critique. La technique de flow point modifiée avait, en général, du succès dans ce but pour rendre des chiffres de l'indice d'agglomération et de la grandeur de l'agglomérat équivalentes ou inférieures à celles mises en évidence par d'autres méthodes. Ainsi la méthode fournit la possibilité d'achever la qualité de dispersion optimale avec la concentration pigmentaire la plus élevée.

On a évalué une série de facteurs liés à la dispersibilité des noirs de carbone. On a démontré que les propriétés les plus importantes des noirs de carbone à l'égard de la facilité de dispersion ce sont une grandeur particulaire importante et une structure évoluée. Des améliorations importantes au point de vue de la dispersibilité mise en évidence par la modification de la surface chimique des noirs de carbone (par exemple, une teneur augmentée d'oygène volatil) ont été notées à la fois dans une résine alkyde de longueur en huile moyenne et dans une encre du type "heat set," celle-ci démontre les effets les plus importants.

A l'égard des applications ultimes des peintures et des encres, les plus importantes corrélations de dispersion ont été liées à l'apparence, notamment le brillant, une meilleure dispersion donne un brillant plus élevé. Cependant, le développement du brillant en fonction de la qualité de dispersion s'est varié en grand mesure selon de différents types des noirs de carbone et également des liants. Les noirs de carbone à plus gros grains ont une tendance de donner des cotes du brillant plus élevées aux niveaux de dispersion specifiques. Au contraire, la stabilité du brillant (au cours des essais de vieillissement accélérés) était largement une fonction de la grandeur particulaire, et en même temps l'état de dispersion était un facteur tres mineur, sauf en achevant le brillant initial, le plus fins les grains des noirs de carbone, le meilleur la stabilité du brillant qui s'ensuit. On a trouvé que le rapport entre l'état de dispersion et le développement du noirceur était relativement sans importance.

Die Dispersion von Gasruss in Lacken und Druckfarben

Zusammenfassung

Zur automatisierten Analyse von Gasrussdispersionen in den verschiedensten Lack- und Druckfarbensystemen wurde der Quantimet Image Analysencomputer (QTM) mit Erfolg angewandt. Dispersionsfunktionen wurden entwickelt und ausgedrückt als Agglomerationsfrequenz (Agglomerationsindex), die mittlere gewichtsmässige Agglomeratgrösse und das Produkt dieser beiden Funktionen: DISPERSIONSQUALITÄTSINDEX. Mit Hilfe dieser Methode wurden Lichtmikrographien dünner Abzüge von Lackfilmen analysiert, wobei jede Analyse von 25 oder mehr Feldern weniger als 5 Minuten für die Aufspeicherung der Daten auf gelochten Karten benötigte. Endresultate basierten auf dem Programmieren des Papierbandausstosses in einem grösseren Computersystem.

Um eine grössere Auswahl von Gasrussen in mittelöligen Alkydharz-, wärmehärtbaren Akrylharz-und Polyurethan-Bindemittelsystemen zu beurteilen, wurde eine modifizierte Version der Daniel Flow Point Methode benutzt. Um den grössten Nutzen von einem Pigment zu haben, mass man es mit einem Polymersystem, dessen Bestandteile alle in einem kritischen Gleichgewicht stehen, verarbeiten. Hierfür war die modifizierte Flow Point Technik im

allgemeinen insofern erfolgreich als sie Agglomerationsindex- und Agglomerationsgrössenwerte ergab, die denen mit anderen Methoden erhaltenen entsprachen oder unter diesen lagen und somit optimale Dispersionsqualität bei höchster Pigmentkonzentration ergab.

Eine Anzahl mit der Dispergierbarkeit von Gasrussen in Beziehung stehender Faktoren wurden bewertet. Für leichtes Dispergieren erwiesen sich grosse Teilchengrösse und hohe Strukturbildung als die bei Gasrussen wichtigsten Eigenschaften. Wesentliche Verbesserungen in der Dispergierbarkeit durch Modifizierung des chemischen Verhaltens der Carbon Black Oberfläche (z.B. höhere Sauerstofflüchtigkeit) wurden in beiden, nämlich einem mittelöligen Alkydharz- und einem heatset (warmegehärteten) Druckfarbensystem beobachtet; bei letzterem äusserten sie sich am stärksten.

In der Endanwendung von Anstrich- und Druckfarbensystemen wurden die wesentlichen Korrelationen zur Dispersion auf Aussehen bezogen, vor allem auf Glanz: je besser die Dispersion, um so höher der Glanz. Zwischen verschiedenen Gasruss- und Bindemitteltyps variierte jedoch die Entwicklung des Glanzes wesentlich als Funktion der Dispersionsqualität, wobei die gröberen Carbon Blacks bei spezifischen Dispersionsgraden zu höheren Glanzablesungen neigten, Andererseits war (bei künstlichen Bewitterungsprüfungen) Glanzerhaltung überwiegend eine Funktion von Teilchengrösse, Dispersion war dabei ausser bei der Anfangsablesung ein sehr untergeordneter Faktor: je feiner das Carbon Black, um so besser war die Glanzerhaltung. Die Beziehungen zwischen Dispersion und Schwärzeentwicklung stellte sich ebenfalls als verhältnismässig unbedeutend heraus.

Дисперсия сажи в красках и печатных чернилах

Резюме

Отображательная аналитическая вычислительная машина Квантимет успешно применялась для автоматического анализа дисперсии сажи в различных красочных и чернильных системах. Были выведены функции дисперсии выраженные через частоту агломерации (показателя агломерации), среднего весового размера агломерата и произведения следующих двух функций: дисперсии и показателя качества. Микроснимки тонких срезов красочных пленок анализировались этим методом, каждый анализ из 25-ти или более полей, требуя менее 5-ти минут для записи и запоминания данных на перфорированной ленте. Конечные результаты основывались на программировании выхода бумажной ленты на более крупной вычислительной системе.

Модифицированный тип метода точки текучести Даниеля применялся для оценки различных саж в средних масляных алкидных, термореактивных акриловых и полиуретановых растворительных системах. Чтобы получить наибольшую пользу от пигмента, необходимо его соединить в полимерной системе с критическим равновесием всех составных частей. Для этой цели видоизмененная техника точки текучести оказалась в общем более успешной для получения значений показателя агломерации и размеров частиц эквивалентных или более низких чем значения получаемые другими методами, давая таким образом оптимальное качество дисперсии при наивысшей концентрации пигмента.

Оценивался ряд факторов связанных с дисперсивностью саж. Показано что большой размер частиц и сложная структура являются наиболее важными свойствами углеродных пигментов для улучшения дисперсивности. Существенное улучшение дисперсивности полученное модификацией поверхностной химии саж (т.е. увеличение кислорода в летучем), наблюдалось как в сердне-масляной алкидной так и в схватывающей чернильных системах, последняя проявляя наиболее важные эффекты.

В конечном применении красочных и чернильных систем, наиболее существенные соотношения дисперсии были отнесены к наружному виду, в частности к лоску: чем лучше дисперсия, тем выше лоск. Однако развитие лоска, как функции качества дисперсии, изменялось значительно в разных углеродных и растворительных системах, более грубые углероды проявляя тенденцию давать более высокую характеристику лоска при специфических уровнях дисперсии. С другой стороны, сохранение лоска (в ускоренных испытаниях на выветривание), являлось преимущественно функцией размера частиц, дисперсия играя значительно менее важную роль, за исключением получения исходных параметров: чем мельче углерод, тем лучше сохранение лоска. Найдено также что соотношение между дисперсией и развитием непроницаемости является сравнительно несущественным.

Introduction

Quantitative dispersion analyses of paint and ink systems have seen limited application, chiefly because they are so time consuming and because the evaluation of paint and ink is highly appearance oriented. But while the grind gauge has long been considered the most practical means of analysis, its use can be misleading on dispersion quality, particularly in carbon black systems. This was demonstrated in a previous paper[1] in which excellent grind gauge readings were obtained even though entire pigment concentrations remained undispersed in the form of agglomerates a few microns in size. Moreover, grind gauge dispersion ratings tend to be somewhat subjective and may vary with different operators. Thus, there is a real need for better methods of dispersion analysis in paints and inks.

The previous microscopical studies on paint dispersions were carried out on a medium oil alkyd system, pigmented with MCC-1 type carbon black, a red iron oxide, and a rutile TiO_2. The carbon black dispersions were evaluated with an optical microscope on drawdowns about 10 microns in thickness. Since the concentrations of carbon black in paint systems are quite low (around 5 per cent), the optical microscope is an ideal means of dispersion evaluation. Carbon agglomerates are opaque to light and can readily be detected down to a few microns in size. Contact X-ray microradiography was employed for evaluating the iron oxide and TiO_2 dispersions. This method relies on the high X-ray absorption of such pigments. Paint drawdowns are made in the thickness range of 20 microns directly on to the emulsion of a fine grain photographic film. The paint is allowed to dry until it is no longer fluid and is then exposed to a beam of soft X-rays (e.g., 3.5-5 kV) for about four minutes. The paint is washed off the emulsion with a solvent and the film developed in the conventional manner. The resultant X-ray negative permits resolution of clumps of pigment down to 1 or 2 microns. The major drawback of the X-ray method is that it is time consuming, requiring exposure and development in addition to subsequent enlargement and analysis under an optical microscope.

Another difficulty with microscopical assessments of dispersion quality is in the analysis of the data. Measurements of agglomerate size and frequency can be tedious if carried out by conventional methods. Such methods involve the use of a graticule in the eyepiece of an optical microscope for direct assessments[2] or the use of micrographs with a measuring device such as the Zeiss Particle Size Analyser.[3] The Zeiss Analyser was used in the previous work because it facilitated determination of agglomerate size and distributional data. Paint films tend towards wide ranges of agglomerate size, particularly at relatively short dispersing times, (i.e. 4-8 hours of ball milling). It was found that weighted averages provide the most useful information on agglomerate size. The percentage of pigment dispersed was expressed as the ratio of the measured volume of undispersed agglomerates to the total pigment volume loading in the paint film.

Such measurements and computations are quite lengthy, particularly if an adequate level of test precision is sought through proper sampling. Hence, a prime objective of the present work was to find ways to simplify these procedures. This was accomplished through the use of a Quantimet Image Analysing Computer (QTM).[4] This is a television scanning device which is capable of analysing microscope images or micrographs for size, frequency, area and shape information on high contrast areas (e.g., pigment agglomerations). Previous use of this instrument for dispersion analysis has been reported by Smith.[5] In the present work, the recording of dispersion information has been fully automated, using a data multiplexer for programming agglomerate size distribution analysis and a paper tape punch for recording data output. The final output is then further programmed for the desired dispersion parameters using a conventional computer. The entire recording process is quite rapid, requiring about six seconds for each individual analysis. A complete dispersion analysis on 25-30 fields may be carried out in as little as 3-5 minutes.

Another objective was to study the dispersion characteristics of a wide variety of carbon blacks in different vehicle systems. Finally, the significance of carbon black dispersion in end use performance of paint and ink systems was examined.

Experimental procedures

Pigment types

This study was restricted to different carbon black types, including 14 commercial samples, one development carbon and three treated samples. Their colloidal properties are shown in Tables 1, 3, 7, 10, and 13*. They include both

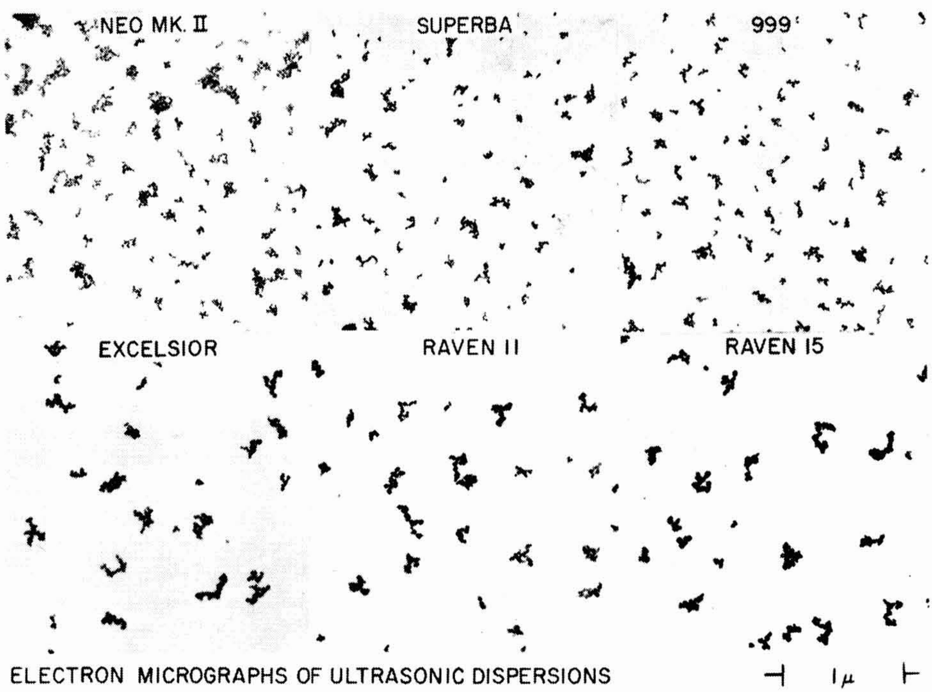

Fig. 1. Aggregate and particle size of different channel blacks

*For all Tables, see Appendix 1

channel and furnace types and range in particle size from 3,000 Å (MT type) to about 130 Å (HCC-3). Electron micrographs illustrate the particle size and aggregate size differences among the commercial blacks (Figs. 1, 2, and 3).

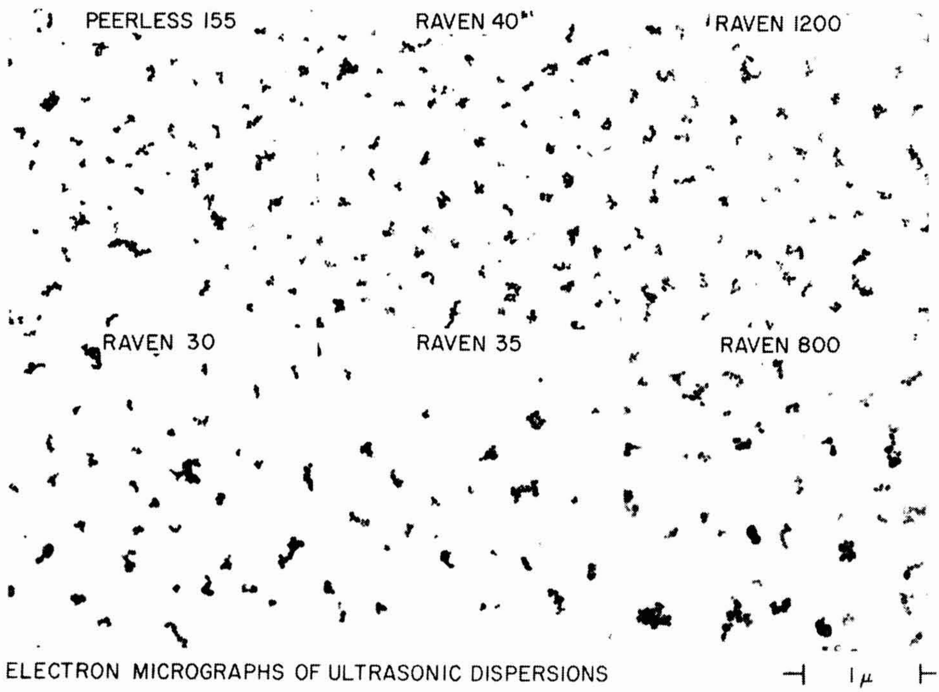

Fig. 2. Aggregate and particle size of different furnace carbon blacks

The specimens were dispersed ultrasonically in chloroform prior to deposition on thin carbon substrates for examination in the electron microscope.[6] Such dispersions approach the primary aggregate units of the different blacks, although some agglomeration due to physical bonding effects does exist, particularly with the very fine particle channel types. In many blacks, there is a further reduction in aggregate size during dispersion in different vehicle systems owing to a breakdown of the primary aggregate units. Carbon black aggregates are now defined as single graphite para-crystals,[6, 7] which contain a continuous network of distorted graphite layers. The atomic spacing of these layers approximates that of graphite, but there appears to be little or no three-dimensional grouping into crystallites as previously supposed. The high surface energy of carbon black can be attributed to the out-of-phase stacking of the surface graphite layers and also to layer bending. The latter may be associated with basal dislocation areas or actual atomic vacancies. Oxygen functionality on the black surface is generally associated with exposed edges of the graphite layers, but can also exist within the layers if surface dislocations or vacancies were present during the oxidation process.

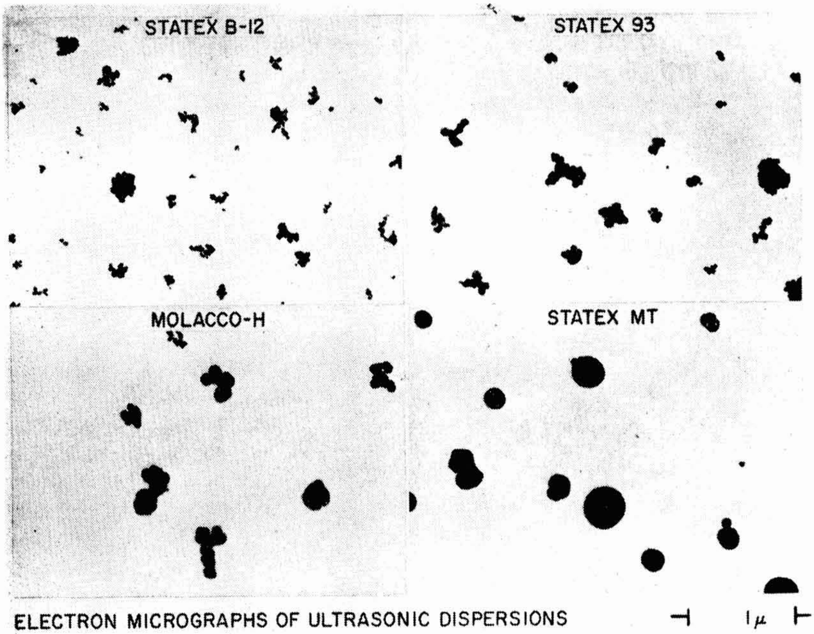

Fig. 3. Aggregate and particle size of different furnace carbon blacks

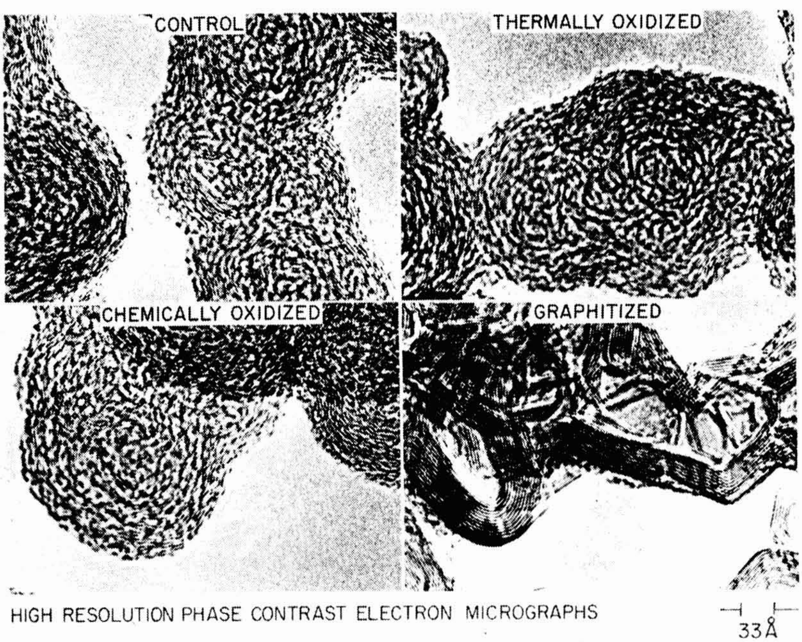

Fig. 4. Particle microstructure of oxidized and partially graphitized Raven 1200

Examples of the microstructure of carbon black are shown in high resolution electron micrographs (Fig. 4): (a) an untreated sample of Raven 1200 and the same black after, (b) thermal oxidation, (c) chemical oxidation, and (d) partial graphitisation at 2,000°C. These are phase contrast images in which much of the detail is attributable to interference between the axial beam of electrons and the (002) diffracted beam from the graphite layers. This interference mechanism is controlled by fine focusing of the electron microscope.[8] The light and dark lines which are visible on these micrographs (e.g., peripheral regions of particles) represent a vertical projection of the graphite layers with a spacing of about 3.5 Å. The appearance of the standard and oxidised samples is typical of the para-crystalline graphite structure found in all carbon blacks. The layers show considerable bending and form a continuous network between the adjoining particle units. The term particle is actually a misnomer in the characterisation of carbon blacks, in that particle size measurements do not reflect the size of the ultimate black units that are dispersed in different vehicle systems. Particle size probably reflects the state of the hydrocarbon feedstock prior to carbonisation. It is likely that aggregates (e.g., structure units) are formed by simultaneous carbonisation of small hydrocarbon units which have partially coalesced while in a fairly liquid state. However, although carbon black particles rarely exist as discrete entities, the size of these sub-units is an important property, fundamental to the light scattering characteristics of carbon black and thus a controlling factor in blackness index and ultraviolet screening. Particle size also affects aggregate irregularity and is related to the total surface area of the carbon black.

The microstructures of the untreated and the oxidised samples of Raven 1200 are quite similar, although some porosity effects were observed for the thermally oxidised sample, which showed a large increase in its total surface area. The effects of thermal oxidation manifest themselves in terms of greater particle edge irregularity in images of this type or in actual removal of graphite layers. However, much of the new surface area developed by thermal oxidation is internal and not necessarily available to the vehicle in which the black is dispersed.

A marked microstructural change is evident in the partially graphitised Raven 1200 (Fig. 4) as compared to the other samples. The effects of heat treating a carbon black at elevated temperatures are: removal of most of the surface functional groups (e.g., chemisorbed oxygen and hydrogen); and joining of neighbouring graphite layers into a more continuous network. The treatment also anneals out most of the previously mentioned surface defects. The end result is to seal off the carbon surface to form capsular units. The final shape of the particle sub-units approximates that of hollow polyhedrons with continuous graphite layers bending from one facet to another.

All carbon blacks heat treated in this manner have a common low surface activity. Such samples are useful as inert controls in studying surface chemistry effects in different media.

Paint and ink formulations

The paint systems studied in this work include medium oil alkyd, thermosetting acrylic, and polyurethane systems (Tables 2, 4, 5, 6, 8, and 12A).

Two printing ink systems were evaluated for dispersion effects: a flexographic-rotogravure system (polyamide type), and a heatset system. (Tables 9 and 12B).

The medium oil alkyd dispersions were prepared by means of conventional ball milling and by a modified sand mill procedure using zirconium oxide beads. The thermosetting acrylic and polyurethane systems were evaluated by ball milling only.

The heatset ink dispersions were prepared by means of a three-roll mill; ball milling was used for the flexographic-rotogravure dispersions.

Analytical procedures and data processing

The dispersion analyses were carried out by means of a Quantimet Type "B" Image Analysing Computer (Metals Research Ltd., Melbourne, Royston, Herts.). The Quantimet is a television scanning device which can analyse a microscope image directly or by means of an epidiascope using micrographs. The direct approach, using conventional transmission optical microscopy, was employed exclusively for the work in this paper. The various functions of the QTM system have been described in detail by Fisher and Cole[4] and will only be discussed briefly here. A simple block diagram illustrating the QTM system is shown in Fig. 5.[4] The camera output of the QTM system is displayed on a monitor and is also fed into an electronic detector which responds to changes in output voltage as the scanning spot in the vidicon tube passes over the features (e.g., carbon black agglomerates) in the field which vary in optical density. The detection threshold may be set to record the desired features, either a light or dark phase. The contrast of the image to be analysed is an important factor. High contrast images are desirable in that background noise can readily be eliminated. Paint systems, in which the pigment volume concentration of the carbon black is generally quite low, are ideal in this respect. Pigment volume concentrations of 3 per cent (dry film) were employed for all of the

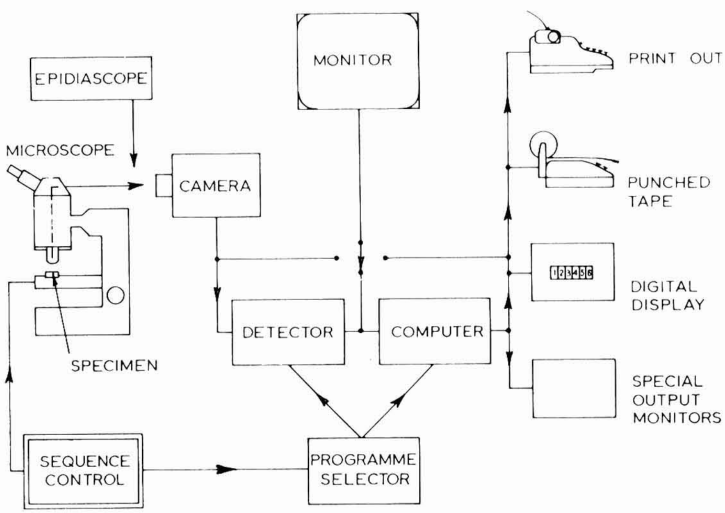

Fig. 5. Schematic of QTM system

different systems that were analysed, including the printing inks. The latter were let down to this level from their final paste form according to the formulations shown in Table 9. All preparations were made on 2 × 3in glass slides using a drawdown bar (0.001in Bird Applicator, Gardner Laboratories, Inc., Bethesda, Maryland, USA) which produced films about 10-15 microns thick. It is also possible to analyse ink pastes in their undiluted form by the use of high pressure pressouts. However, such preparations give relatively low image contrast and the final evaluations must be made from micrographs rather than the much quicker direct readout method. Therefore, all of the ink dispersion analyses in this work were carried out using letdowns at 3 per cent pigment volume concentration (PVC). The letdown procedure does not appear to alter the dispersion quality of the original paste.

Monitor displays showing the various functions of the Quantimet, as applied to the analysis of carbon black dispersion, are illustrated in Fig. 6: the normal light microscope image of a poor carbon black dispersion, the agglomerate area (total measured area, agglomerates in white), the counting mode, and the projection mode (chord count). The agglomerate area mode demonstrates the setting of the threshold for detection of black agglomerates in the field. All agglomerates in white within the blank frame area are detected and measured. The Quantimet has three different resolution levels for the threshold setting. In the present studies, most of the examinations were made at minimum resolu-

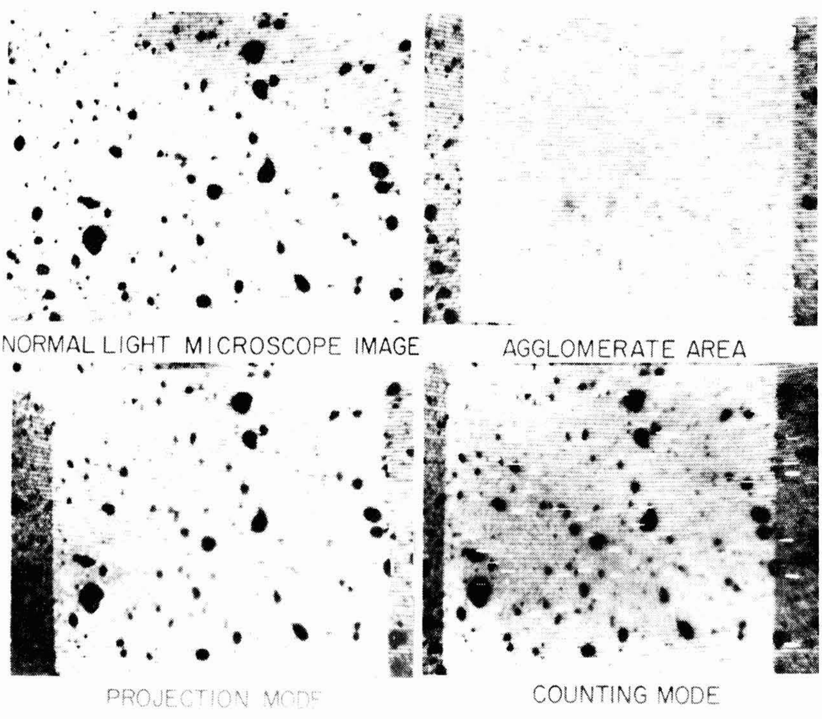

Fig. 6. QTM monitor displays on paint film showing poor carbon black dispersion

tion to eliminate background noise caused by very small black agglomerations. The lower size limit of the agglomerates measured was about 3 microns. The total agglomerate area is measured as a ratio of the area covered by the agglomerates to the total area of the blank frame, the latter being kept at a constant setting. A magnification (on the monitor) of 600× was used for most of these dispersion analyses. Lower magnifications were occasionally employed for some of the very poor dispersions.

The agglomerate counting mode is illustrated in Fig. 6. Agglomerates are counted on the basis of their longest scan line (chord). During the counting operation, marker pulses are generated to the lower right of each agglomerate and the number of these corresponds to the total count. In the projection mode all of the chords across the agglomerate are counted. These are denoted by the white edge on the right side of the agglomerates. Studies in size distribution may be carried out using either the count or projection functions. The former was used in the present studies because the agglomerates generally represent discrete units that are roughly spheroidal in shape. For networks or more irregular shaped objects, the chord distribution generally produces more favourable results. In the present instance, both types of measurements gave comparable size results. Size distributions are carried out by means of a series of seven potentiometers on the data multiplexer. These are programmed in uniform increments up to the largest agglomerate to be measured. The first potentiometer records the total count and projection and each subsequent potentiometer accumulatively eliminates all those chords up to the size level at which it is programmed. The measured values are registered on the output of a paper tape punch and appear alternately in a count, projection sequence. Thus, for the seven potentiometers, a total of 14 readings is recorded. The 15th and final measurement appearing on the tape output is the total agglomerate area, relative to the area of blank frame. All of the measurements appear as four digit numbers. Any values less than four digits are preceded by zeros to satisfy this requirement. Each individual measurement is separated by a space symbol. The final area value is followed by a symbol for end of field which separates each set of measurements from the one following.

From 15 to 40 fields were analysed for each dispersion, an average sampling being 25 fields. Larger samplings were required for specimens showing a very wide agglomerate size distribution, as may occur in the early stages of ball milling. About six seconds is required to record the measurements on paper tape. Hence, a complete dispersion evaluation can be completed in less than five minutes. Each dispersion was initially screened under the light microscope to determine the best area to be scanned. The selection of fields was based both on representative sampling and the overall optical density of the preparation. This added precaution was taken to minimise errors due to thickness variation. Field selection was carried out in a lateral and vertical step-wise pattern, refocusing the microscope whenever necessary. The threshold setting of the Quantimet was kept constant for each series of dispersion analyses. A rough pre-screening of all the dispersions was also carried out in order to group them according to quality (e.g., agglomerate size range). Dispersions similar in agglomerate size were run as a series to minimise changes in the potentiometer settings on the multiplexer.

During the initial programming of the Quantimet paper tape output, it was found that punching errors sometimes occur (almost always in the form of missed digits), seriously effecting the final values. Punching errors are eliminated by means of the final computer program (IBM-1130). All normal fields of data are based on a final punched output of 60 digits, and the programme is set to recognise this output only. All scans containing other than 60 digits are rejected. This requires making a few extra scans for each dispersion analysis because the programmes are based on a specific number of fields. For example, if a dispersion analysis is to be based on 25 fields, then a total of about 30 fields are generally run to insure a sampling of 25 good ones. The computer responds to the first 25 good scans and then disregards all others and moves on to the next sample.

Dispersion parameters

The agglomerate size distributions for carbon blacks in paint and ink systems often tend to be highly skewed, showing high incidence of small agglomerates and low incidence of very large ones. To emphasise the large agglomerate content, which is most detrimental to the performance characteristics of paint and ink systems, a weight mean average[9] is used to express agglomerate size. This average is determined from the following expression:

$$d_{wm} = \frac{\Sigma fd^4}{\Sigma fd^3}$$

where d represents the agglomerate diameter based on its longest chord as measured by the Quantimet, and f is the frequency of agglomerates in each size range.

In the earlier work[1] the degree of black agglomeration was determined from the measured volume concentration of the agglomerates divided by the total volume concentration of carbon black in the paint film. From this expression, it is possible to calculate the percentage of pigment dispersed down to a specific agglomerate size within the limits of the measurements (e.g., 3 microns). However, these per cent dispersion measurements are only suitable when good dispersion levels exist. For poor dispersions, negative ratings frequently occur, because most carbon black agglomerates contain appreciable quantities of vehicle. A more meaningful type of agglomerate frequency rating for paint and ink systems can therefore be expressed in terms of the actual total area covered by black agglomerates. On this basis, an agglomeration index (A.I.) is calculated from the following expression:

$$\text{A.I.} = \frac{\text{\% Area covered by agglomerates}}{\text{Pigment Volume Concentration (PVC)}} \times 100$$

where the per cent area is the direct Quantimet measurement and the PVC refers to the pigment volume concentration in the paint film (e.g., 3 per cent in this work). Generally speaking, a good dispersion may be considered as one having an agglomeration index below 30 and a weight mean agglomerate size of 5 or lower.

In evaluating the performance characteristics of different systems (gloss, jetness, durability) the most useful measure of dispersion was found to be the product of the agglomerate size times the agglomeration index. As a general rule, a value of 100 or lower for this product indicates a good dispersion.

In most of the accompanying plots that relate dispersion quality to paint or ink performance, the reciprocal of the product has been utilised. The reciprocal permits plotting dispersion as a positive function in correlations with performance characteristics. (Because of the limited significance of values at the upper limits, it is often desirable to plot these dispersion ratings on a logarithmic scale.) Such an expression is the best means of describing the quality of carbon black dispersions, and is thus termed the dispersion quality index (DQI).

$$\mathrm{DQI} = \frac{1}{\text{Agglomeration Index} \times \text{Weight Mean Agglomerate Size}}$$

For convenience in plotting the data this reciprocal is multiplied by 10^2, 10^3, or 10^4 depending on dispersion range involved. The dispersion quality index takes into account both the frequency of agglomeration and the size of the agglomerates, weighting the area of large agglomerates which are most detrimental. The higher the dispersion quality index value, the better the dispersion.

Carbon blacks of varied particle size in medium oil alkyd vehicles

Ten carbon blacks of varied particle size, including furnace, channel, and thermal types, (Table 1) were studied in a medium oil alkyd formulation (Table 2). Dispersion profiles of these blacks were obtained, after ball milling, for agglomeration index (Fig. 7) and weight mean agglomerate size (Fig. 8). All samples were examined in the same formulation to provide a direct comparison of their relative dispersibility. In actual practice, of course, different formulations would be utilised for some of these carbon blacks. More detailed dispersion

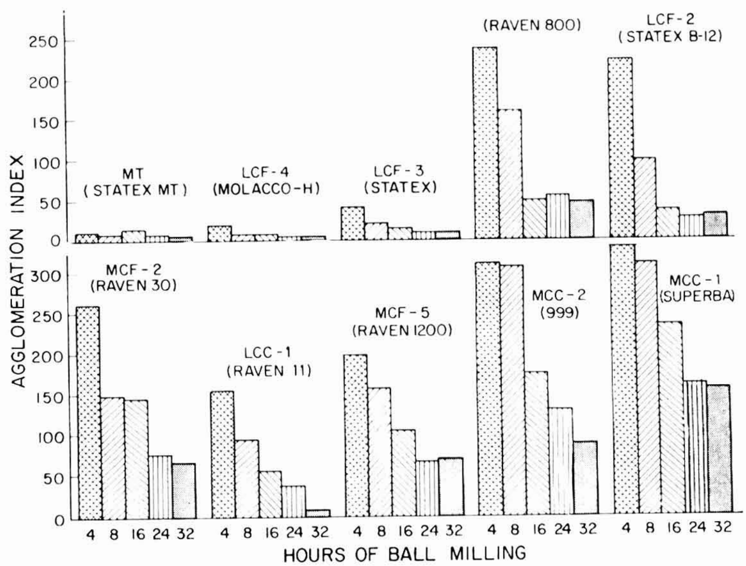

Fig. 7. The effect of carbon black type on agglomeration index in medium oil alkyd

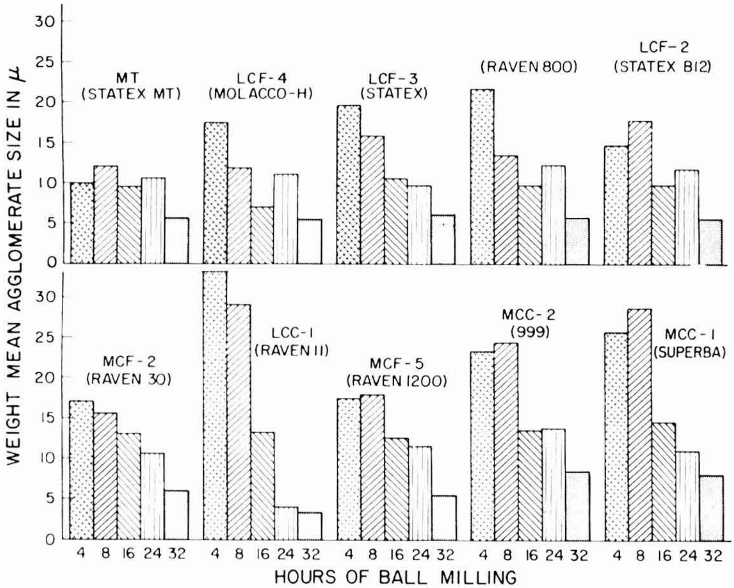

Fig. 8. The effect of carbon black type on agglomerate size in medium oil alkyd

analyses using the flow point method will be discussed in subsequent sections of the paper.

Pronounced differences in agglomeration index are evident among these carbon blacks (Fig. 7). The coarser blacks (MT, LCF-4, LCF-3) rapidly reach a low level of agglomeration index (i.e., good dispersion). Satisfactory dispersion levels may also be achieved for some of the intermediate fineness furnace grades, but only after ball milling for 24-32 hours. Of the three channel type carbons included in this study, only the largest particle size sample (LCC-1) reached a satisfactory final dispersion level. The two fine particle size blacks (MCC-1 and MCC-2) were very poorly dispersed even after 32 hours of ball milling. The LCC-1 black had, initially, a poor dispersion, but after 32 hours of ball milling it was comparable to that of the very large particle size carbon blacks at an excellent dispersion level. This behaviour seems to be related at least in part to surface chemistry effects (e.g., the initial wetting of the black surface) and is further manifest in the agglomerate size data (Fig. 8). Here, the LCC-1 carbon has the largest agglomerate size after 4 and 8 hours of ball milling, but the lowest agglomerate size after 32 hours. The agglomerate size patterns for the different carbons do not differ as much as the agglomeration index values. Agglomerate size is not a dispersion function related to the type of carbon, but is more of a reflection of the method of dispersion. Ball milling is shown to be an effective grinding method for reducing agglomerate size. All final agglomerate size ratings for the 32 hour dispersions are comparable, despite the large variations in agglomeration index.

Modified sand grinder dispersions (zirconium oxide media) were prepared for six of the blacks which had been studied by ball milling. (Figs. 9 and 10).

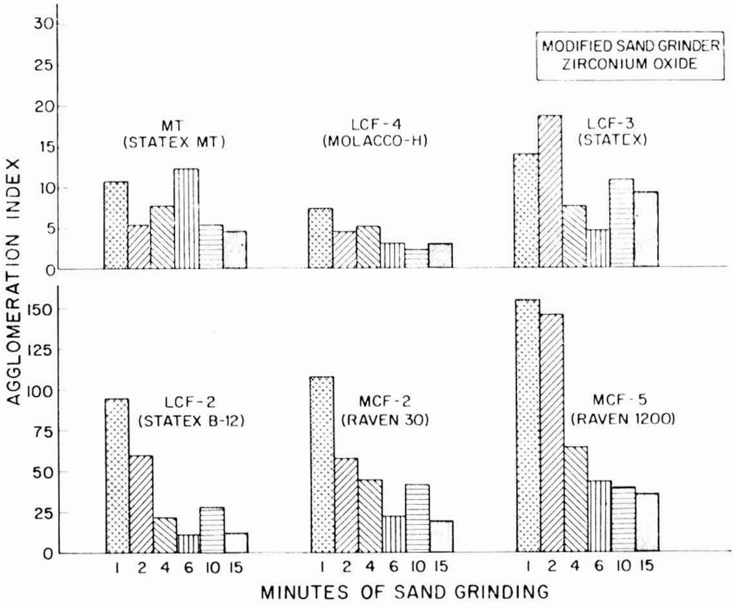

Fig. 9. The effect of carbon black type on agglomeration index in medium oil alkyd

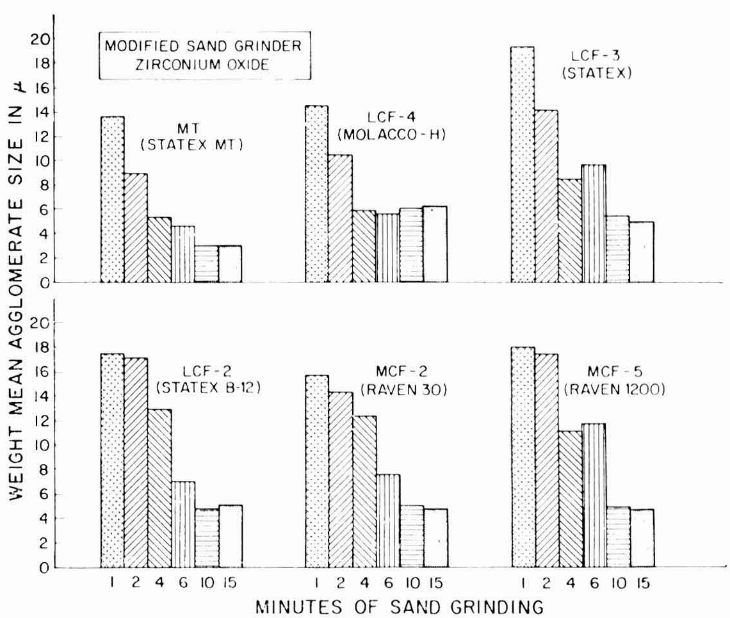

Fig. 10. The effect of carbon black type on agglomerate size in medium oil alkyd

The very fine particle size carbon blacks were omitted from this study because they could not be compared in the same formulations. The sand grinder dispersions were evaluated after 1, 2, 4, 6, 10, and 15 minute treatments. Both the agglomeration index determinations (Fig. 9) and the weight mean agglomerate size measurements (Fig. 10) demonstrate the greater effectiveness of the sand grinding method in dispersing the medium-large particle size carbon blacks. In all instances, the sand grinder produced better dispersions and smaller agglomerate size in a small fraction of the time required for the ball mill dispersions. Another comparison of the two methods is shown for two other carbon blacks in Fig. 11. The differences in dispersion are most apparent in the agglomeration indexes. At prolonged ball milling times, there generally appears to be a levelling off in agglomerate size in the range of 5 μ. However, this level is achieved in the sand grinder in as little as 10 minutes.

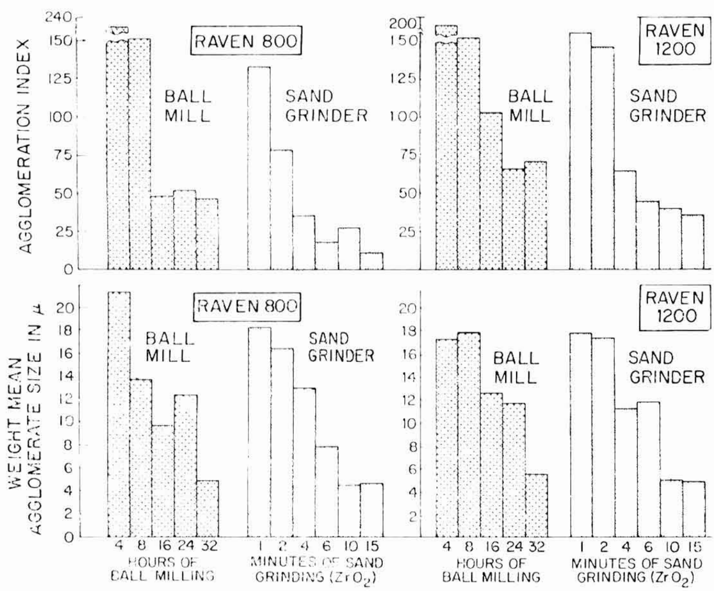

Fig. 11. Comparison of dispersing procedure in medium oil alkyd—ball milling vs. modified sand grinding

Light photomicrographs (Fig. 12) illustrate some of the black dispersions in the particle size ball milling study. The differences in black dispersibility as a function of particle size are readily discernible. The advantages of the Quantimet system in carrying out analyses of this sort are quite evident. For each carbon black dispersion evaluated in this series (six ball milling times) a total of 150-200 fields similar to those shown in Fig. 12 were analysed in a few minutes. This kind of study would have been quite impractical by more conventional methods.

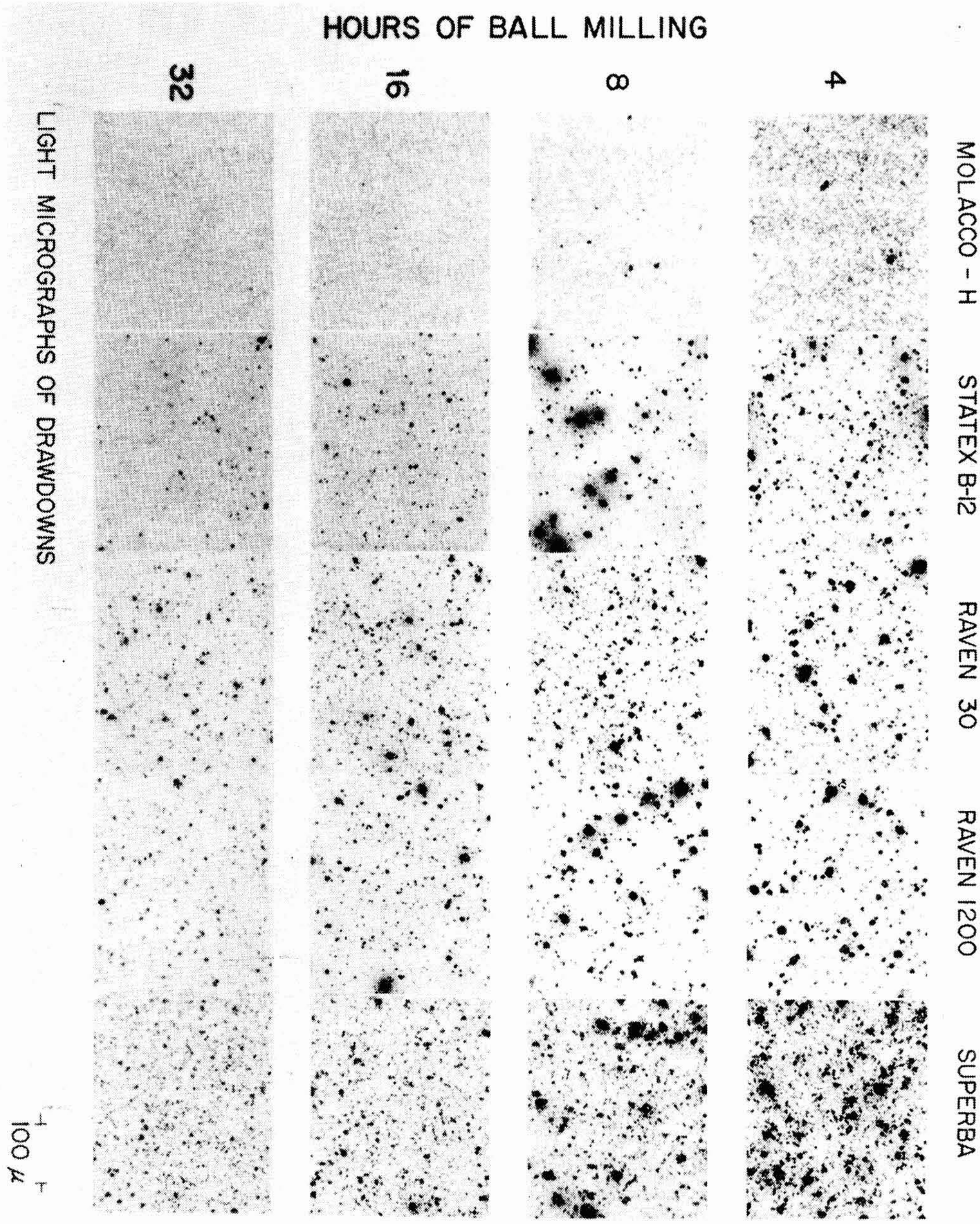

Fig. 12. Dispersion of different carbon blacks in medium oil alkyd

Gloss development as a function of dispersion quality

The effect of dispersion quality on gloss development in a medium oil alkyd vehicle was compared for four of the medium-large particle size carbon blacks using ball mill (Fig. 13) and modified sand mill (Fig. 14) dispersions. Gloss ratings are plotted against the dispersion quality index. The gloss ratings are 20° (angle of incidence) values using the Hunterlab glossmeter (Hunter Associates Laboratory, Inc., Fairfax, Virginia, USA). The improved dispersion of these blacks with sand milling is again evidenced by the more rapid gloss development. For each of the carbon black plots, the successive points for ball milling indicate dispersing times of 4, 8, 16, 24, and 32 hours, respectively. Similarly, the points for the sand mill dispersions represent times of 1, 2, 4, 6, 10, and 15 minutes.

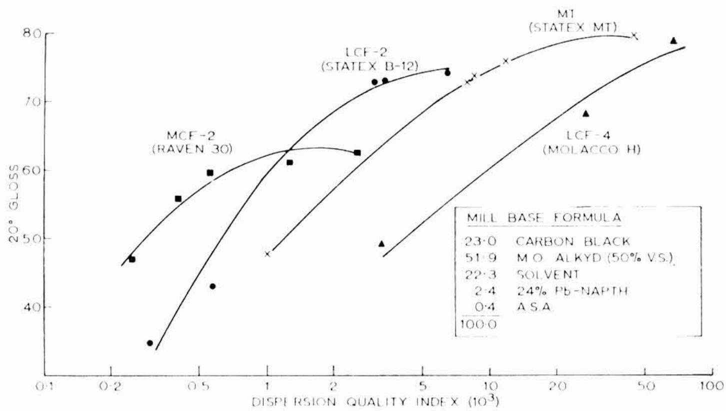

Fig. 13. Gloss development of carbon blacks in medium oil alkyd ball milling dispersions

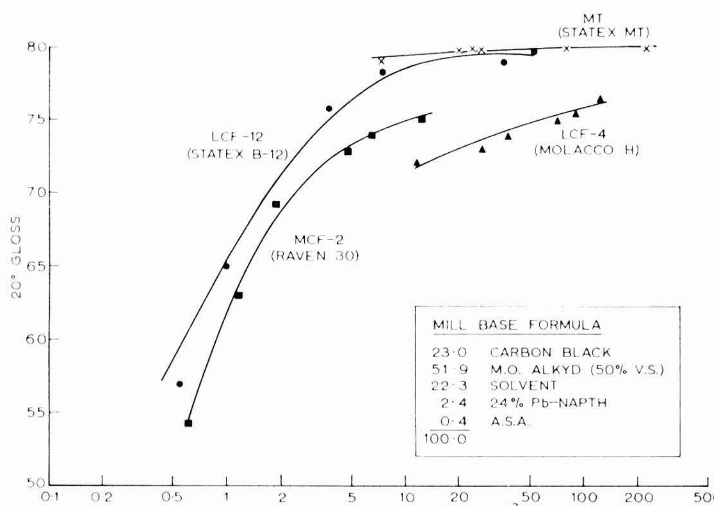

Fig. 14. Gloss development of carbon blacks in medium oil alkyd modified sand mill (ZrO_2) dispersions

A definite gloss-dispersion relationship is also evident for each different carbon black. The differences between blacks are minimised in the sand mill dispersions, and difference in gloss ratings tend to level out once a black has reached a high level of dispersion quality.

Comparison of Quantimet and grind gauge dispersion ratings

Because of the widespread use of the grind gauge for assessing paint and ink dispersion quality, a comparison of this method with Quantimet measurements is desirable. PC (Production Club) gauge ratings (Production Club grind gauge, Precision Gage and Tool Company, Dayton, Ohio, USA) are plotted against the product of the agglomeration index times the weight mean agglomerate size (Fig. 15). This correlation was the best of the three Quantimet functions utilised. Previous studies[1] had shown that the grind gauge is most sensitive to agglomerate size. Excellent grind gauge ratings are achieved when the agglomerate size approaches the range of about 5 microns, regardless of the agglomeration index. Under normal dispersion conditions, however, the reduction in agglomerate size is generally accompanied by a decrease in agglomeration index. The exceptions to this are some dispersions for the high colour type channel blacks. These eventually yield small agglomerate size, but often remain at a high level of agglomeration index.

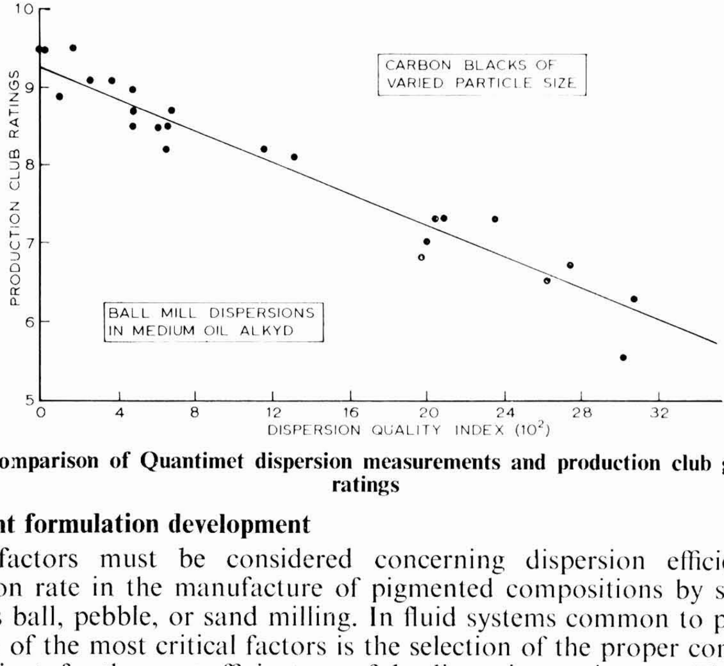

Fig. 15. Comparison of Quantimet dispersion measurements and production club grind gauge ratings

Flow point formulation development

Several factors must be considered concerning dispersion efficiency and production rate in the manufacture of pigmented compositions by such techniques as ball, pebble, or sand milling. In fluid systems common to paints and inks, one of the most critical factors is the selection of the proper combination of ingredients for the most efficient use of the dispersing equipment. The primary concern is to disperse adequately the most pigment in the mill base paste in the shortest time to maintain a high production rate. With a ball mill, for example, such factors as the mill speed, ball size, volume of ball charge and ingredients, paste viscosity, and milling time are all important. These have been discussed in detail by a number of authors, including Cooper[10] and Patton[11]. However, this phase of the study was directed at the formulation aspects of ball mill dispersions, using a set of constant conditions relating to the other factors mentioned. The two principle variables were the various carbon pigment types, and the different paint vehicles used in testing. The prime objective was to disperse the maximum amount of each pigment into its respective mill base paste.

Medium-high colour carbon blacks

Four channel blacks and one furnace black were examined. These pigments vary widely in the physical and chemical properties by which they are classified. [12, 13]

Daniel flow point determination

A modification of the Daniel flow point method [14] was employed to determine the optimum paste grinding consistency and the highest pigment concentration in three different vehicle systems (medium oil alkyd, thermosetting acrylic melamine, and polyurethane). Because of their fine particle size, carbon blacks do not readily lend themselves to the standard procedure. The original method of hand stirring by rod or spatula was therefore altered, and a modified technique suitable for carbon blacks was adopted in which a miniature sand mill was used. The original flow point method is described below.

Procedure: Place a measured quantity of pigment in a suitable container. Add to it a resin solution of known solids content, stirring continuously with a glass rod, until a smooth heavy paste is obtained. Add more solution gradually until the mass can be stirred without much resistance. Lift the rod from the container and hold vertically. If the paste does not flow from the end of the rod, add more of the resin solution with continued stirring. When enough of the solution is present to wet the pigment adequately, a recognisable and reproducible (with repeated dipping of the rod into the mixture) state of fluidity has been achieved. This is the flow point. It occurs when a thin film of material remains on the rod, the last few drops of which break away from the tip with an elastic-like snap-back. (If too much of the vehicle is used, there is a more rapid flow from the rod and no snap-back of the last few drops.) Record the volume of resin solution added. Repeat the test using different proportions of resin solids in the solutions (usually at 5 per cent intervals) to a limit of 40 per cent vehicle solids content. Plot the quantities of resin solution against the solids content to determine the minimum amount of solution required to wet the pigment. Thus, the maximum amount of a pigment dispersible in a vehicle system can be determined. The mixture at the flow point represents those proportions of solvent, binder, and pigment suitable for the most efficient use of ball mill. Such mixtures may be termed "ideal" formulations. The solvent/binder ratio is particularly important in that excess solvent tends to induce pigment flocculation, while excess binder increases the premix and mill base viscosity. Both are undesirable departures from the optimum blend derived from the minimum point curve.

Modified procedure for carbon blacks: Carbon blacks, because of their fine particle size, require a more rigorous technique to ensure a homogeneous mixture. In this work a miniature sand mill was used that consisted of a single 2in diameter disc rotated in a bed of 20-30 mesh Ottawa Sand (ASTM C-190, type, Ottawa Silica Company, Ottawa, Illinois, USA) in a half-pint can. Resin solution was added to a mixture of 7g of carbon black and 114g of sand. When the point of elastic snap-back was being approached, a small amount of the "paste" (the carbon/vehicle mixture in the sand) was tested by placing it on a fine mesh paint screen. The flow behaviour of the filtered mixture indicated whether more or less vehicle was required or if retesting was necessary, as in the regular procedure.

Results

Flow point curves (Fig. 16) for the five medium-high colour carbon blacks were derived in a medium oil alkyd vehicle system (Beckosol P-531-50, Reichold Chemicals, Inc., White Plains, New York, USA). From these determinations, the mill base formulations were calculated for each vehicle solids level and are shown in Table 4. There is a good correlation between the surface area of these pigments and the amount of resinous material required to achieve the optimum consistency in the paste, as determined by the modified flow point procedure.

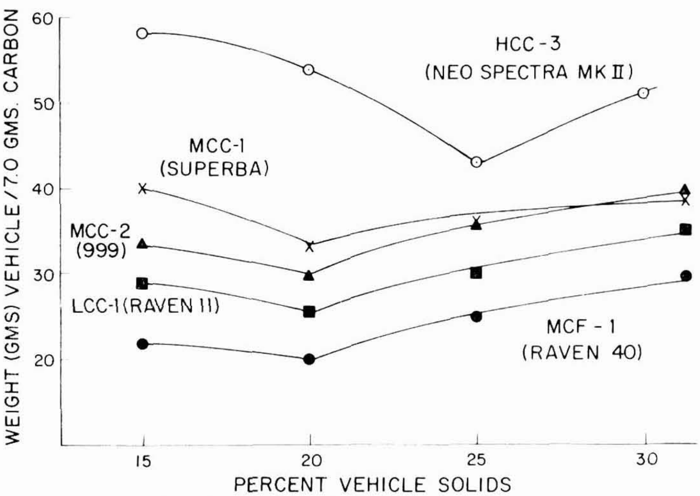

Fig. 16. Flow point determinations for different carbon blacks in medium oil alkyd

It can thus be observed that the greater the surface area of the pigment, the greater the quantity of resinous material required to attain an "ideal" consistency. For example, the finest particle size carbon, HCC-3 type (Neo Spectra Mark II) with a surface area of 900 $m^2 g^{-1}$ required 42g of a 25 per cent vehicle solids solution for every 7g of carbon; the coarsest particle size carbon of the set, MCF-1 (Raven 40), with a surface area of 102 $m^2 g^{-1}$, required only 20g of 20 per cent solids vehicle to attain "ideal" consistency. Comparative pigment to binder ratios are 0.64 and 1.72, respectively, indicating the difference in vehicle demand of each carbon black.

At the "ideal" formulation for each grade of carbon, it can be seen that the highest level of pigment concentration in the paste is achieved. These formulations were calculated on a weight percentage basis, but can also be expressed in the normal manner in terms of volume concentration.

The relative viscosities (measured by Brookfield viscometer) for the five blacks (Table 3) in each of four vehicle solids formulations are shown (Fig. 17) after 48 hour dispersion cycles. These bar graphs illustrate the specific pattern that emerges for each pigment. The maximum viscosity for each black generally

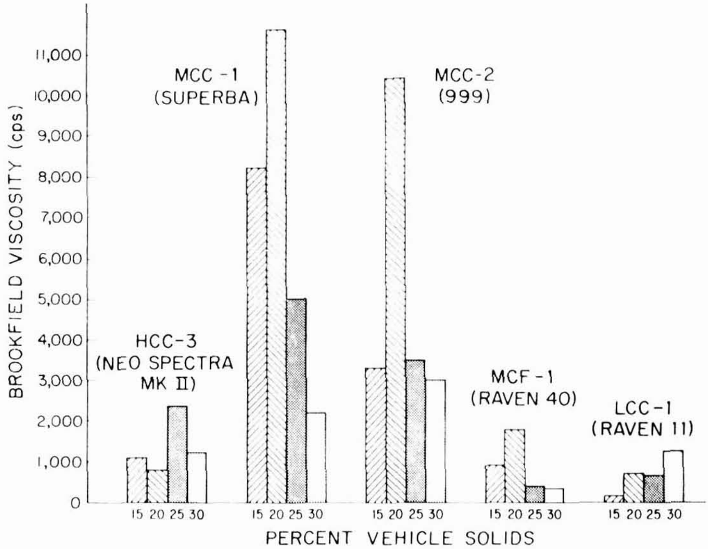

Fig. 17. Viscosity variations for different carbon blacks in medium oil alkyd

occurs in the "ideal" formulation, which contains the largest quantities of each carbon black. The large differences in Brookfield viscosities are due to the fact that each pigment, in its optimum formulation, exhibits a different rheological pattern. The factors affecting viscosity include the solvent content, the pigment/binder ratios, the particle size and structure of each pigment and its surface chemistry.

Similar studies were carried out with four of these carbon blacks in a thermosetting acrylic vehicle (Acryloid AT-56 and Uformite MM-47, Rohm and Haas Company, Philadelphia, Pennsylvania, USA), as well as in an oil modified polyurethane system (1210-MS, Cargill, Inc., Minneapolis, Minnesota, USA). For the polyurethane system only three of the carbon blacks, 999 (MCC-2), Raven 11 (LCC-1), and Raven 40 (MCF-1) were studied. Flow point curves for the acrylic and polyurethane systems are shown in Figs. 18 and 19, respectively. The "ideal" mill base formulations for these systems are shown in Tables 5 and 6. Again, the carbon black surface area, as it affects vehicle demand, appears to be a critical factor in determining the proper combination of ingredients for these blacks with the ball mill dispersion technique.

Although the flow point technique outlined above is by no means a complete answer to all the problems in preparing suitable coatings products, it does serve as a useful guideline. These studies were based on simple formulations which are not necessarily of a commercial nature. In actual practice, several other ingredients may be used and must be accounted for in the formulation.

Evaluation of paint films

To evaluate the quality of these formulations the paste concentrates were let down in a normal manner to the same final pigment to binder ratio (approximately 5 weight per cent of pigment on total film forming solids) for quality

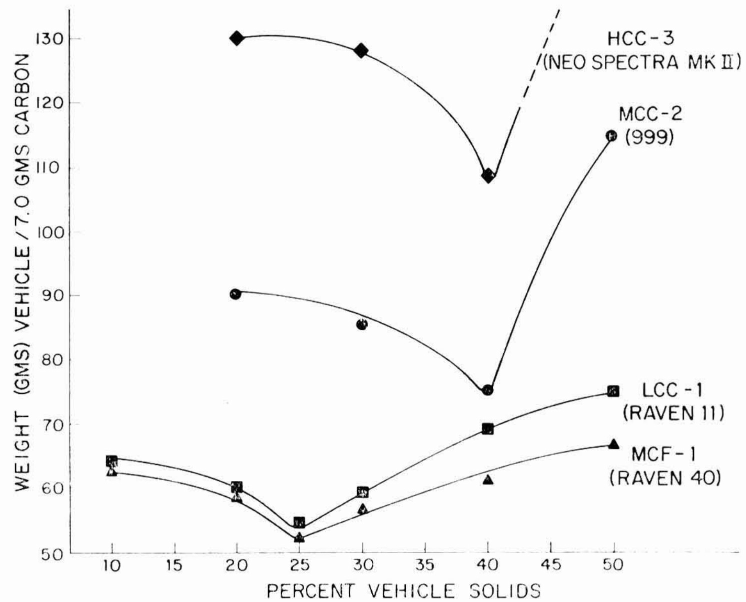

Fig. 18. Flow point determinations for different carbon blacks in acrylic

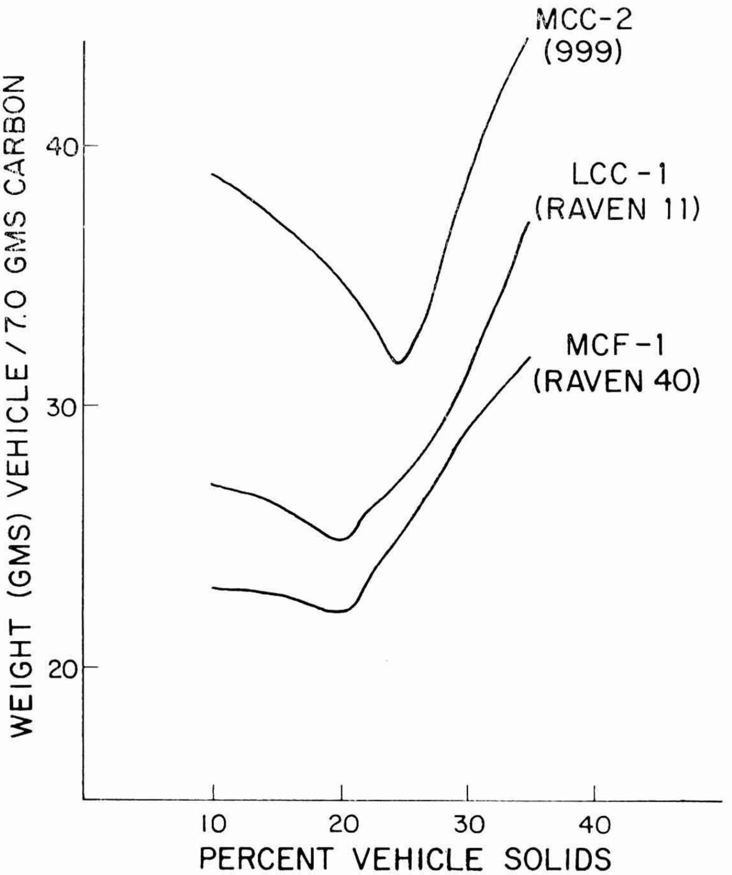

Fig. 19. Flow point determinations for different carbon blacks in polyurethane

appraisal. The dispersion characteristics of four of the carbons in the alkyd system are plotted for weight mean agglomerate size (Fig. 20) and agglomeration index (Fig. 21). Dispersion functions are plotted against hours of ball milling for each of the four vehicle solids levels evaluated. The dispersion patterns are similar at each of the vehicle solids levels, with the flow point formulation being

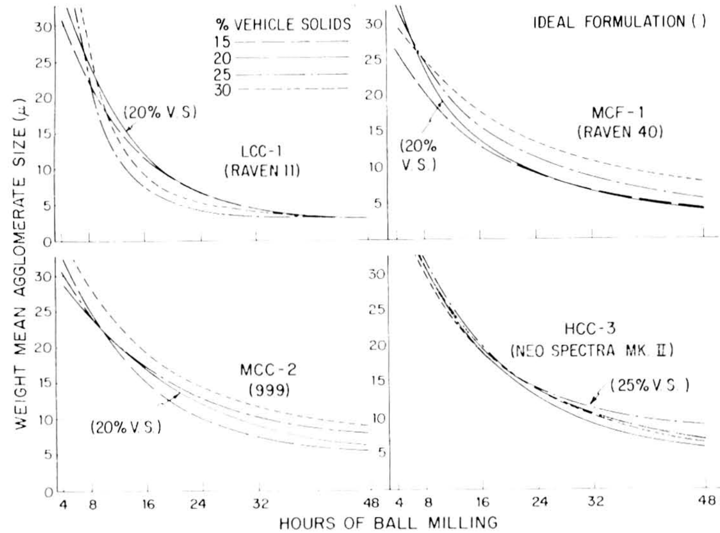

Fig. 20. The effect of flow point technique on carbon black agglomerate size in a medium oil alkyd system

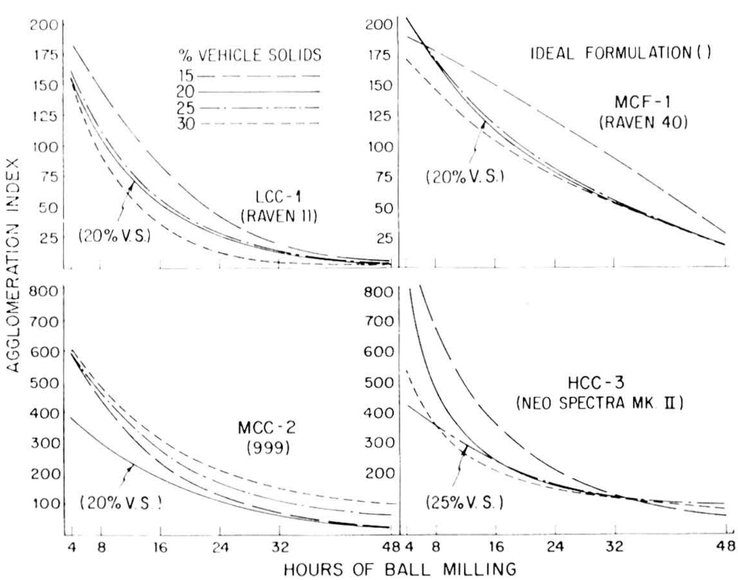

Fig. 21. The effect of flow point technique on carbon black dispersibility in medium oil alkyd system

either comparable to or slightly better than the other vehicle solids levels. However, the important point is that, at the flow point, the maximum amount of pigment has been incorporated into the mill base paste without any sacrifice in dispersion quality. This is also apparent in terms of gloss development. Hunterlab 20° gloss readings are plotted against the dispersion quality index for the 999 (MCC-2) Fig. 22, and Raven 11 LCC-1 Fig. 23, type carbon blacks. These blacks differ appreciably in their surface area, but each showed negligible fluctuation in gloss development as a function of the per cent vehicle solids in the mill base paste. Similar results were obtained for all the carbons in this phase of the study.

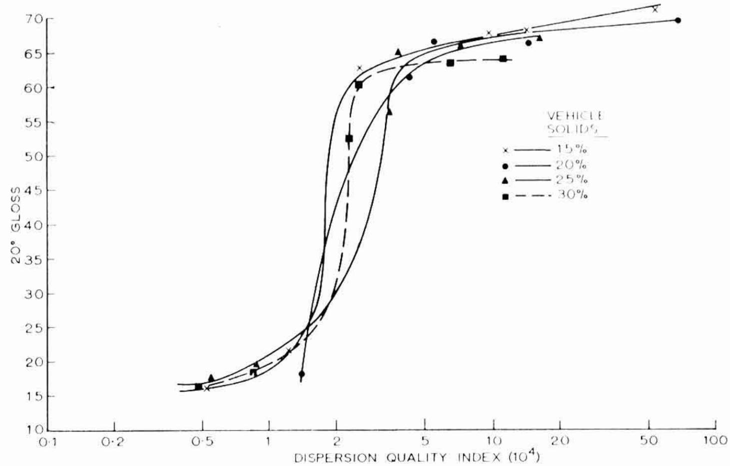

Fig. 22. Gloss development of MCC-2 black (999) in medium oil alkyd at different vehicle solids levels

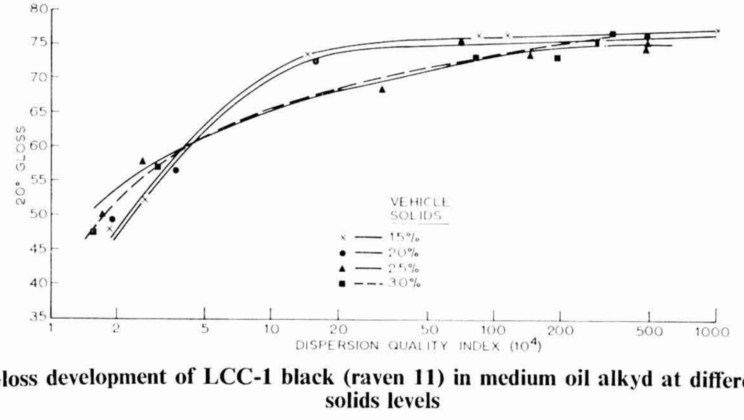

Fig. 23. Gloss development of LCC-1 black (raven 11) in medium oil alkyd at different vehicle solids levels

The gloss development of MCC-2 and LCC-1 is compared in their respective "ideal" formulations (Fig. 24), by plotting gloss ratings against the ball milling time. The gloss differences between the two blacks appear to be consistent with their dispersion differences as shown in Fig. 21. The coarser Raven 11 black has a more rapid rate of dispersion and gloss development under these test conditions, and maintains this advantage throughout the entire dispersion cycle. The final difference between the two blacks, however, also relates to their basic properties and cannot be entirely attributed to dispersion differences. From the flow point curves and the formulations for these two blacks, it is evident that, although the vehicle solids content for each pigment is the same, the finer 999 carbon black requires more resinous material to satisfy its surface vehicle demand.

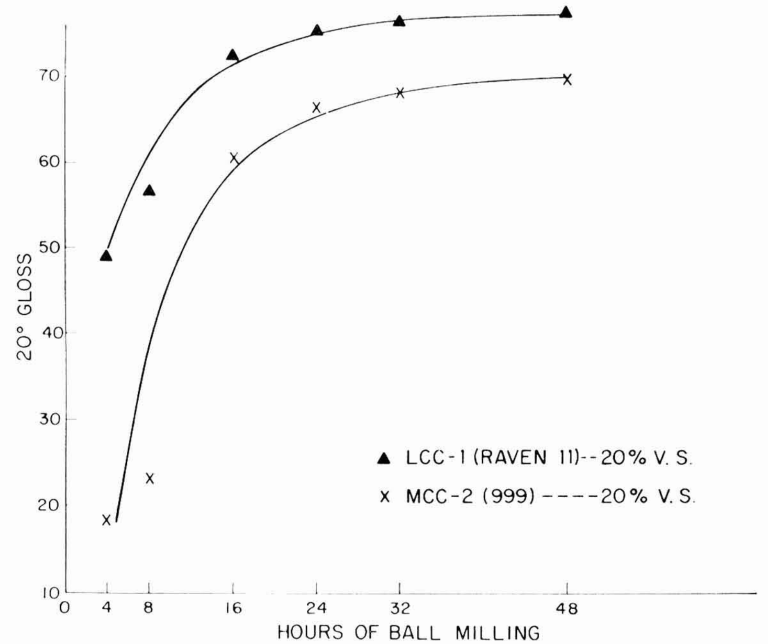

Fig. 24. Carbon blacks at ideal formulations in medium oil alkyd

Similar flow point determinations were performed in a thermosetting acrylic and in an oil modified polyurethane system. The blacks studied in these vehicles also exhibited a dispersion pattern similar to that shown in medium oil alkyd vehicle, i.e., the dispersion development was similar at different vehicle solids levels. The principle advantage of the flow point method is in achieving maximum pigment concentration in the mill base paste. Because of this similarity in dispersion development, only the "ideal" formulations will be discussed. Gloss development in the acrylic system was determined for four carbon blacks as a function of dispersion (Fig. 25) and as a function of ball milling time (Fig. 26). It would appear that the gloss differences among these blacks are predominantly attributable to the dispersion variations. The separate dispersion plots (Fig. 25) fall close together; actually, a single curve could be plotted through all of the data points. On the other hand, the plots against ball milling time (Fig. 26) show distinctly different patterns, which may be attributable to differences in the particle size or aggregate morphology of the blacks, factors which affect dispersibility.

The gloss-dispersion relationship for three carbon blacks in the polyurethane

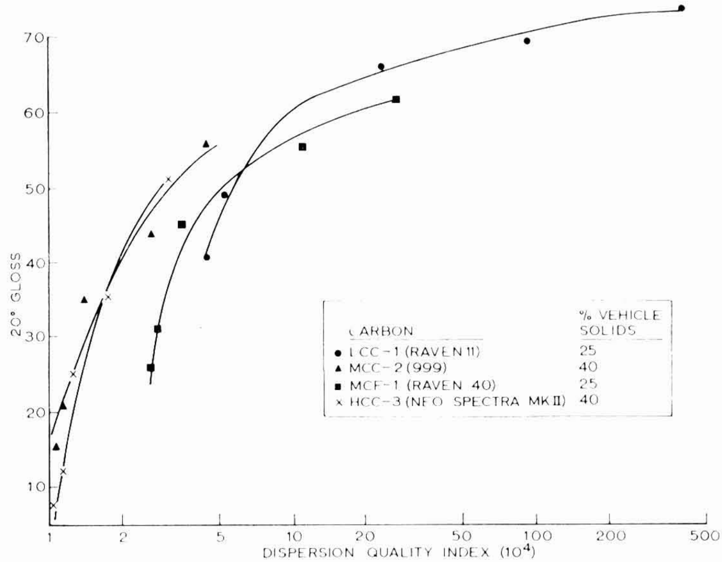

Fig. 25. Gloss development in TS acrylic using flow point formulations

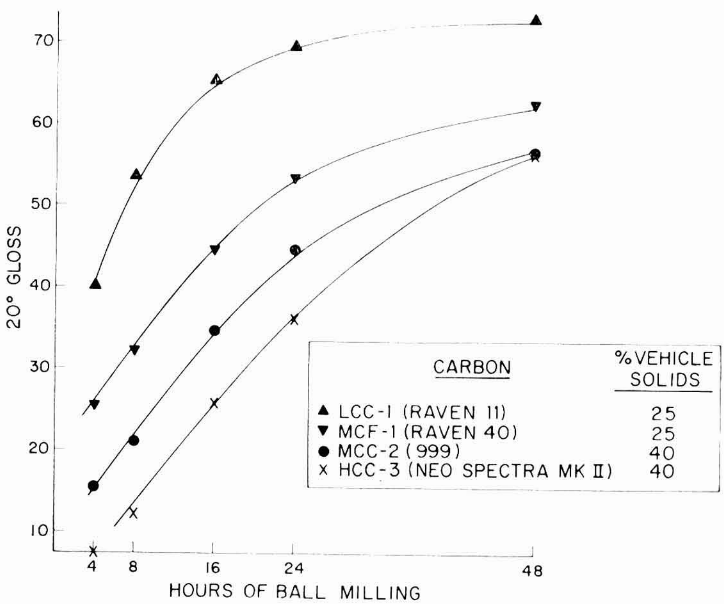

Fig. 26. Gloss development of different carbon blacks in TS acrylic

system is shown in Figs. 27 and 28. Again, the dispersion results play a major role in the gloss development but, in this instance, the basic carbon black characteristics appear to have a greater bearing *per se*. For example, the 999 type black shows a better dispersion in the polyurethane system in comparison with the acrylic. However, the gloss differential between Raven 11 and 999 is similar in both systems.

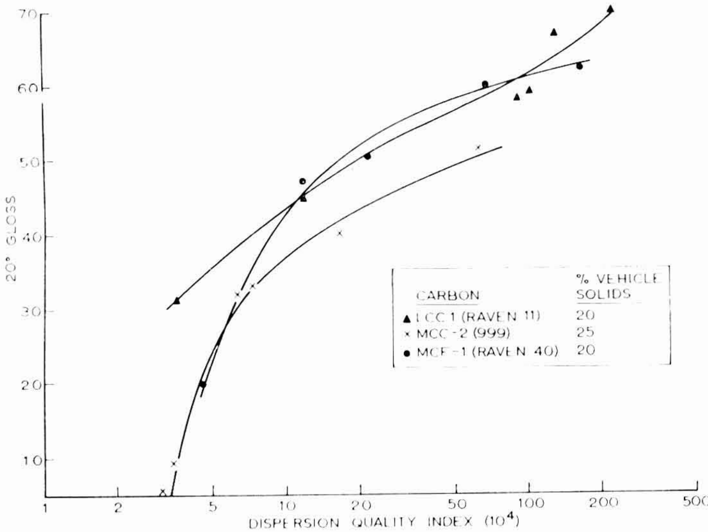

Fig. 27. Gloss development in polyurethane using flow point formulations

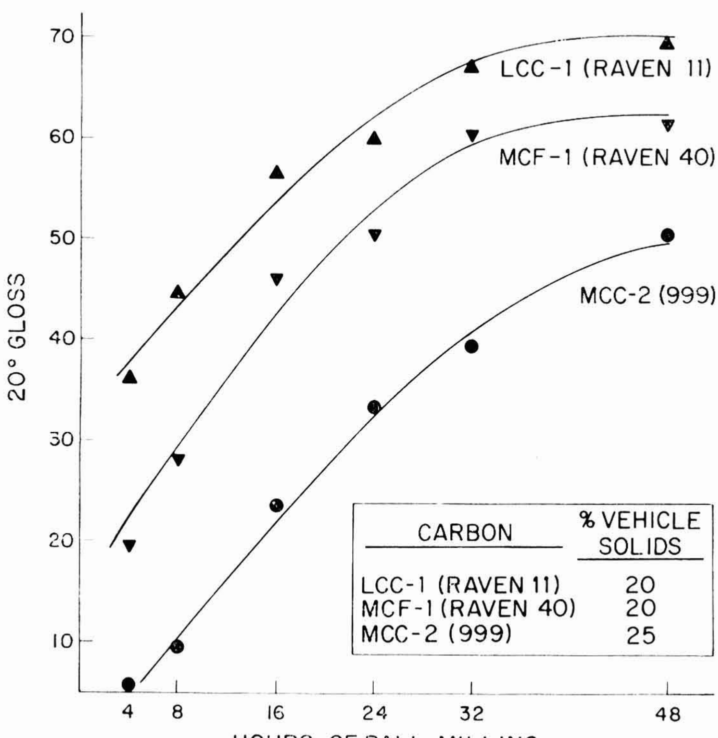

Fig. 28. Gloss development of different carbon blacks in polyurethane system

Although not a prime objective, accelerated weathering tests were made on the five carbon blacks dispersed in the medium oil alkyd system. These studies were carried out using the "ideal" formulations. Coatings were prepared on alodine-treated aluminium panels at a dry film thickness of approximately 1 mil. Enamels of low PVC, approximately 3 per cent, were used to ensure high initial gloss. Each black was ball milled for 48 hours to achieve good dispersion. The Atlas X-W Weatherometer (Atlas Electric Devices Company, Chicago, Illinois, USA) was employed in these studies, using a cycle of 2 hours of simulated sunlight and 15 minutes of water spray for a total of 800 hours. Plots of gloss versus hours of weathering for the five different blacks are shown in Fig. 29. The results

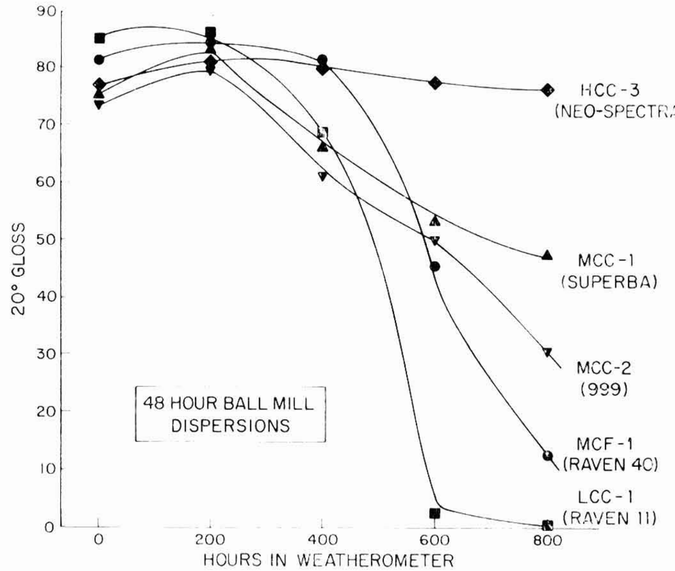

Fig. 29. Durability of medium oil alkyd paint films as a function of carbon black type

are consistent with previous correlations which have shown that the durability of black enamels is closely related to the particle size and surface area of the pigments. Dispersion appears to have very little bearing on these weathering results, although a reasonable level of dispersion is, of course, required for satisfactory initial gloss development. The highest surface area black, Neo Spectra Mk II (HCC-3) showed the poorest dispersion after 48 hours, yet gave by far the best weathering characteristics. The largest particle size blacks, Raven 11 and Raven 40, were the poorest in weathering.

Comparison of blacks in three different vehicle systems

The performance characteristics of a carbon black may vary widely according to the vehicle system in which it is employed. This is not surprising in view of the many resinous vehicle systems which are available in the coatings industry, each one having its own specific chemical and physical characteristics. Combined with the unique properties of many of the different type carbon blacks, a variety of different pigment-vehicle interactions are to be expected.

The dispersion and performance characteristics of the medium oil alkyd, thermosetting acrylic, and polyurethane systems were compared on the basis of three different carbon blacks which vary in their particle size and surface chemistry: Raven 40 (MCF-1), Raven 11 (LCC-1), and 999 (MCC-2). The MCF-1 type of black is a relatively large particle size (240 Å) furnace black with low oxygen volatile content (~ 1 per cent) on the surface. The LCC-1 type of carbon black is made by the channel process and shows relatively high oxygen volatile content (5.5 per cent) while being in the particle size range of the MCF-1. The MCC-2 type of black combines the characteristics of very small particle size (160 Å) and a high surface oxygen content (5 per cent). All comparisons were based on the "ideal" mill base formulations using the flow point method (Tables 4, 5, and 6).

A comparison of the blackness (or jetness) developed by each of these blacks in each of the three different vehicle systems was made with the medium oil alkyd system as the control at zero level. (Fig. 30.) These observations were

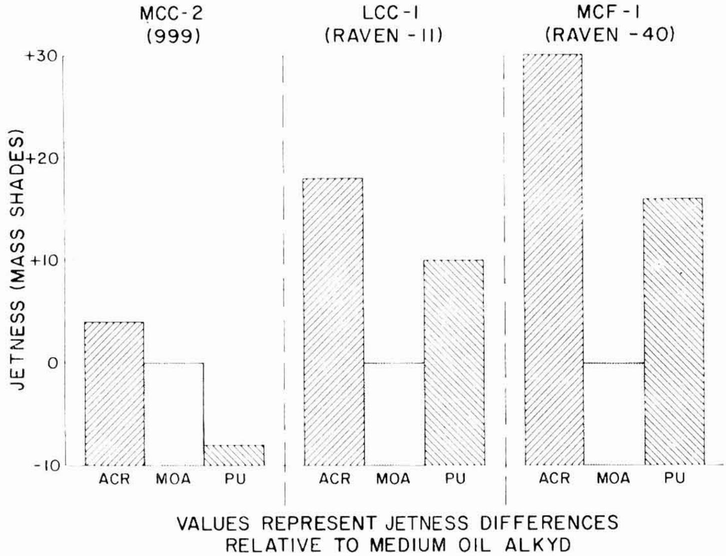

Fig. 30. Carbon black colour comparison in different vehicles using flow point formulations

made separately for each of the blacks in the three vehicles and comparisons are valid only between compositions of the same black in different vehicles. Comparisons are not valid between different blacks in different vehicles. Jetness evaluations were made on drawdowns on a non-absorbent stock at a uniform film thickness. They were rated visually, the test being performed in a completely darkened area using an intense light source (3,400°K., supplied by a Photoflood Lamp, General Electric Company, Nela Park, Cleveland, Ohio, USA). Jetness, as determined by this procedure, has no absolute value and is always rated relative to a control standard along with the other samples to be tested. The smallest difference observed between two black panels is referred to as "one mass shade". Although it can be somewhat subjective, the visual method is the preferred procedure in colour rating dispersions of carbon black pigments, especially those in the fine particle size range. These cannot be rated effectively by the colorimetric instruments currently used in the coatings field, because the major portion of the light from the source is absorbed by the carbon black and very little is reflected for the sensor to record.

The acrylic system gave the greatest jetness development with all three carbon blacks. Dispersion would appear to have little bearing on these results, in that the acrylic system tended to have the poorest dispersion. The greatest differences in jetness in any vehicle occurred with the MCF-1 type black. Comparison of these data with those of the LCC-1 black, which has a similar particle size, suggests that the acrylic system is the least sensitive of the three to black surface chemistry effects. On the other hand, the medium oil alkyd system appears to be the most sensitive of the three to black surface chemistry effects as indicated

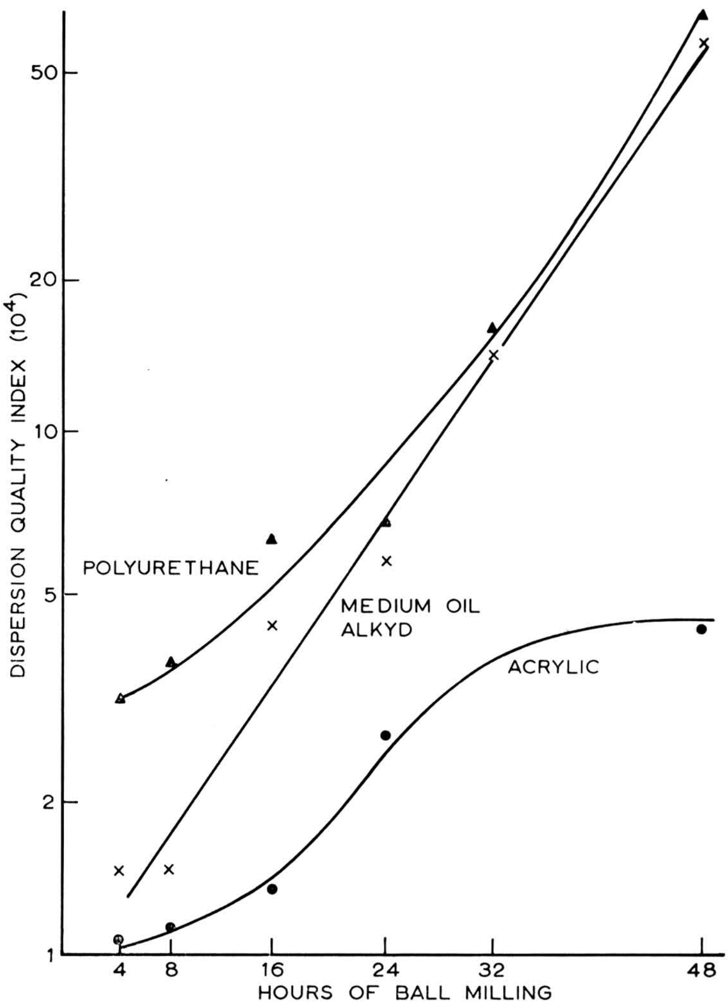

Fig. 31. Dispersion of MCC-2 (999) carbon in different vehicles using flow point formulations

by the similarity in jetness among the three vehicles with the MCC-2 and LCC-1 type carbon blacks, both of which are high in oxygen volatile content. The relative jetness in the medium oil alkyd and polyurethane systems are reversed with these two channel blacks. In acrylic and polyurethane systems, the jetness differential is consistent for all three blacks, although the spread is greatest with the MCF-1 type black, presumably owing to the lack of surface chemistry effects.

The relation of dispersion to gloss in the three systems was determined with the LCC-1 (Raven 11) and MCC-2 (999) carbons (Figs. 31 to 34). For the finer MCC-2 black, the acrylic system shows by far the poorest dispersion, while polyurethane was slightly higher than medium oil alkyd. The dispersion differences were minimal with the LCC-1 type of black, but the medium oil alkyd vehicle did show the best overall dispersion. The gloss development of these two blacks in the three different systems can be explained only partially on the basis of dispersion (Figs. 33, 34). The pigment-vehicle interactions appear to have the

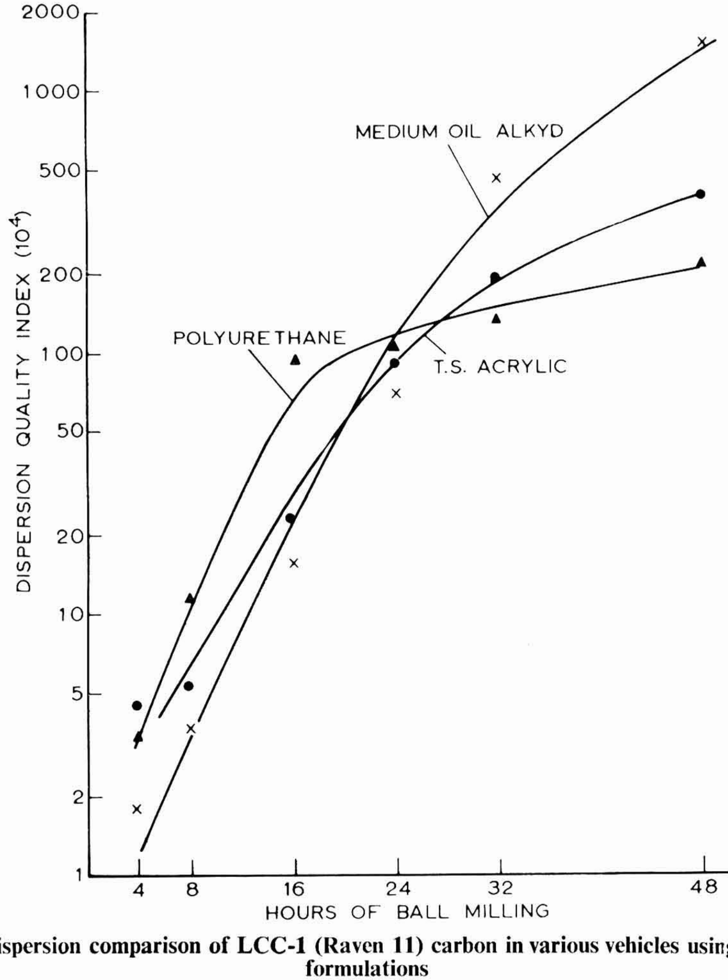

Fig. 32. Dispersion comparison of LCC-1 (Raven 11) carbon in various vehicles using flow point formulations

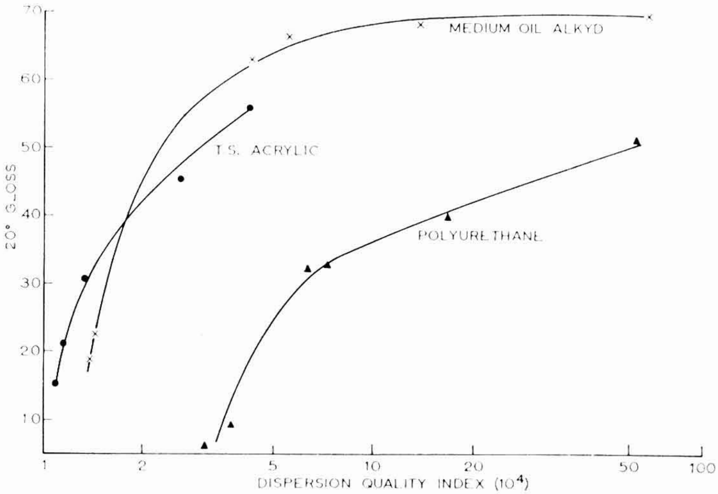

Fig. 33. Gloss development of MCC-2 (999) carbon in different vehicle systems using flow point formulations

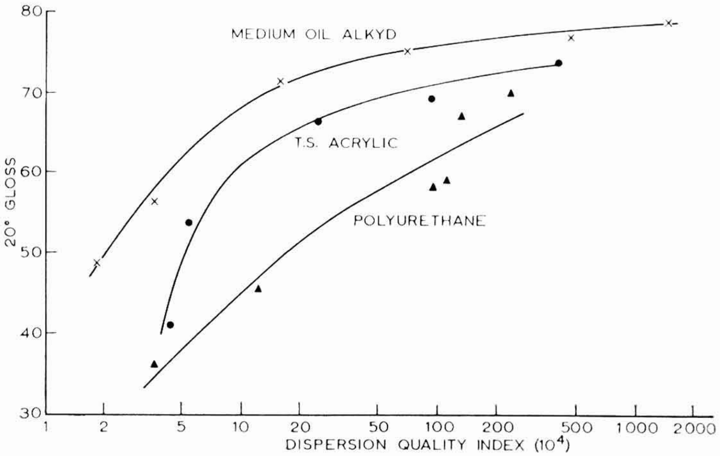

Fig. 34. Gloss development of LCC-1 (Raven 11) carbon in different vehicles systems using flow point formulations

most effect on the gloss of the MCC-2 (999) black in the alkyd and the polyurethane systems, both of which are at a good final dispersion level. The gloss of the MCC-2 black in the acrylic system does not reflect its dispersion ratings and is more indicative of a specific carbon/polymer interaction. The dispersion curves for the acrylic and alkyd systems follow a similar line, with the former simply ending at a lower level. The gloss development of the LCC-1 type of black (Fig. 34) appears more closely related to the basic gloss characteristics of the vehicles themselves, with a slight reversal between the acrylic and the polyurethane. Hunterlab gloss-meter ratings of the unpigmented vehicles were: 84 for the alkyd vehicle, 76 for the polyurethane, and 70 for the acrylic, a at all 20° angle.

Gloss comparisons for the MCC-2, LCC-1 and MCF-1 blacks in the three systems were based on the final 48 hour ball mill dispersions (Fig. 35). These data, in contrast to those in a similar chart for blackness (Fig. 30), are absolute. The relative gloss ratings of the three blacks was the same in all three systems, the differences being the least in the medium oil alkyd vehicle (MOA). In comparing the gloss development for each black in the three different systems, the pattern was not always consistent with the unpigmented gloss ratings of the three vehicles. For example, with the very good dispersing LCC-1 type of black the gloss rating of the acrylic system surpasses that of the polyurethane and approaches the medium oil alkyd rating, which was the highest in all instances.

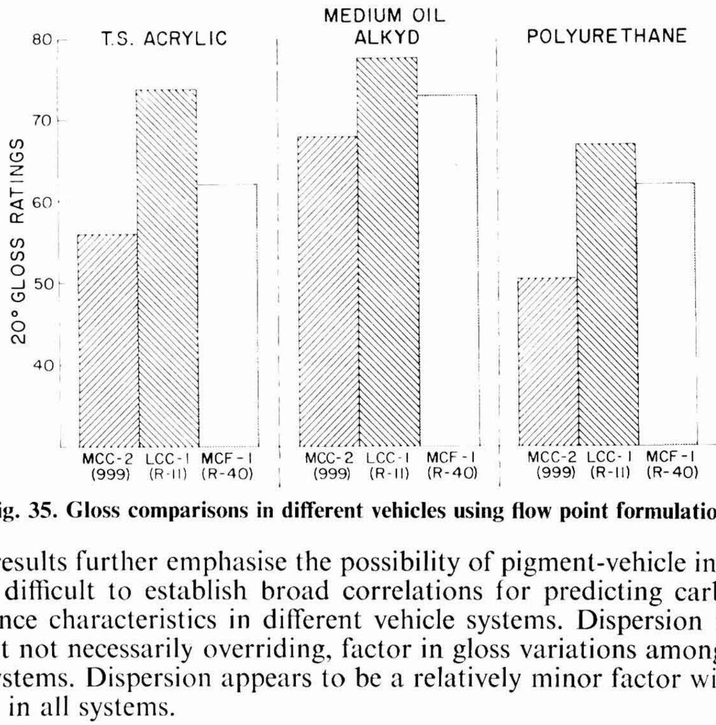

Fig. 35. Gloss comparisons in different vehicles using flow point formulations

These results further emphasise the possibility of pigment-vehicle interactions and it is difficult to establish broad correlations for predicting carbon black performance characteristics in different vehicle systems. Dispersion is a significant, but not necessarily overriding, factor in gloss variations among different vehicle systems. Dispersion appears to be a relatively minor factor with respect to jetness in all systems.

Medium-low colour carbon blacks in medium oil alkyd

The initial dispersion studies were focused on the high colour type carbon blacks. Subsequently, the work was broadened to include some of the larger particle size blacks to provide a more thorough study of the relationship between the type of black and its flow point formulation. Flow point curves for four medium-low colour blacks are shown in Fig. 36, together with the flow point curve for the MCC-2 (999) type of black as a reference. The colloidal properties of the blacks are shown in Table 7, and the formulations in Table 8. These carbons have a particle size range of 160-700 Å. As suggested by previous studies, each black has its own specific flow point curve. The pigment to binder ratio in the mill base paste shows a significant relationship to the surface area, with the coarsest sample requiring the lowest amount of binder. A plot of pigment to binder ratio vs. surface area is shown in Fig. 37 for the entire series

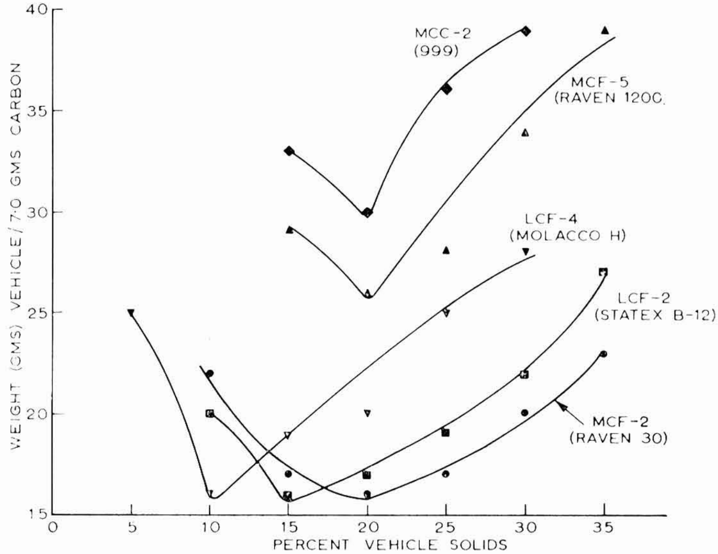

Fig. 36. Flow point determinations for different carbon blacks in medium oil alkyd

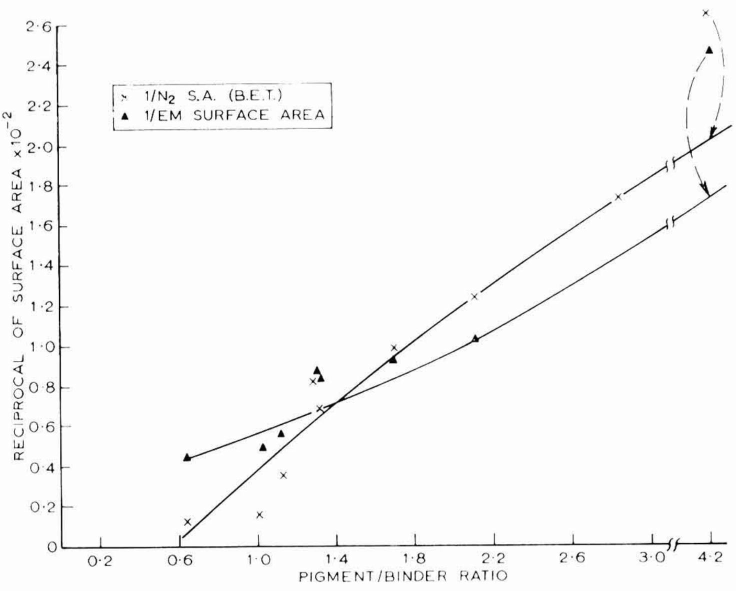

Fig. 37. The effect of carbon black surface area on mill base formulations in medium oil alkyd

of blacks studied in the medium oil alkyd system. The carbon black surface areas are plotted as reciprocal functions of both the nitrogen adsorption (BET) and the electron microscope surface area (based on particle size). Both plots give a similar relationship, with the nitrogen values showing a somewhat better correlation. A similar plot of pigment to binder ratio against surface area in the thermosetting acrylic system shows a better correlation with electron microscope surface area. This is consistent with some of the previous comparisons between the alkyd and acrylic systems which had indicated that surface chemistry effects (e.g., wetting of the pigment surface) were less significant in the acrylic system.

Gloss development as a function of dispersion was plotted for three of the medium-low colour carbon blacks in the medium oil alkyd flow point formulations (Figs. 38 and 39), the latter plot showing gloss development as a function

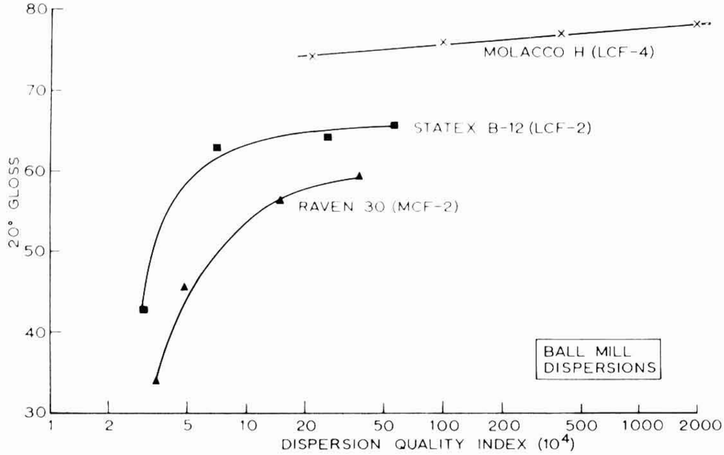

Fig. 38. Gloss development of medium-coarse particle size carbons: flow point formulations in medium oil alkyd

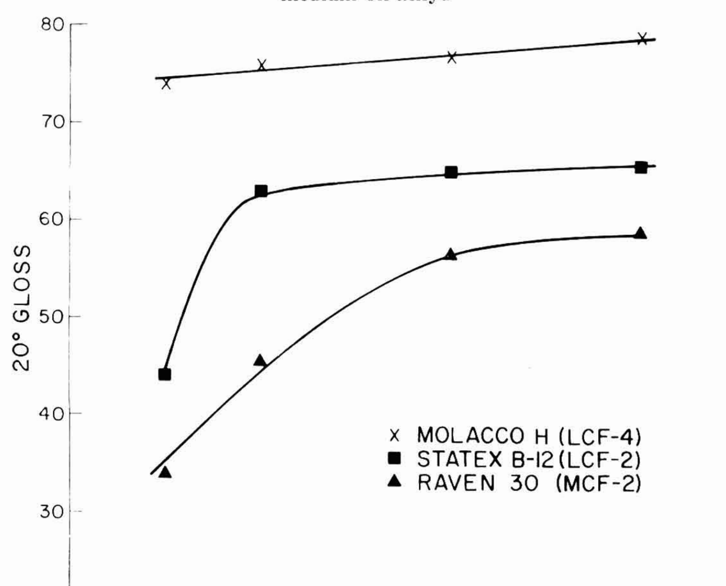

Fig. 39. Gloss development of medium-coarse particle size carbons: flow point formulations in medium oil alkyd

of ball milling time. The dispersion ratings of the three blacks are consistent with their particle size characteristics, i.e., the coarser LCF-4 (Molacco H) black gave the best dispersion and the MCF-2 (Raven 30) the poorest of the three. However, the gloss differences among the three blacks are again only partially attributable to the dispersion differences. At common ratings in the range of 20-40 on the dispersion quality index scale (Fig. 38), the dispersion curves are parallel and there is an increase in gloss with increasing particle size, presumably due to lower vehicle demand of the coarser pigments.

Flow point vs. conventional formulations

To illustrate further the advantage of the flow point formulation method for more efficient compounding of carbon black pigments, the dispersion and performance characteristics of several black samples were compared by both the flow point and conventional dispersing methods in the same medium oil alkyd vehicle. The term "conventional" implies a less detailed method of formulation, wherein the carbon black is simply compounded on an arbitrary weight or volume concentration basis. The dispersion/gloss development curves for MCF-2 (Raven 30) and MCF-5 (Raven 1200) carbons are compared, separately for each carbon, by the flow point and conventional formulating procedures in Figs. 40 and 41. Each successive point on the graph represents 4, 8, 16, and 24 hour times of dispersion. Specific formulations for the compounds shown in these two plots are given in Table 8 (flow point) and Table 2 (conventional). The "conventional" formulation of ingredients was arbitrarily chosen earlier for comparisons of the dispersing characteristics of a variety of blacks which varied appreciably in particle size and surface area.

The advantage of a shorter dispersing cycle for a higher pigment loading using the flow point method is demonstrated for the MCF-2 type of carbon black in Fig. 40. In 16 hours of ball milling, the flow point formulation (pigment to binder ratio of 2.15) achieves approximately the same final gloss level that requires 24 hours for the other formulation (pigment to binder ratio of 0.89). The advantage of obtaining improved gloss development at equivalent dispersing time is shown in Fig. 41 for the MCF-5 type of carbon black. These two examples illustrate the potential benefits that can be derived with the flow point formulation technique. The magnitude of these effects will, of course, vary

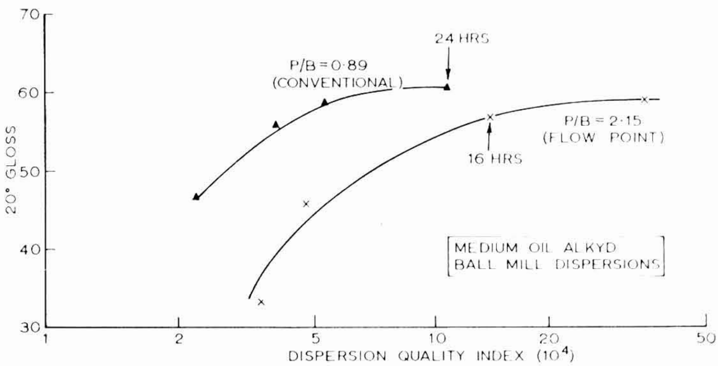

Fig. 40. Gloss development of MCF-2 (Raven 30) carbon black: comparison of flow point and conventional formulas

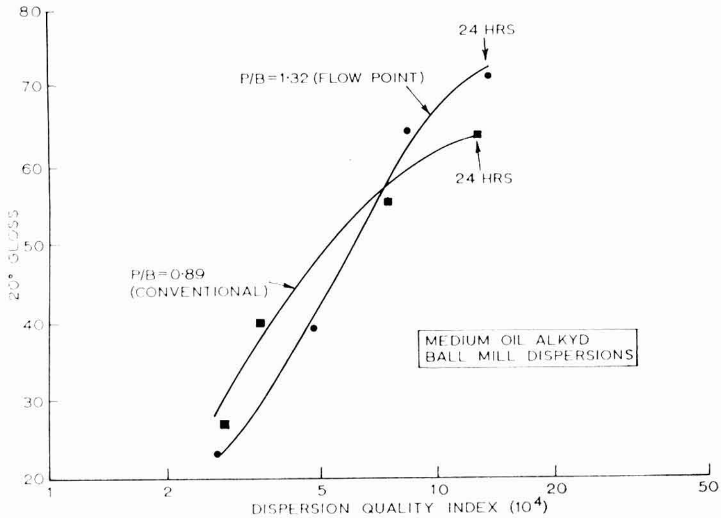

Fig. 41. Gloss development of MCF-5 (Raven 1200) carbon black: comparison of flow point and conventional formulas

according to the type of carbon black and the particular vehicle system. Generally, the greatest advantages in dispersing efficiency and improved performance by the flow point method are obtained with the finer particle carbon blacks. Arbitrary or empirical formulating techniques may not derive the fullest capabilities of these finer particle size pigments. The prime advantage of the flow point method is in achieving the maximum amount of dispersed pigment per batch.

Flexographic-rotogravure inks

Seven carbon blacks (Table 10) were compounded in a polymer system common to rotogravure and flexographic inks, the resin being a polyamide type used in co-solvent flexographic or D-type rotogravure ink formulations (generally with a blend of alcohols and aromatic or aliphatic solvents in the vehicle). Dispersions were produced in a typical ball mill grind, the prime objective being to study the effect of carbon black type under identical formulation conditions (Table 9). The carbon blacks and their colloidal properties are included in Table 10. A 16 hour ball milling cycle was used for these carbon blacks, this being similar to accepted laboratory testing procedures approximating normal production cycles. Samples were also extracted after 3 and 8 hours of dispersing time in order to assess the rate of quality development in terms of the QTM dispersion analyses. As in the other studies for this paper, the QTM measurements were made on inks that were reduced to approximately 5 per cent (by weight) in the film forming solids. Quality appraisal (e.g., blackness and gloss development) was performed on inks reduced 33 per cent with solvent on a weight basis. This is similar to the quantities used when the inks are reduced to actual press viscosity (standardised as 25 seconds in a No. 2 Zahn cup). Thus, the ink letdowns for colour and gloss testing were not the same as those used for the QTM ratings. However, it is felt that this did not have a significant effect on the results. The letdowns for the Quantimet were visually compared to pressouts of the same ink pastes in the unreduced state. In all instances, the same relative dispersion patterns were shown for all the blacks studied. The major effect of the letdown procedure is to reduce the concentration of agglomerates in the samples without changing the relative dispersion ratings significantly.

The dispersion patterns of the seven blacks were determined in terms of agglomeration index and weight mean agglomerate size (Fig. 42). All of the blacks had a relatively low weight mean agglomerate size (in the range of 5 microns) after 16 hours of ball milling. However, there were significant differences in the reduction of agglomeration index. The large particle size carbon blacks—LCF-3 (Statex 93) and Raven 800—both gave excellent dispersion in this respect, as did the LCC-2 (Raven 15). The reduction in agglomerate frequency was not as complete for the other four blacks, although acceptable final levels of agglomeration index were reached by the LFF-1 (Peerless 155), MFF-1 (Raven 35), and MCF-5 (Raven 1200) blacks after 16 hours of ball milling. The MCF-2 (Raven 30) types of black remained at a fairly high agglomeration index even after 16 hours of ball milling, presumably owing to the combination of the low oxygen volatile content and small aggregate size (low structure) of this carbon.

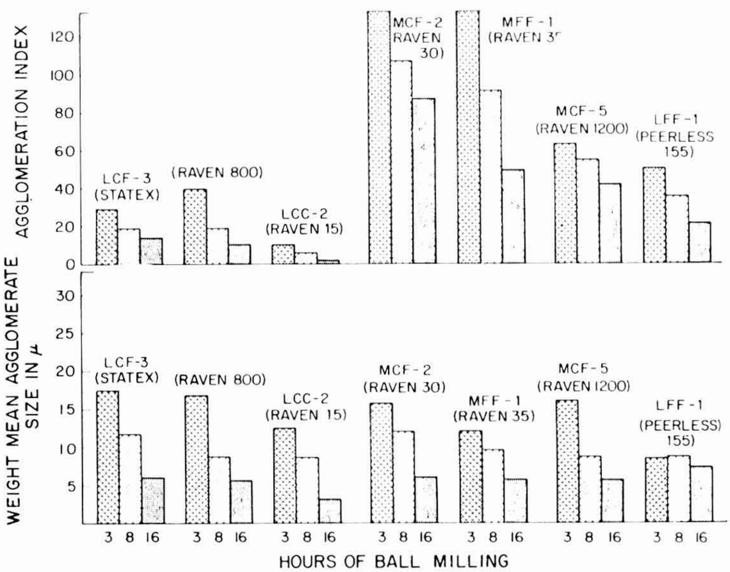

Fig. 42. The effect of carbon black type on dispersibility in a flexographic ink

Blackness and gloss development

The blackness development for these seven carbon blacks as a function of ball milling time is illustrated in Fig. 43 (Table 11). These data are plotted relative to the largest particle size black, Statex 93 (LCF-3) at a rating of zero at 16 hours of dispersing time. In contrast to most of the data for paint systems, there were some significant blackness differences attributable to dispersion. These are most apparent for the Raven 30 (MCF-2) and Raven 35 (MFF-1) type carbon blacks, which had the slowest dispersion development of all the samples. Both blacks increased about 10 shades in jetness between the 3 hour and 16 hour ball mill grinds. (A shade is the smallest difference in jetness detectable to the human eye. By standard procedures[13] some 260 jetness shades are distinguishable between the coarsest and finest grades of carbon black.) Blackness differences as functions of dispersion were minimal for the other samples. Blackness variations between the different types of black, however, are quite pronounced. These differences are predominantly attributable to particle size and structure differences (Table 10).

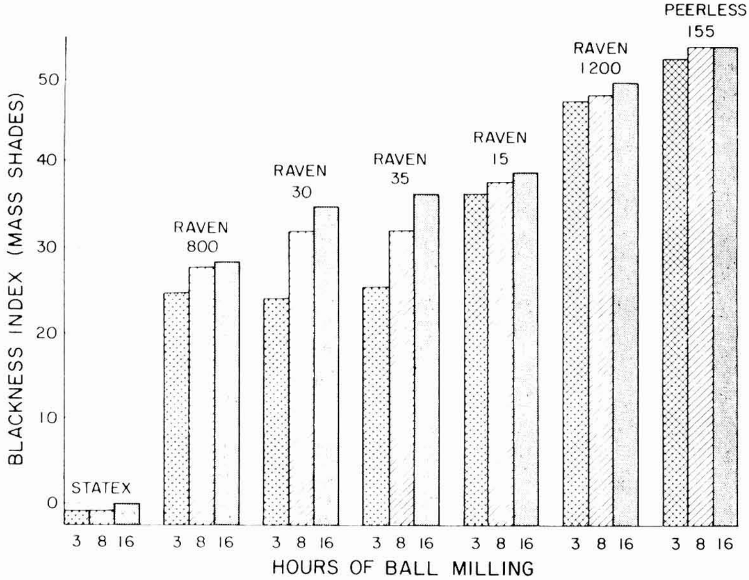

Fig. 43. Jetness development—carbon blacks in a flexographic ink system

The gloss ratings of the inks containing these different blacks (Fig. 44) were closely related to the dispersion characteristics. The LCC-2 (Raven 15) black had the best final dispersion and the highest gloss level, while the MCF-2 (Raven 30) was the poorest in dispersion and gloss development. It was again observed, however, that each type of carbon black appears to have its own specific pattern for gloss development as a function of dispersion. Some of the results cannot be fully explained. For example, the MCF-5 type carbon has a significantly higher gloss than the MFF-1 at roughly equivalent dispersion quality. Surface chemistry effects, inducing specific carbon-polymer interactions, are also important factors. The LCC-2 (Raven 15) and the LFF-1 (Peerless 155) carbons have the most active surfaces of all the pigments in this series, as seen in their colloidal properties (Table 10). No doubt, the enhanced activity of these pigments is a contributing factor in wetting and dispersibility and, hence, rapid attainment of gloss. Raven 800 (the development carbon) and LCF-3, both coarser and easier to disperse than the others, have acceptable dispersion and quality classifications.

Surface chemistry studies

For this part of the investigation, the surface of a medium colour furnace carbon black (Raven 1200, MCF-5) was modified by chemical oxidation,

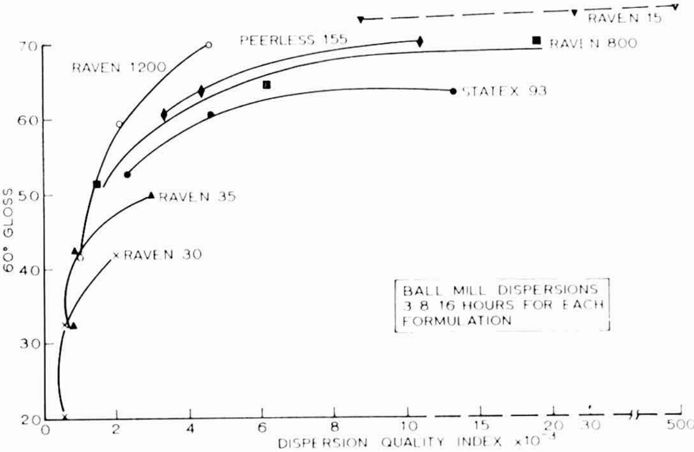

Fig. 44. The effect of dispersion on gloss development in a flexographic ink

thermal oxidation, and partial graphitisation (Table 13). Both the chemical and thermal oxidation treatments produce a significant change in surface activity in terms of increased oxygen functionality.[15, 16, 17] Partial graphitisation, on the other hand, lowers surface activity by removing most of the oxygen functional groups and also by forming more continuous graphite layers at the surface and removing internal layer defects. Their dispersion characteristics were studied, with LCC-1 (Raven 11) and MCF-1 (Raven 40) samples, in a heatset ink formulation as well as the medium oil alkyd system discussed earlier. The formulations used for these experiments are listed in Table 12. The ink pastes were reduced for QTM analysis as described in a previous section.

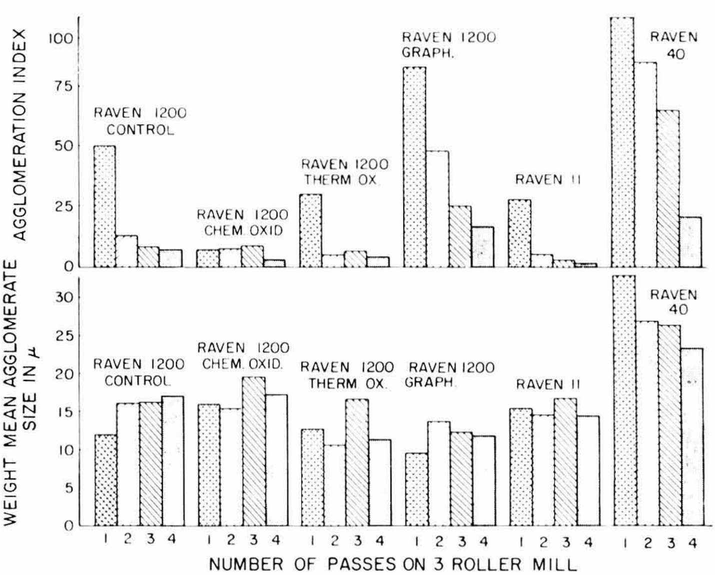

Fig. 45. The effect of carbon black surface chemistry on dispersibility in a heatset ink

Heatset system

The dispersion patterns of the six blacks in the heatset ink are shown in Fig. 45. A simple ink formulation was used to facilitate observation of the basic pigment-vehicle interactions without side effects from other ingredients. The samples were dispersed for four passes on a three-roll mill. Striking differences in agglomeration index were observed, attributable directly to the surface chemistry variations among these carbon blacks. The best dispersion was obtained with the chemically oxidised Raven 1200. This sample showed a very low agglomeration index after only one pass. Increased oxygen functionality (surface volatile matter) generally acts as a built-in wetting and dispersing aid in many vehicle systems used in the coatings industry. The enhanced acidity and polarity[15, 16, 17] on the carbon surface serves to reduce the interfacial tension that retards wetting of pigments by vehicles, thereby aiding the vehicle to penetrate the clusters of pigment particles and induce a more rapid rate of dispersion of these particles.

The thermally oxidised sample gave the same excellent dispersion level as the chemically oxidised black after the second pass, but did not match the quality achieved by the latter after the first mill pass. Partial graphitisation produced a significant drop in dispersion quality, showing a higher agglomeration index than the control sample at each stage of the dispersing procedure. The poorest dispersion was obtained with the MCF-1 (Raven 40) type of carbon owing to its low structure and the lack of surface oxygen functionality. The LCC-1 black (Raven 11) gave very poor dispersion and with results similar to the thermally oxidised sample. Similarity of the two blacks is to be expected because the LCC-1 type (Raven 11) is manufactured by the channel process and is also subjected to thermal oxidation. Both these blacks are more poorly dispersed after the first pass on the three roll mill than the chemically oxidised specimen of Raven 1200. This suggests a small degree of aggregate sintering which is often caused by thermal oxidation.

The agglomerate size data were relatively insignificant in these experiments, largely because of the relatively low agglomeration index figures for many of these samples. Only the MCF-1 (Raven 40) type of black was characterised by significantly larger agglomerate size than the other carbons.

None of these blacks had weight mean values in the range of 5 microns even after four passes on the three-roll mill. This contrasts with the ball milling or modified sand grinding results. Both ball milling and modified sand grinding almost always produced a noticeable reduction in agglomerate size after long dispersing times. The three-roll mill appears to be quite superior to other dispersing equipment in reducing the amount of agglomeration, while the ball mill and the sand mill are more efficient in reducing agglomerate size. Earlier studies[1] did show, however, that, when operated under high pressure, the three-roll mill is very efficient in terms of both dispersion and agglomerate size reduction.

Light micrographs (Fig. 46) illustrate the dispersion characteristics of five of the carbon blacks in this series. The areas reflect primarily the differences in agglomeration index, rather than agglomerate size. The latter function is based on QTM analyses of a large number of fields. In view of the high level of dispersion quality for most of these samples, it is quite difficult to select exact areas which reflect both the agglomerate size and agglomeration index average results as determined by the Quantimet. Nevertheless, the improvement in dispersibility as a function of increased oxygen functionality is quite apparent in these sets of micrographs. The heatset system appeared to be the most sensitive in this respect of all the different vehicles studied in this work.

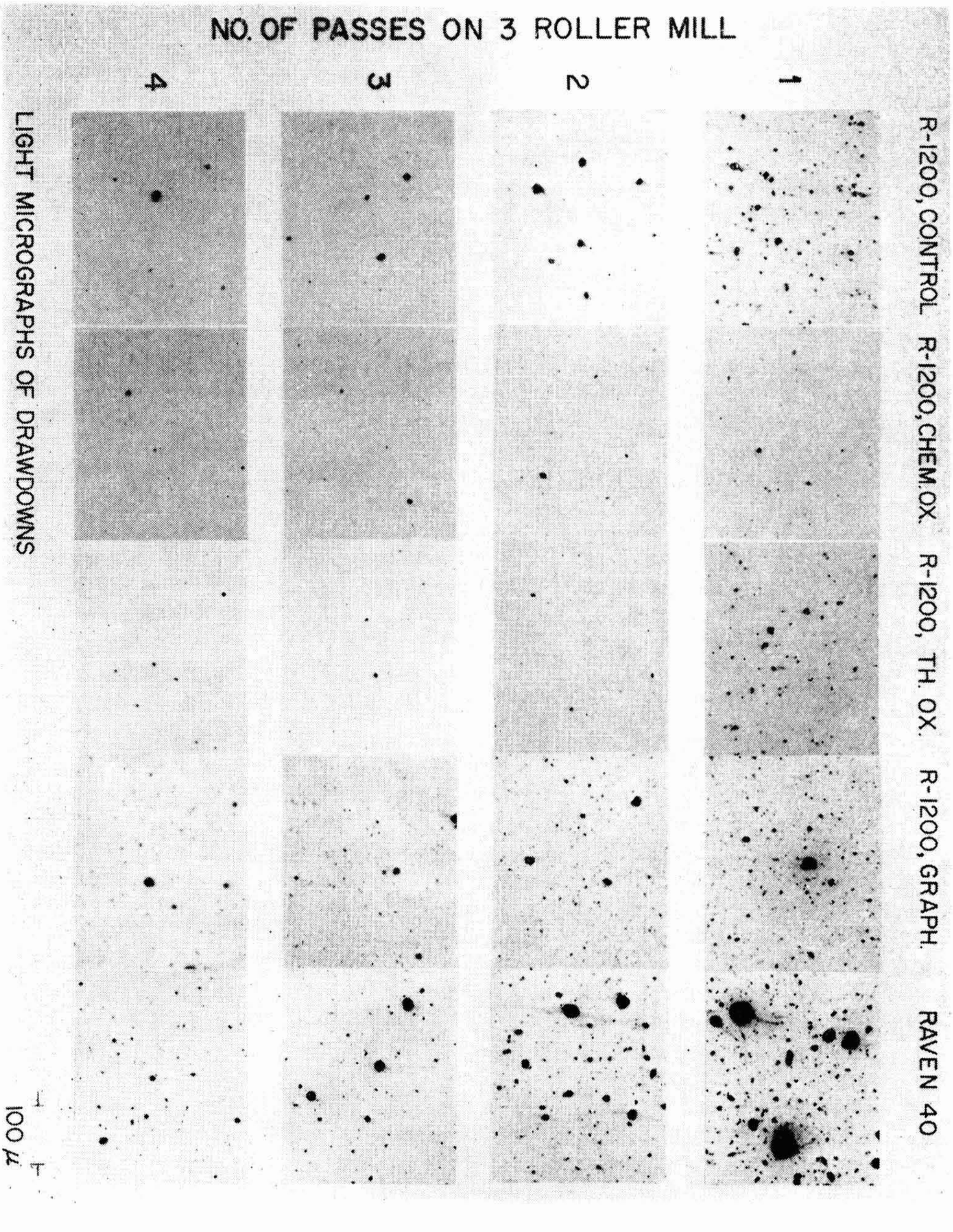

Fig. 46. Dispersion of different carbon blacks in a heatset ink formulation

The resultant inks were evaluated by examining prints made with a Vandercook Universal I Test Press (Vandercook and Sons, Inc., Chicago, Illinois, USA) on a 60 pound coated magazine cover stock. Prints were made with the ink samples extracted after each pass on the roller mill, using a constant volume of ink on the press. Identical prints from each run were tested for surface gloss in the full tone areas and compared to the dispersion ratings as measured by the QTM.

The QTM analyses, as in all instances in this work, were performed with reduction in the carbon loadings. However, print quality, in contrast to the other property assessments, was established with the inks in their original dispersed state. As in every instance, quality interpretations were made in a fashion similar to that which would be utilised on the product in its particular area of application.

The dispersion/gloss relationship of the different blacks in the heatset system is illustrated in Fig. 47. The gloss ratings are plotted against the reciprocal of agglomeration index alone, because the agglomerate size data were relatively insignificant. The results show a significant correlation with dispersion, but can be only partially explained on this basis. At equivalent dispersion, the chemically oxidised sample showed significantly higher gloss than either the thermally oxidised black or its channel black counterpart, the LCC-1 (Raven 11) sample. The untreated Raven 1200 sample also gave higher gloss than the thermally oxidised black at equivalent dispersion.

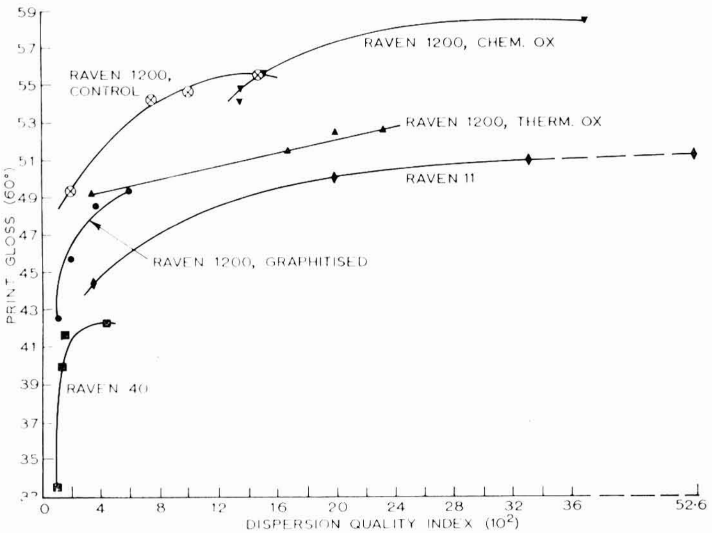

Fig. 47. The effect of dispersion on print quality of a heatset ink

Medium oil alkyd vehicle

Dispersion profiles (Fig. 48) on the same series of treated Raven 1200 samples were obtained after ball milling in a medium oil alkyd vehicle. Because of the small quantity of sample available for the oxidised and partially graphitised blacks, the ball mill dispersions were prepared using a reduced batch of material (100 grams total) in a $\frac{1}{2}$ pint container using $\frac{1}{4}$in steel shot. However, the results appear comparable to the larger 500g or 1,000g batches which were dispersed with ⅝in steel shot in the other studies. The Raven 1200 control sample showed a similar dispersion pattern under both conditions (e.g., Fig. 48 vs. Fig. 7).

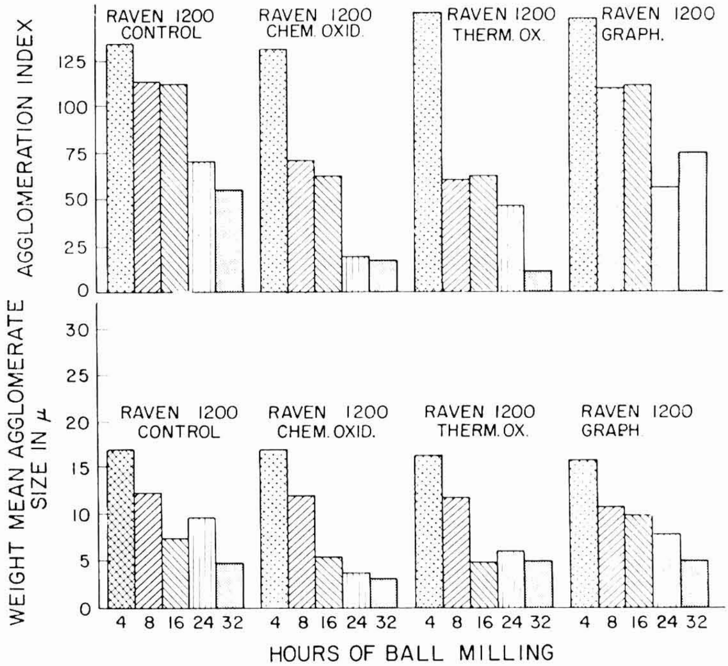

Fig. 48. The effect of carbon black surface chemistry on dispersibility in medium oil alkyd

Significant dispersion improvements were seen with both the chemically and thermally oxidised samples relative to the untreated control. A marked drop in agglomeration index was observed after 8 hours of ball milling in comparison to the control. Both the oxidised blacks also showed the best dispersions after the final ball milling cycle. The dispersion of the partially graphitised sample was similar to the control.

All the blacks showed a similar pattern in agglomerate size reduction, which is again typical of the ball milling procedure. Small agglomerate size was observed for all of the different samples after the final ball milling cycle. However, the most rapid reduction in agglomerate size was shown by the chemically and thermally oxidised blacks.

Rheology measurements on the four blacks are illustrated in Fig. 49. These viscosities were taken at three different shear rates with a Brookfield viscometer (Brookfield Engineering Laboratories, Stoughton, Massachusetts, USA). Of course, these are, again, relative viscosities. Any true measurement of viscosity must be observed relative to a specific shear rate. The Brookfield is widely accepted as a quality control instrument. More sophisticated viscometers, such as those possessing a cone and plate assembly, may be preferred for determining true viscosities at specific shear rates. The results for the treated samples showed an interesting pattern relative to the untreated control black. The thermally oxidised black, possibly due to the large increase in surface area with such treatment (Table 13), gave relatively high viscosity at the lowest shear rate, but was significantly lower in viscosity than the control black under higher shear conditions. This reflects the better wetting characteristics attributable to the oxygen volatile on the black surface. The chemically oxidised black, on the other hand, showed very low viscosity at all three shear rates, which is attributable both to its high surface volatile and also to the fact that there is no increase in surface area with this type of treatment. The consistently low viscosity of the partially graphitised black may be attributed to the low surface activity of such a black, e.g., the aggregates neither bond very strongly to themselves (a condition conducive to high thixotropy) nor to the vehicle. The resultant gloss-dispersion relationship (Fig. 50) appears to be influenced by the different viscosities as well as the dispersion variations. The latter ratings were again expressed in terms of agglomeration index only for these samples.

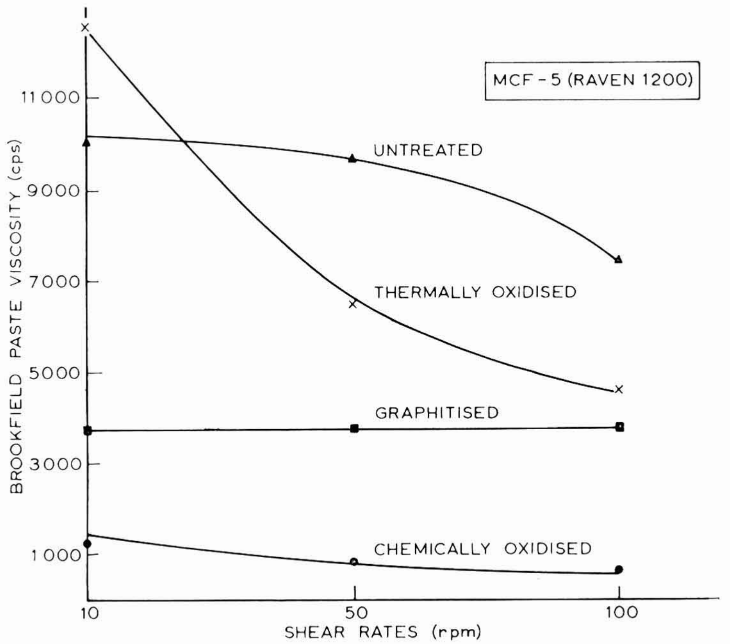

Fig. 49. Rheology of medium oil alkyd mill base pastes as a function of carbon black surface chemistry

Acknowledgments

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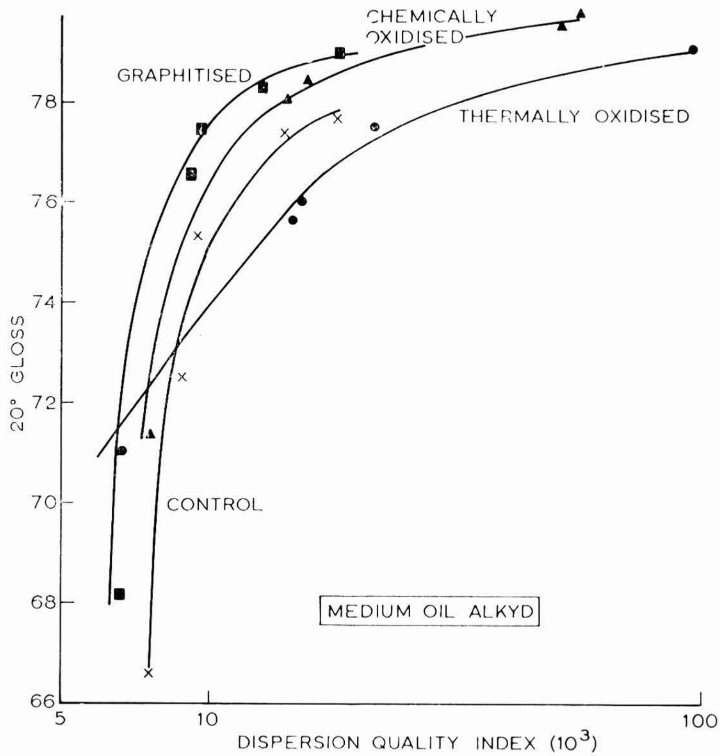

Fig. 50. Gloss development for MCF-5 (Raven 1200) carbon samples of varied surface chemistry

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Appendix I

Table 1
Carbon black colloidal properties
particle size series

Trade name	Process — Industry symbol		Particle diameter, arithmetic mean (Å)	Surface area N_2 adsorption-bet (m^2/g)	Structure-dbp absorption (cc/100 g)	% Volatile
Superba	Channel	MCC-1	140	695	145	10.5
999	Channel	MCC-2	160	275	112	5.0
Raven 11	Channel	LCC-1	250	147	106	5.5
Raven 1200	Furnace	MCF-5	210	120	72	1.5
Raven 30	Furnace	MCF-2	270	82	67	1.0
Raven 800	Furnace	Development Carbon	290	77	56	0.4
Statex B-12	Furnace	LCF-2	330	58	84	1.0
Statex 93	Furnace	LCF-3	540	33	79	0.3
Molacco H	Furnace	LCF-4	700	28	79	0.3
Statex MT	Thermal	MT	3000	10	35	0.3

Table 2
Particle size series
Medium oil alkyd paint—ball mill and modified sand mill dispersions

Mill base formula	
23.0	Carbon black
51.9	Medium oil alkyd vehicle (50% N.V.)
22.3	VM&P naptha
2.4	24% lead napthenate
0.4	ASA
100.0	
Paste reduction formula	
8.8	Mill base
69.4	Medium oil alkyd vehicle
20.4	VM&P naptha
1.4	Drier solution*
100.0	

*6% cobalt napthenate, 6% manganese napthenate, 24% lead napthenate @ 2/1/1 ratio

Table 3

Carbon black colloidal properties flow point series

Trade name	Process	Industry symbol	Particle diameter, arithmetic mean (Å)	Surface area N_2 adsorption-BET (m^2/g)	Structure-DBP absorption (cc/100g)	% volatile	DPG adsorption index
Neo Spectra Mk II	Channel	HCC-3	130	900	190	12.0	98
Superba	Channel	MCC-1	140	695	145	10.5	70
999	Channel	MCC-2	160	275	112	5.0	41
Raven 40	Furnace	MCF-1	240	102	58	1.0	6
Raven 11	Channel	LCC-1	250	147	106	5.5	17

Table 4
Mill base formulations
from flow point determinations in a
medium oil alkyd vehicle

Formulation†	Wt. % vehicle solids			
	15	20	25	30
Neo Spectra Mk II	11	11	**14***	12
Vehicle	27	36	43	53
Mineral spirits	62	53	42	35
Total solids	24	30	36	39
Pigment/binder ratio	.79	.64	.64	.45
Superba	15	**17**	16	16
Vehicle	26	33	42	51
Mineral spirits	59	49	41	33
Total solids	28	34	38	41
Pigment/binder ratio	1.15	1.02	.77	.61
No. 999	18	**19**	16	15
Vehicle	25	32	42	51
Mineral spirits	57	48	42	34
Total solids	30	35	37	41
Pigment/binder ratio	1.38	1.15	.77	.59
Raven 11	19	**21**	19	17
Vehicle	24	32	41	50
Mineral spirits	56	47	40	33
Total solids	32	37	39	42
Pigment/binder ratio	1.57	1.33	.92	.66
Raven 40	24	**26**	22	20
Vehicle	23	30	39	48
Mineral spirits	53	44	39	32
Total solids	36	41	42	44
Pigment/binder ratio	2.09	1.72	1.11	.80

*Ideal formulations indicated in bold-face type.
†All formulations contain 0.4 per cent drier solution.

Table 5
Mill base formulations from flow point determination in a thermosetting acrylic/melamine vehicle

	Neo Spectra Mark II	No. 999	Raven 11	Raven 40
Vehicle solids, %	40	40	25	25
Carbon	6.1	8.4	11.3	11.9
AT-56 (50% N.V.)*	52.6	51.4	31.0	30.8
MM-47 (60% N.V.)†	18.8	18.3	11.1	11 0
Solvesso 100	22.5	21.9	49.6	46.3
Pigment/binder	0.16	0.23	0.51	0.54

*Acryloid AT-56 (50 per cent non-volatile) } Rohm & Haas Co.
†Uformite MM-47 (60 per cent non-volatile) }

Table 6
Mill base formulations from flow point determination polyurethane vehicle

	No. 999	Raven 11	Raven 40
Vehicle solids, %	25	20	20
Carbon	18.2	21.9	24.1
1210-MS*	30.7	23.4	22.8
Soya lecithin	0.1	0.1	0.1
Mineral spirits	48.0	52.3	50.8
Drier solution	3.0	2.3	2.2
Pigment/binder ratio	0.99	1.56	1.76

*Oil modified polyurethane vehicle, Cargill, Inc.

Table 7
Carbon black colloidal properties particle size—flow point series

Trade name	Process — Industry		Particle diameter arithmetic mean (Å)	Surface area N_2 absorption-BET (m^2/g)	Structure-DBP absorption (cc/100 g)	% Volatile
999	Channel	MCC-2	160	275	112	5.0
Raven 1200	Furnace	MCF-5	210	120	72	1.5
Raven 30	Furnace	MCF-2	270	82	67	1.0
Statex B-12	Furnace	LCF-2	330	58	84	1.0
Molacco H	Furnace	LCF-4	700	28	79	0.3

Table 8

Mill base formulations: medium to coarse carbons in flow point determinations medium oil alkyd vehicle

	No. 999	Raven 1200	Raven 30	Statex B-12	Molacco H
Vehicle solids, % ..	20	20	20	15	10
Carbon	18.9	21.2	30.4	30.4	30.4
P-531-50*	32.4	31.6	27.8	21.0	14.0
Mineral spirits ..	48.3	46.8	41.4	48.2	55.2
Drier solution ..	0.4	0.4	0.4	0.4	0.4
Pigment/binder ..	1.15	1.32	2.15	2.83	4.19

*Medium oil alkyd vehicle, Beckasol P-531-50, Reichold Chemicals, Inc.

Table 9

Flexographic-rotogravure series ball mill dispersions

	Polyamide type
Dispersion of unreduced ink	
13.8	Carbon black
41.4	Polyamide resin
31.4	Isopropyl alcohol
13.4	Toluene
100.0	
Reduction for QTM ratings	
14.6	Unreduced ink
85.4	Polyamide resin varnish { 32.0 Resin; 37.4 Isopropyl alcohol; 16.0 Toluene }
100.0	

Table 10

Carbon black colloidal properties flexographic-rotogravure series

Trade name	Process	Industry symbol	Particle diameter, arithmetic mean (Å)	Surface area N_2 absorption-BET (m^2/g)	Structure-DBP absorption (cc/100g)	% volatile	DPG absorption index
Peerless 155	Furnace	LFF-1	220	130	55	4.0	30
Raven 1200	Furnace	MCF-5	210	120	72	1.5	6
Raven 15	Channel	LCC-2	270	126	103	6.0	10
Raven 30	Furnace	MCF-2	270	82	67	1.0	6
Raven 35	Furnace	MFF-1	270	87	55	2.0	9
Raven 800	Furnace	Development carbon	290	77	56	0.4	5
Statex 93	Furnace	LCF-3	540	33	79	0.3	4

Table 11

Quality evaluation
gloss and jetness of carbon blacks in
flexographic-rotogravure inks

Carbon black	Dispersion time (hours)	60° Gloss	Blackness development* A. Jetness shades (individual)	B. Jetness shades (series)
Raven 1200 ..	3	41.4	0	
	8	59.4	+ 1	
	16	69.9	+ 3	+50
Peerless 155 ..	3	59.2	0	
	8	63.2	+ 1	
	16	67.9	+ 1	+58
Raven 15 ..	3	72.6	0	
	8	73.2	+ 2	
	16	74.9	+ 3	+38
Raven 30 ..	3	19.9	0	
	8	32.8	+ 8	
	16	41.9	+11	+34
Raven 35 ..	3	32.7	0	
	8	42.4	+ 6	
	16	49.7	+10	+36
Raven 800 ..	3	51.4	0	
	8	64.3	+ 3	
	16	69.6	+ 4	+28
Statex 93 ..	3	52.8	0	
	8	60.5	0	
	16	62.9	+ 1	0

* The number of shades of jetness increased by ball milling each (individual) carbon black (column A) are relative values for each carbon black. The number of shades in jetness increased by ball milling the (series) of seven blacks (column B) permits comparison of the jetness of the different carbon blacks.

Table 12
Surface treatment series

A. Medium oil alkyd paint—ball mill dispersions

Mill base formula

20.0	Carbon black
54.0	Medium oil alkyd vehicle (50% N.V.)
23.2	VM & P Naptha
2.5	24% Lead napthenate
0.3	ASA
100.0	

Paste reduction formula—5% CB on FFS

10.0	Mill base
68.3	Medium oil alkyd vehicle
20.1	VM & P naptha
1.6	Drier solution*

*6% cobalt napthenate, 6% manganese napthenate, 24% lead napthenate @ 2/1/1 ratio

B. Heatset ink—three-roll mill dispersions

Dispersion formula

15.0	Carbon black
70.0	Heatset vehicle (60% NV)
15.0	Solvent (High boiling petroleum hydrocarbon fraction)
100.0	

Cutback formula for QTM ratings

9	Dispersion
91	Heatset vehicle
100	

Table 13
Carbon black colloidal properties
Surface treatment series

Trade name	Process — Industry symbol		Type of treatment	Oil absorption stiff paste (gal/100 lb.)	% Volatile	Surface area N_2 absorption-BET (m^2/g)
Raven 1200	Furnace	MCF-5	None	9.7	1.5	120
Raven 1200	Furnace	MCF-5	Chem. ox.	12.2	5.1	123
Raven 1200	Furnace	MCF-5	Ther. ox.	12.7	6.6	361
Raven 1200	Furnace	MCF-5	Graph.	13.3	0.1	95
Raven 40	Furnace	MCF-1	None	8.4	1.0	102
Raven 11	Furnace	LCC-1	None	13.9	5 5	147

Table 14

Carbon black colloidal properties

Trade name	Process	Industry symbol	Particle diameter, arithmetic mean (Å)	Surface area N_2 absorption-BET (m^2/g)	Structure-DBP absorption (cc/100g)	% Volatile	DPG absorption index
Neo Spectra Mk II	Channel	HCC-3	130	900	190	12.0	98
Superba	Channel	MCC-1	140	695	145	10.5	70
999	Channel	MCC-2	160	275	112	5.0	41
Raven 1200	Furnace	MCF-5	210	120	72	1.5	6
Peerless 155	Furnace	LFF-1	220	130	55	4.0	30
Raven 40	Furnace	MCF-1	240	102	58	1.0	6
Raven 11	Channel	LCC-1	250	147	106	5.5	17
Raven 15	Channel	LCC-2	270	126	103	6.0	10
Raven 30	Furnace	MCF-2	270	82	67	1.0	6
Raven 35	Furnace	MFF-1	270	87	55	2.0	9
Raven 800	Furnace	Development carbon	290	77	56	0.4	5
Statex B-12	Furnace	LCF-2	330	58	84	1.0	3
Statex 93	Furnace	LCF-3	540	33	79	0.3	4
Molacco H	Furnace	LCF-4	700	28	79	0.3	2
Statex MT	Thermal	MT	3000	10	35	0.3	—

Appendix 2

Vehicles and resins used in formulations

Medium oil alkyd vehicle—Beckasol P-531-50
Reichold Chemicals, Inc., White Plains, New York

Heatset vehicle—Thermex A-6-E
Lawter Chemicals, Inc., Chicago, Illinois

Polyamide resin—Versamid 940
General Mills Chemical Division, Kankakee, Illinois

Thermosetting acrylic vehicle—Acryloid AT-56
Rohm and Haas Company, Philadelphia, Pennsylvania

Melamine formaldehyde vehicle—Uformite MM-47
Rohm and Haas Company, Philadelphia, Pennsylvania

Polyurethane—1210-MS
Cargill, Incorporated
Minneapolis, Minnesota

Pigments

All carbon blacks used are under registered trademarks of Cities Service Company (formerly of Columbian Carbon Company).

Discussion at the Scottish Symposium

MR J. A. L. HAWKEY referred to a particular feature which was evident in many of the results, the apparent anomaly between density, gloss and other visual characteristics. This might be due to the fact that the systems studied had all been heterogeneous, and the differing chemical nature of the surfaces of the different carbon blacks might cause loss of compatibility in the vehicle phase to varying degrees. Had the authors any views on the possibility of the resin components that remained in the continuous phase being different for different blacks? If this was the case, one would expect as many differences within a series of formulations based on say, alkyds, as one would when comparing with formulations based on other resins.

MR M. D. GARRET agreed that this effect might occur. No specific investigation on those lines had been carried out, but he could remember no incompatibilities, or haze, in the test panels.

MR N. SCOTT, following on from Mr Hawkey's point, said that he agreed that gloss comparisons could be misleading, owing to the number of variables present. For instance, high surface area pigments would be formulated at lower PVCs, allowing more free binder and hence giving higher gloss. Further, in the ink systems, as the authors had pointed out, different viscosities would result in different degrees of "hold-out" on the paper. Had any attempts been made to equalise the viscosity of the formulations, both to give a more representative dispersibility and improve the usefulness of gloss comparisons?

Secondly, he noted that the Daniel flow point method had been used. It seemed obvious that the standard method of mulling would not provide adequate dispersion of the black. What modifications had been used to ensure adequate dispersion? In general, dispersions made by this method were subject to instability, and colloidal or thermal shock could occur on let-down, causing reflocculation. Had determinations been carried out on fresh dispersions, or had consideration been given to this effect?

MR W. M. HESS began by pointing out that the aim of the paper had not been to optimise the performance characteristics of formulations, but to compare the properties of various carbon blacks under similar conditions, and to relate dispersion characteristics to final properties. Perhaps under ideal conditions the methods the authors had applied would not be used, but it had been necessary to keep the procedure simple to obtain a simple comparison.

MR GARRET replied to the points referring to the practical approach. The basic Daniel flow point method would not have been satisfactory; in fact, a modified technique, using a mini sand mill and a fine mesh paint strainer, had been applied. They had been aware of the instability problem, and the dispersions were examined when fresh, and let down carefully to the same PVC for the microscopical analyses.

As far as viscosity was concerned, no attempt had been made to equalise this for various formulations. The effects of the variation in carbon black properties were being studied, as well as the qualities imparted to the compounds in which they were incorporated. There was little variation in viscosity of the paints, which were all reduced to spray viscosities. Gloss readings were made on these by drawdowns on a coated, non-porous stock.

The amounts of pigment, in each case, were the same. Therefore, any variation in gloss was due to the difference in the properties of the carbon blacks, which was the object of the investigation. It is obvious that different pigments are formulated with regard to their respective properties, and the author had been aware of this; the intent, however, was to study the carbon blacks in these systems and not to formulate commercial compositions.

Regarding the heatset ink system to which Mr Scott referred, again it was desired to test the pigments under similar conditions and not formulate for each one. The prints and quality determinations, unlike the others in this study, were made with the concentrates themselves, containing the higher pigment loadings that would be typical in this area as opposed to testing of the letdowns or reductions with most of the other compounds in the series. The comparative viscosities were similar, and it was not thought that they played a significant part in quality development.

DR S. H. BELL said that, in order to obtain a complete picture of the effect of dispersion, the paint should be studied at all stages from the initial manufacture; e.g. after storing, during brushing, the wet film, and the dried film: and the particular property under review related to the dispersion at the appropriate stage, e.g. gloss to the dispersion in the dried film. Would the authors comment?

MR HESS agreed that this was a valid point, particularly in the case of pigments other than carbon black, where effects due to dispersion were more pronounced. In fact, some work on the examination of dispersion at all levels was planned. Agglomeration had, in fact, been studied in thin drawdowns on microscope slides, and it had been found that agglomerations of particles of around 5-10 microns in size in a carbon black system had little effect on the final properties, and none on the jetness.

Further investigation was difficult, and had not been attempted as yet. Generally speaking, the Quantimet technique had been developed as a practical, relatively easy, method of examination. As, with carbon black, small agglomerates did not appear to affect final properties appreciably, the scope offered by the technique was adequate for most purposes.

MR W. F. MCDONNELL said that in some cases the use of a low molecular weight solvent could aid the prevention of agglomeration, as the smaller solvent molecules could penetrate the agglomerates more easily. Had the authors any information on the use of specific solvents to improve the dispersion of the fine particle size carbon blacks during ball or sand milling?

MR GARRET replied that this aspect would be worthy of investigation, but no work had been done as yet. The paper had considered many parameters to a moderate degree, but a study of the individual parameters in depth was planned.

MR M. HESS commented on investigations he had carried out at the Ostwald Institute, in conjunction with Professor Kruger. A Zeiss spectrophotometer had been used in an attempt to determine the white contents of various blacks. It had been found that visual judgments were superior to those obtained instrumentally.

MR GARRET agreed that any instrument capable of measuring blackness accurately would be of interest. He knew of no equipment yet produced which was superior to the human eye.

MR D. ALDCROFT said that the correlation between the surface areas obtained from size measurements with the electron microscope and nitrogen BET surface area values was very good. What model had the authors used as a basis for surface area calculation by electron microscopy?

MR W. M. HESS replied that it was very difficult to find a model for carbon aggregates. As the slides had shown, they were very irregular, and no two were the same. In fact, much work was being carried out on this; individual aggregates were being studied by the Quantimet system, and attempts being made to obtain form factors based on total projected length related to average width. Particle frequency functions, based on the rate of the projected aggregate area to the average particle area, had also been obtained. Most grades of blacks had been examined in the dry state, using ultrasonic dispersion techniques. High structure rubber grade blacks were shown to have length and width ratios as high as 4.8, and low structure paint and ink blacks about 2.8.

Similar work was also being carried out on blacks in various vehicle systems; this was much more difficult and time consuming, but results to date seemed quite promising.

In regard to the specific question on the electron microscope surface areas used in the paper, these were based on the size distribution of the particles within the aggregates. For these determinations, the particles were assumed to be unattached spheres, which was the conventional electron microscope model that had been employed for a number of years. The correlation between electron microscope and BET surface area was generally quite good, provided that the carbon blacks did not differ appreciably in surface porosity. With the exception of the highly porous channel blacks, EM surface areas were generally somewhat higher than the BET values. This was attributable to the surface that was lost because of particle fusion within the aggregates.

MR HAWKEY, returning to the topic of measurement of jetness, said that he felt that it was impossible to have adequate instrumental measurement unless a large statistical survey comparing the assessments of panels by observers with instrumental values was carried out. Although, formally, black was not a colour, it could not really be considered as such, as the ultimate judge was the consumer, who judged it by physiological and psychological processes, and often required a black to have, for instance, a blue tinge. Hence, instrumental assessment without correlation with observer judgment might be of little value.

MR GARRET agreed that this was so. His own company had a visual rating system of 260 mass shades which could be distinguished by a trained observer. Instrumentally, many of these shades were not distinguishable, and there might be no difference to the untrained eye.

It was obvious that accurate instrumental measurement would be of great value, and he did not think that this was impossible; using the right light source and sensor, possibly with a photomultiplier, it might even be possible to include the kind of the colour difference Mr Hawkey had mentioned.

MR T. HANRAHAN commented on the studies on agglomeration index. It appeared from the data that 32 hours of ball milling was equivalent to 15 minutes of sand milling. What type of ball mill had been used, and could the authors comment on the use of various types of ball mill and their comparison for the agglomeration index?

MR GARRET said that the relationship between ball milling times and modified sand milling times was merely a comparison! The assumption that 32 hours on the ball mill equalled 15 minutes on the sand mill was erroneous. In fact, it was not possible to obtain correlations of this type from the work they had done.

The mill used had been a steel mill with steel balls, and this had been found to be more effective than, say, a pebble mill. The important feature was the density of the grinding media; the higher the density at the same relative size and shape, the better and faster would be the pigment dispersion. Regarding size of the media, the smaller sizes were better because of more particle contact with the pigment itself, thus imparting the improvement in rate and quality of dispersion over larger size dispersion media, under the same conditions of testing. This fact had also shown up in sand milling, where finer media, such as small steel shot and fine grade zirconium oxide, were more effective.

Ultimately, a ball mill would usually give better dispersion with carbon black, but the sand mill was much quicker.

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Operating and design principles of high speed dispersers*

By F. K. Daniel

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Summary

The high speed disperser (HSD) has become an indispensable tool for premixing, for premixing *and* dispersing soft textured pigments, as well as for postmixing. It does not break up hard agglomerates, nor can it disperse highly viscous systems. It therefore cannot replace all other mills.

No one impeller works best in all situations; therefore, a paint plant needs several different impeller types as well as different sizes. Experience as well as pilot studies are needed to determine which impeller performs a given job best, and/or to adapt the mill base composition to the impeller characteristics. Such studies, and the burden of switching impellers, pay off in greater output and often in superior paint quality.

Skill and full co-operation of the batchmaker are vital for getting optimum results from the HSD. The HSD operator should be the most highly trained man on the production floor.

Keywords

Equipment primarily associated with manufacturing or synthesis

high speed disperser

Les principes du dessein et de l'opération des disperseurs à grande vitesse

Résumé

Le disperseur à grande vitesse est devenu un outil indispensable pour faire le pré-mélange et la dispersion des pigments de texture tendre, et d'ailleurs pour faire aucun mélange subséquent à la fabrication de la peinture elle-même. Il ne peut ni reduire les agglomérats durs ni disperser les systèmes très visqueux. Ainsi il ne peut pas remplacer tous les autres types de broyeur.

Nul impulseur se comporte à son meilleur dans toutes les applications où l'on en pourrait employer. Par conséquent le fabricant de peintures a besoin de plusieurs différents types d'impulseurs et de capacités également. Il exige des études-pilotes détaillées afin de décider de l'impulseur qui répond le mieux aux besoins particuliers, ou de modifier la composition de la masse broyante aux caractéristiques de l'impulseur. Telles études, et la peine de faire changer des impulseurs sont compensées par la production augmentée et souvent par les peintures de qualité supérieure.

Afin d'obtenir les résultats optimaux à partir des disperseurs à grande vitesse, il est essentiel d'avoir du personnel très habile sur lequel on peut compter. Celui qui s'occupe des disperseurs à grande vitesse devrait être le membre de l'équipe de production le plus expérimenté.

Arbeits- und Konstruktionsprinzipien von Schnellmischwerken

Zusammenfassung

Der Schnellmischer ist zu einem unentbehrlichen Werkzeug fuer das Vormischen, sowie das Vormischen *und* Dispergieren weichkoerniger Pigmentagglomerate, und letzthin fuer das Nachmischen geworden. Er ist nicht faehig, harte Aggregate zu zerkleinern oder hochviskose Systeme zu dispergieren. Daher ersetzt er nicht alle andern Dispergiermaschinen und Muehlen.

*Presented to the West Riding Section on 24 April 1970 and to the Trent Valley Branch of the Midlands Section on 28 May 1970

Kein Impeller, egal welcher Konstruktion, eignet sich gleich gut fuer alle Zwecke; infolgedessen sollte jede Lackfabrik verschiedene Impeller Typen und Groessen einsetzen. Erfahrung und Versuchsarbeit sind erforderlich, um den geeignetsten Impeller zu bestimmen, oder um die Mahlgut Zusammensetzung auf einen gegebenen Impeller abzustimmen. Solche Vorarbeit, und das Auswechseln der Impeller, machen sich haeufig durch erhoehte Produktion, und oft auch durch bessere Qualitaet des Lackes bezahlt.

Fachkenntnis und Willigkeit seitens des Bedienungspersonals sind unerlaessliche Vorbedingung zur Erziehlung optimaler Ergebnisse. Daher sollte der Mann am Schnellmischwerk der hoechstbezahlte und best trainierte Arbeiter in der Lackfabrik sein.

Рабочие и расчетные принципы скоростных рассеивателей

Резюме

Рассеиватели высокой скорости являются обязательно необходимыми инструментами для предварительного перемешивания и дисперсии пигментов мягкой структуры, а также для последующего перемешивания. Они не раздробляют твердых агломератов и не могут рассеять высоковязкую систему и поэтому не могут заменить всех других типов дробилок.

Никакой импеллер не может проявлять наилучшие качества при всяких условиях, и поэтому красочная установка требует нескольких типов импеллеров и импеллеров различных размеров. Необходимо детальное предварительное изучение для того чтобы определить какой импеллер лучше всего выполняет данное задание и чтобы подобрать основную смесь дробилки к характеристикам импеллера. Такое изучение и усилия утраченные на замену импеллеров, вполне оплачиваются более высокой производительностью и часто более высоким качеством краски.

Высокое мастерство, квалификация и полное сотрудничество дозировщика, играют первостепенную роль в достижении оптимальных результатов в работе скоростных рассеивателей. Механик, следящий за работой скоростного диспергатора, должен быть наиболее высоко тренированным и квалифицированным человеком в производственном цехе.

Introduction

The high speed disperser (HSD) is like a car in that it gets by, for ordinary purposes, on part of its full potential. But, whereas the car owner knows that he is wasting fuel when the engine runs roughly, and eventually has it tuned, the HSD owner seldom knows when he is wasting time and money, or is getting only second-best results. Even if he is aware of the problem, the HSD owner rarely does anything about it. His alibis are:

Nobody has told him how to run the machine; in fact, it is supposed to be so foolproof that no operating instructions are considered to be necessary;

Even if he knew how to run the machine best, it would be impossible to write the exact procedure down on the batch card for the operator to follow, step by step. Slight differences in impeller position and speed at any stage of the operation can make the difference between good and poor results. It takes a skilled operator to know what to do.

This dependence on skill makes the HSD, in a sense, an old-fashioned machine, like the roller mill. Yet there are enough advantages to make the paint manufacturer accept gratefully whatever results he happens to get from his HSD with semi-skilled or unskilled labour.

In the author's opinion and experience, this willingness to sacrifice optimum results is only partly justified. It is admittedly difficult to find skilled batchmakers. Yet, even today, batchmakers respond to careful training if their craftsmanship is recognised in the form of better pay and high prestige among operators. The real obstacle is not so much the lack of trainable operators as the shortage of qualified trainers and of suitable teaching material. This paper is meant to be a "primer" for teaching the fundamentals of high speed dispersion.

Triple function of impeller

The paintmaking ability of high speed dispersers depends on how well the impeller fulfils each of its three functions: (1) to wet dry pigment, (2) to disperse pigment agglomerates, and (3) to circulate the mill base. The three functions partly overlap, but they are, nevertheless, independent parameters.

Optimum high speed dispersion can only be achieved by impellers with properly balanced wetting, dispersing and circulating actions. The required balance differs with the mill base consistency, batch size and several other variables. Consequently, no one impeller design can ever be "best" for all purposes. Each can justly claim superiority, but only for a limited set of conditions.

The batchmaker or his supervisor must be able to select the most suitable impeller (size and design) for each mill base, just as a carpenter must know where to use a crosscut saw and where a ripsaw. However, the right tool alone is not enough; the craftsman must also know how to use it.

Operating procedure

In viscous systems, operating conditions favouring good wetting are quite different from those favouring good dispersion. The former needs turbulence, the latter laminar (orderly) flow. Therefore, good high speed dispersion technique usually requires a two-step procedure, one for optimal wetting and the other for optimal dispersion.

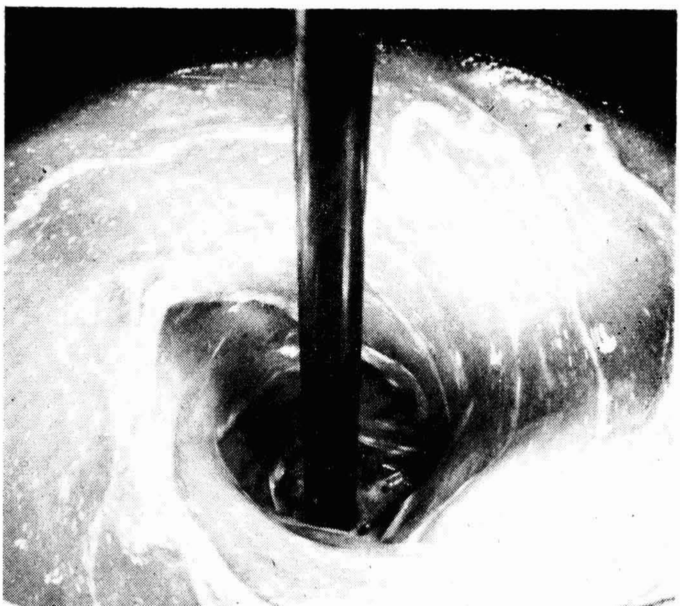

Fig. 1. Wetting—good flow pattern, low pigmentation

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Wetting

For best wetting action, the shaft should be positioned in the centre of a round tank and the impeller height and speed so adjusted that all the liquid moves freely and forms a deep vortex around the shaft (Fig. 1). However, excessive speed, which causes splashing and rapid heat build-up, should be avoided.

The dry pigment should be charged directly into the vortex as fast as the liquid will absorb it, i.e. rapidly at first, and then more slowly. To maintain an effective vortex, the impeller must be raised intermittently and its speed gradually increased as the pigmentation becomes higher (Fig. 2).

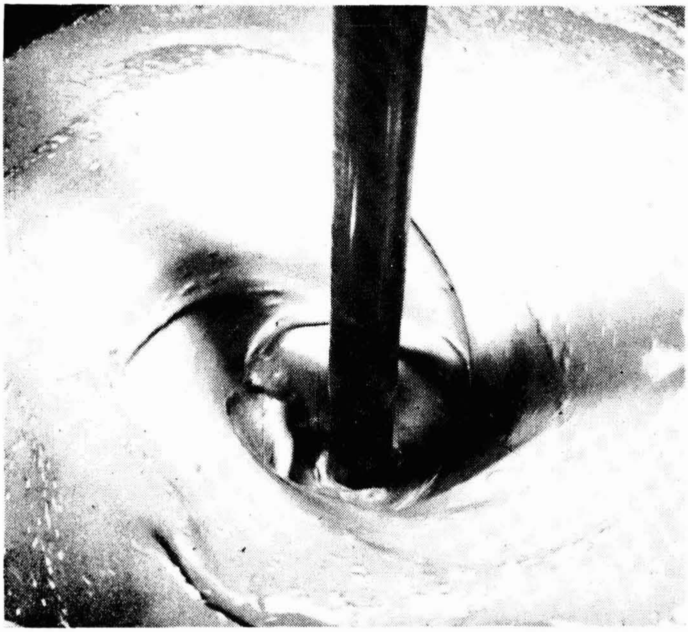

Fig. 2. Wetting—good flow pattern, high pigmentation

With two-speed dispersers, one switches from low to high speed when the mill base begins to move sluggishly (Fig. 3). At no time should the pigment be added so rapidly that big lumps form. Dumping pigment too rapidly often produces specky dispersions; furthermore, it increases rather than decreases total processing time, and in some cases it even damages the machine.

Dispersing

A few minutes after pigment loading is completed, i.e., when no more dry pigment floats on the batch surface and the submerged lumps are broken up, the sides of the tank as well as the shaft should be freed of dry or caked pigment. The machine is then stopped and the shaft is shifted sideways to a position approximately midway between the centre and side of the tank.

The purpose of this manoeuvre is to prevent the concentric motion of the charge, which results in poor and often irregular power utilisation, poor batch circulation at the upper (and lower) rim, excessive heat build-up, air entrapment and generally diminished dispersing efficiency.

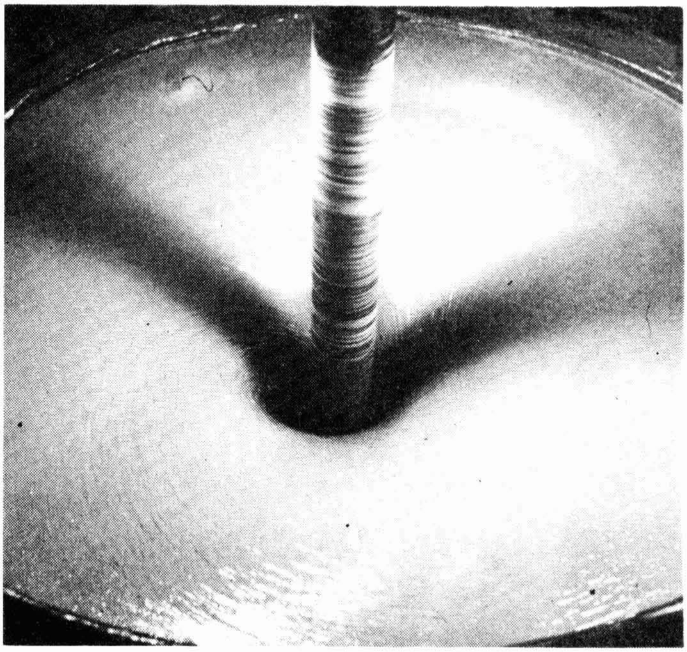

Fig. 3. Wetting—sluggish flow. Needs higher speed or higher impeller position

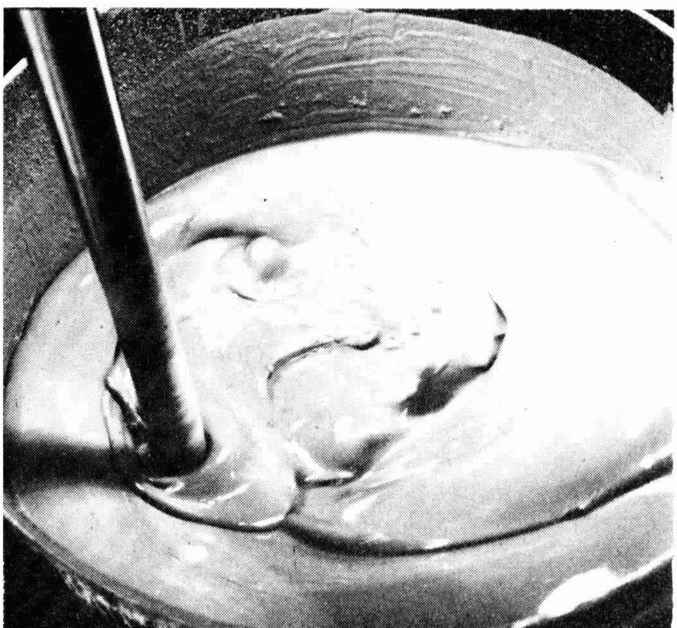

Fig. 4. Dispersing—downstream vortex, no deep shaft vortex

Placing the shaft off-centre increases the power demand, and hence, the dispersing efficiency of any impeller by 25 to 50 per cent. In place of the deep shaft vortex, one or several shallower vortices form on the downstream side of the shaft (Figs. 4 and 5). The distance and depth of the downstream vortex varies with the mill base consistency[1], the position of the shaft, the height of the impeller, and its size, design and speed.

Optimal dispersing speed is usually 4,500 to 6,000ft per minute at the periphery, but it can also be below 3,000ft per minute in dilatant mill bases[2]. Always, proper vortex formation is the key to effective dispersion.

Circulation

Complete circulation of the mill base is, of course, vital to good dispersion. Without it the paint remains specky, regardless of how long it is being dispersed. Undersized impellers are ineffective, not because they have less dispersing power than larger units (run at the same peripheral speed), but because they cannot move the outlying mill base back to the inner zone where dispersion takes place.

However, even correct impeller diameter and type does not automatically assure complete circulation. Pockets of stagnant material can still form if the impeller is positioned too high or too low in the tank, or if it runs too slowly.

The skilled operator detects "dead spots" by periodically checking for low temperature areas along the outside of the tank (including the bottom), and he knows how to eliminate them by manipulation of speed and/or impeller position.

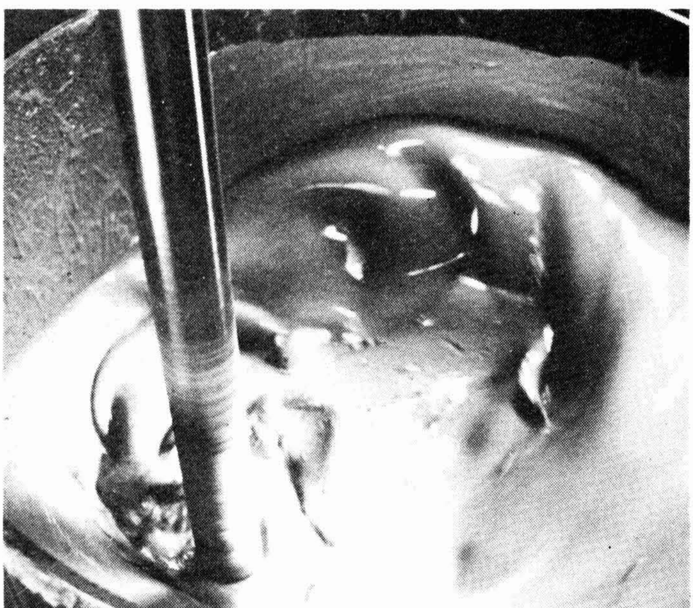

Fig. 5. Dispersing at higher speed or lower viscosity—several downstream vortices, but still no deep shaft vortex

If this fails to restore complete circulation, a larger or different type of impeller is needed, or the mill base viscosity must be reduced.

In two-speed dispersers without swivel action, the manipulation of mill base consistency, batch height, and impeller height are the only means for preventing the shaft vortex from extending down to the impeller, sucking in air and diminishing dispersing action.

As a rule, an impeller measuring one-third to one-quarter of the tank diameter should give sufficient (but not excessive) circulation; sometimes, however, the impeller/tank ratio can go above or below this guide figure. The impeller should be positioned no less than one-half, nor more than one and one-third diameters above the tank bottom. Table 1 shows a typical relationship between impeller and batch dimensions. Generally, the higher the mill base viscosity, the lower the batch height and tank diameter should be.

Design principles

There are many ways in which horsepower can be used for pigment grinding and dispersion; hence the profusion of paintmaking equipment. Yet, all are based on the utilisation, in various combinations, of three basic forces—shear, impact and pressure.

Pressure is the static head-on force that crushes pigment agglomerates and aggregates, regardless of size. Impact is the dynamic force that smashes or shatters them by hammer-like blows or violent collision. Its effectiveness diminishes with decreasing size of the pigment units and with increasing vehicle viscosity.

Shear is generated when layers of liquid slide along each other in parallel direction, but at different speed. This force disperses in two ways. In a highly viscous vehicle it *pulls* apart the agglomerates caught between the moving layers. This effect, called "viscous shear," is independent of pigment concentration, but it diminishes rapidly with decreasing vehicle viscosity.

Conversely, low vehicle viscosity helps dispersion if the pigment concentration is high enough to cause mutual interference of the moving particles. Agglomerate break-up by such *rubbing* action (friction) is called "attrition." In practice, viscous shear and attrition effects can never be entirely separated, but one or other may become the dominant dispersing mechanism. Both depend on laminar flow, whereas impact does not.

It is instructive to analyse how different mills apply these forces in totally different ways. For example, roller mills exert high pressure and high viscous shear, but no impact at all. The full power of the machine is brought to bear on only a small amount of mill base at one time. By contrast, ball and pebble mills continuously move a large fraction of the mill base, along with the grinding elements, which then release their potential energy in the form of high impact and attrition, moderate pressure, but no great amount of viscous shear action.

The high speed disperser is more flexible than other mills in the ways it converts power into dispersion work. The impeller designer can emphasise, at will, impact or shear, or he can strike a fair balance between them. However, no high speed disperser can deliver much pressure and, furthermore, the intensity of the dispersion forces it produces is lower than that generated in roller, ball or even sand mills.

These are the reasons why the high speed disperser cannot break hard or tough aggregates or coarse particles. It can only wet and disperse soft agglomerates in low to medium viscous systems, but this it does faster than any other device, and therein lies its greatest virtue.

Impeller analysis

The simplest impeller one could use, and an element common to all, is a smooth disc which propels a thin layer of liquid radially outward by centrifugal force. The acceleration of flow from the centre towards the periphery followed by the deceleration in the surrounding body of liquid produces some shear and a little pressure, but no impact at all.

The amount of liquid moved by the disc varies with the viscosity of the liquid medium, but is generally insufficient to provide good batch circulation. Nevertheless, much high speed dispersion is carried out with impellers approaching the plain disc shape, not by design but by wear gone unheeded. It is a tribute to the pigment manufacturer's ability to control particle size and to minimise aggregate formation that dispersion is still possible with such a primitive device.

Sawtooth blade

The original and still the most widely used impeller type is the "sawtooth" blade[3] shown in Fig. 6, or modifications thereof. The teeth are formed by bending the serrated rim of a disc alternately up and down, slanting them at an angle of 20° to 40° to the tangent.

The vertical leading edge, *E* of each tooth (Fig. 6A) produces strong impact. The faces *F* shoot streams of mill base outward, causing considerable circulation and some shear action. However, not all of the mill base in front of the teeth is pushed forward. Some can't get out of the way of the oncoming teeth fast enough and slides backward over the horizontal edge, *H*, where it is sheared intensively.

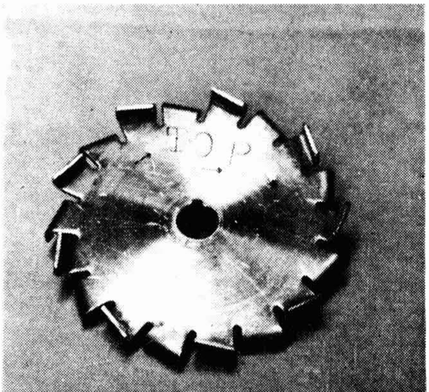

Fig. 6. Sawtooth impeller

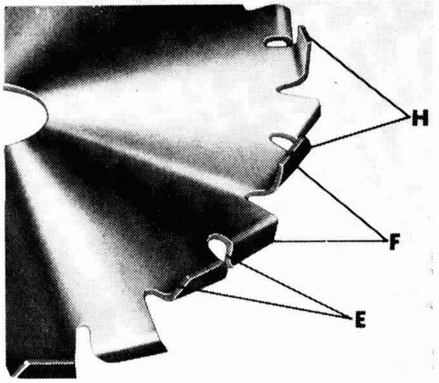

Fig. 6A. Sawtooth detail

In other words, each tooth acts somewhat like a knife applicator pulling a layer of liquid across a substrate (in this case the relatively stationary body of mill base), and shearing it in the process. The accelerated and then decelerated liquid flow at and near the outer edges of the teeth is partly laminar (orderly) and partly turbulent in nature.

The lower the mill base consistency, the more turbulence is created, and since turbulence diminishes shear efficiency, it follows that the sawtooth impeller works better in systems above 80 to 90 poise than in the lower viscosity range. Furthermore, the greater the turbulence, the more metal wear takes place. In aqueous systems containing abrasive extender pigments, the wear on the teeth will often become excessive.

All in all, the sawtooth impeller is the simplest and most nearly foolproof of all commercial impellers, but its effectiveness drops off sharply with decreasing viscosity.

Multi-ring impeller

The "multi-ring" impeller,[4] shown in Fig. 7, works better in low viscosity vehicle systems where attrition rather than viscous shear must do the dispersing. This impeller consists of several downward curved rings mounted approximately one-eighth-of-an-inch apart on an equally curved disc. Adjacent to the inside of the rings are a number of wedge-shaped teeth, slanted inwardly in the direction of rotation. Their leading edge provides impact, while their front faces give the mill base a radial push.

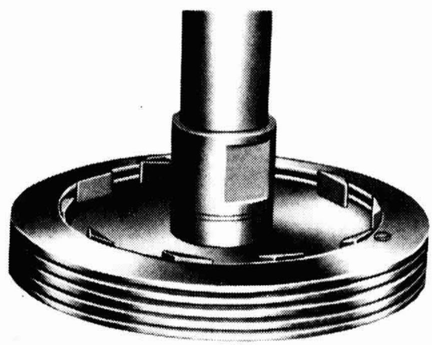

Fig. 7. Multi-ring impeller

Most dispersion takes place in the ring chambers just behind the teeth, as can be seen clearly by the wear pattern shown in Fig. 8. The curvature of the rings accelerates the horizontal radial flow in a downward direction, and thus has a similar effect as higher peripheral speed.

The same accelerating effect is achieved by the tilted planes, *B*, of the modified sawtooth impeller[5] shown in Fig. 9. The vertical flow produced by these shovels greatly increases the circulating action. In oversize batches, or for moving pseudo-plastic liquids, such strong circulating action may be useful, but in many other cases it is detrimental. This impeller produces less impact and viscous shear, but slightly more attrition than the regular sawtooth impeller.

Fig. 8. Worn multi-ring impeller, disassembled, showing wear pattern

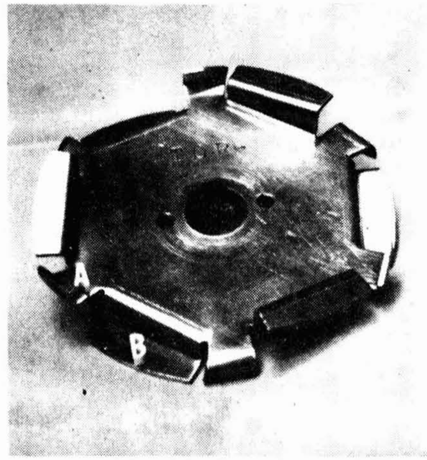

Fig. 9. Modified sawtooth impeller. Note tilted plane, labelled "B"

Power problem

All impellers discussed so far, and all the variants based on the same underlying principles, have one characteristic in common: power consumption drops off sharply as mill base viscosity decreases with progressing dispersion and heat build-up. The power drop is particularly pronounced in solvent based paints. It sets up a vicious cycle of diminishing dispersing efficiency and more conversion of power into heat.

A recent invention[6] has largely eliminated this problem. The "constant-shear impeller" (CSI),[8] shown in Fig. 10, *maintains* power consumption over a wide range of viscosities; in fact, it sometimes consumes more power as viscosity

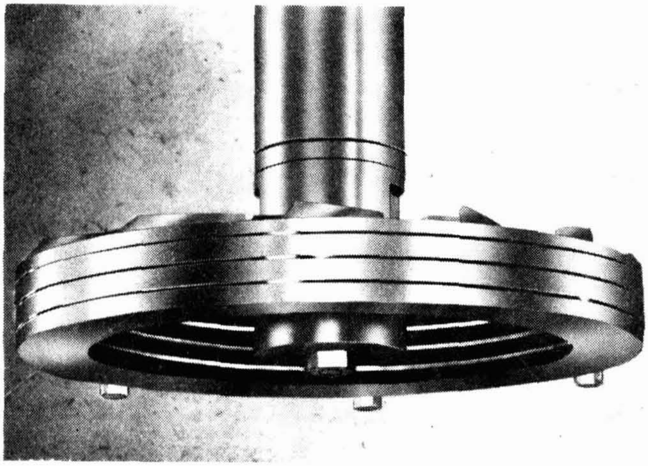

Fig. 10. Constant-shear impeller

drops. Only if and when the viscosity reduction becomes pronounced will the power consumption diminish.

At first glance, the CSI looks much like the multi-ring impeller. Both designs show a number of stacked rings mounted on (or under) a carrier disc. However, the CSI is unique in that it applies the well-known Venturi principle (hitherto used to measure flow or to create a vacuum) to pigment dispersion.

Fig. 11 shows a Venturi tube with its converging and diverging ends and the throat in between. Liquid entering under pressure at one end is greatly accelerated. It reaches maximum flow rates and creates a pressure drop at the throat. Both effects are beneficial for high speed dispersion—the one produces high shear rates, the other more pumping action.

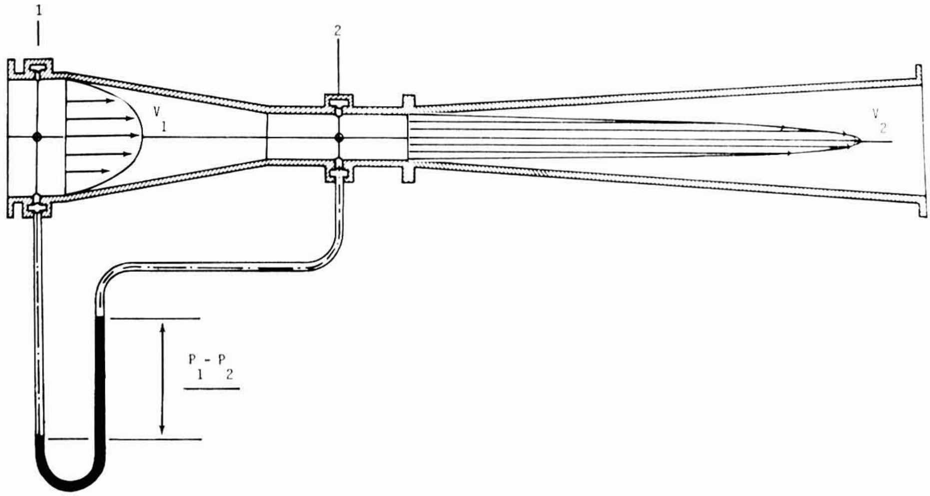

Fig. 11. Venturi tube

Table 1

Average relationship between impeller and batch dimension during dispersion step

Impeller diameter	1D
Tank diameter (round) ..	2.5D—4D
Liquid height	2.2D—4D
Impeller height (above bottom)	1/4 to 1/3 of liquid height (Minimum 1/2D, maximum 4/3D)

The profiled rings shown in Fig. 12 make the CSI a true Venturi device. At the throat, centrifugal force builds up a pressure of 20 to 40 pounds per square inch, depending on the peripheral speed. This is not much pressure in comparison to that produced by roller mills, but it is enough to create a Venturi effect, provided the spacing of the rings is commensurate with the mill base consistency.

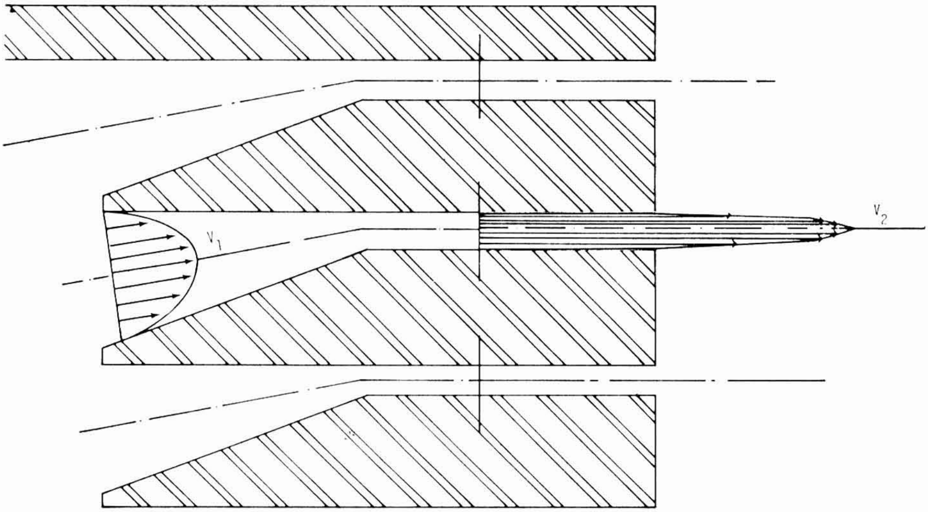

Fig. 12. Constant-shear impeller—section

In low viscosity systems (3,000 to 5,000 cps) a gap of approximately 0.04in (1mm) allows a large volume to flow through the rings at high velocity, giving optimum dispersion. More viscous liquids do not properly flow through such a narrow gap at the available pressure. An opening of approximately 0.1in (2.5mm) is needed when the viscosity reaches 80-100 poises measured by the Brookfield viscometer at 60 rpm or higher (125 to 140 Krebs Units). At still higher viscosities, the device fails altogether; the pressure becomes inadequate to push the mill base through the rings, and the power consumption becomes excessive if the rings are spaced farther apart.

Selective ring spacing is, therefore, needed to achieve optimum performance in a given viscosity range. Yet, each Venturi also compensates to a considerable extent for the viscosity drop taking place during dispersion by letting an increasing volume of mill base flow through. This self-regulating characteristic of the constant-shear impeller is the explanation for an almost constant output of shear energy and nearly constant power consumption.

The CSI often gives qualitatively better results than any other impeller, especially in low-to-medium-low-viscosity systems. It is also less dependent on the wetting characteristics of the vehicle, it develops less heat and it wears less than any other impeller, but it requires somewhat greater operating care to avoid blockage of the ring openings.

Limitations

Useful as the high speed disperser admittedly is, it has definite limitations which should not be over-looked. Its inability to break hard or tough aggregates has already been mentioned. As a result, it cannot produce clean grinds where even a small fraction of the pigment consists of oversized particles, hard aggregates or foreign matter.

More serious, because less obvious, is the opposite situation, where acceptable grind readings are obtained, yet the pigment is not fully dispersed. Even a high Hegman gauge reading of $7\frac{3}{4}$ merely indicates that no units larger than three microns (several hundred TiO_2 particles) are present. The $7\frac{3}{4}$ fineness says nothing about the size distribution of the overwhelming number of smaller units which determines how completely the pigment is really used. Often five, ten and sometimes as much as 25 per cent pigment value may be lost in tint strength or opacity through incomplete dispersion.

Wasting this percentage of pigmentary value may be permissible in the case of inexpensive pigments, but it is harder to defend in the case of the expensive pigments which are now so widely used in the industry. To find out whether high speed dispersion makes economic sense, as opposed to merely technical sense, the production department must set up an equation which balances low production cost but reduced pigment utilisation of high speed dispersers against the higher production costs but better pigment utilisation of other equipment.

The decision will often go against the high speed disperser, even when operated most efficiently with the most suitable impeller. The high speed disperser cannot hope to replace all other paintmaking machines unless and until all pigments are made as soft textured and easy dispersing as the best grades of TiO_2 are now.

Acknowledgment

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7. F. K. Daniel Laboratories, Jersey City, N.J.

Discussion at the West Riding Section

MR P. MELL opened the discussion by asking for the optimum viscosities at which to use the sawtooth impeller.

MR F. DANIEL replied that it was very difficult to answer the question, because one was not really dealing with viscosities but with very complex rheology, and the definition "viscosity" could not be applied. As an approximation, a sawtooth impeller worked quite well anywhere between 110 and 150 Krebs Units or something like 90 to 150 poise., but that was a very rough figure and could, again, be very misleading. It was possible to have much lower viscosities and a very pseudoplastic system, but the pigmentation could not be increased without losing all flow, so a compromise was necessary.

MR C. BUTLER asked if there were limitations to the amount of mill base in the tank during dispersion.

MR DANIEL said there was a very definite relationship between the total volume of mill base that could be dispersed, the tank size, and the impeller diameter. Obviously, the more viscous, the smaller must be the total volume of mill base, otherwise circulation could not be maintained. Circulation was the limiting factor. One could use a small impeller for all purposes if one could somehow feed the material effectively to the spinning head; it would then be immaterial how much mill base there was. A small and a large impeller had equal dispersing power when run at equal peripheral speed, but they differed in their pumping or circulating capacity. As a rule of thumb, under many conditions the tank diameter should be about 3 to 4 times the impeller diameter and that the batch height should be about 2 to 2½ times as high as the diameter of the impeller. The impeller should be located about one-third of the batch height above the bottom. These were very rough rules. One had to keep in mind at all times the inter-relationship between the mill base consistency, i.e. the flow characteristics and all other rheological characteristics, and the action of the impeller.

Mr C. F. Bottomley said that Mr Daniel had mentioned the reason for offsetting the shaft, but he wanted to know if this applied irrespective of the shape of the vessel, and whether this had a sloping or flat bottom.

Mr Daniel replied that of all the tank designs, the round tank, unbaffled with a dish bottom, was probably the most advantageous.

With a square tank, even if it had rounded corners, it was a problem to maintain complete circulation, with a baffled tank it was almost impossible to maintain full circulation, both with on- and off-centre operation. However, even in a square tank with rounded corners, a shaft position resulting in a deep vortex should be avoided; the shaft should be far enough off-centre to eliminate it. If the shaft was too far off-centre, dead zones of material were created at the far side of the tank where the mill base did not move. Prediction was difficult but the flow pattern would give the answer, and the appearance of cold spots around the tank would also give the answer about proper circulation.

The Next Speaker asked which Mr Daniel would use, to get a better decorative paint, a roller mill or a high speed disperser.

Mr Daniel said that in the high speed disperser there was not much leeway in the viscosity range. The answer was that a much better dispersion was obtained on a roller mill when high shear was needed to break hard aggregates. On the other hand, with easy dispersing pigments, an adequate paint could be made in high speed dispersers, which have many advantages over the roller mill in cost without sacrificing too much pigment value. The answer was also that in either case the mill base composition must be adapted to the dispersing equipment.

Mr S. Duckworth suggested that an off-centre position of the shaft increased turbulence in the mill base.

Mr Daniel answered this by saying that this was not really so. It was true that there was more circulation, but this was due to the deflection of the mill base off the wall of the tank, which did not really consume much power. Much more power was consumed by turbulence at the periphery of the impeller. In other words, the objectionable kind of turbulence was that generated at the impeller and not that created by using the tank wall as a baffle. If the results achieved by on-centre and off-centre positions were compared, the on-centre batch was very much hotter than the off-centre batch brought to the same degree of dispersion. This was of course indirect reasoning, but really quite compelling. The extra heat generated was due to excessive turbulence at the impeller.

Mr Duckworth commented on the "magic number" 4,000 to 5,000 feet per minute peripheral speed.

Mr Daniel said that this involved the examination of mill base rheology, but there is a very close relationship between the peripheral speed needed for optimal dispersion and the rheology of the system. With a dilatant mill base, very good results could be obtained at 3,000 or 2,500 feet per minute. It was sometimes possible to get better results at the lower peripheral speed than at the higher because at the higher speed, with too much dilatancy, there was no longer laminar flow. Instead, there was plug flow, which was unsuitable for dispersing. In spite of tremendous circulation, very little dispersion was obtained in such systems, so he was the last to want to stick rigidly to any "magic numbers." On the contrary, he had pointed out several times that the peripheral speed itself may be meaningless if the impeller construction affected the shear rates, as the slanted teeth in the multi-ring impeller and the downward curvature of the rings did. If a multi-ring impeller was run at 5,000 feet per minute, the shear rates were really much higher than those generated at 5,000 ft/min by the sawtooth impeller of the same diameter. So there was nothing sacred about the 4,000 to 5,000 number, but there was this to be said: if the machine ran at much over 6,000 ft/min considerable secondary problems were usually created.

MR P. ROUT asked if there was any significant difference in the type of circulation between the sawtooth and Venturi type of impellers.

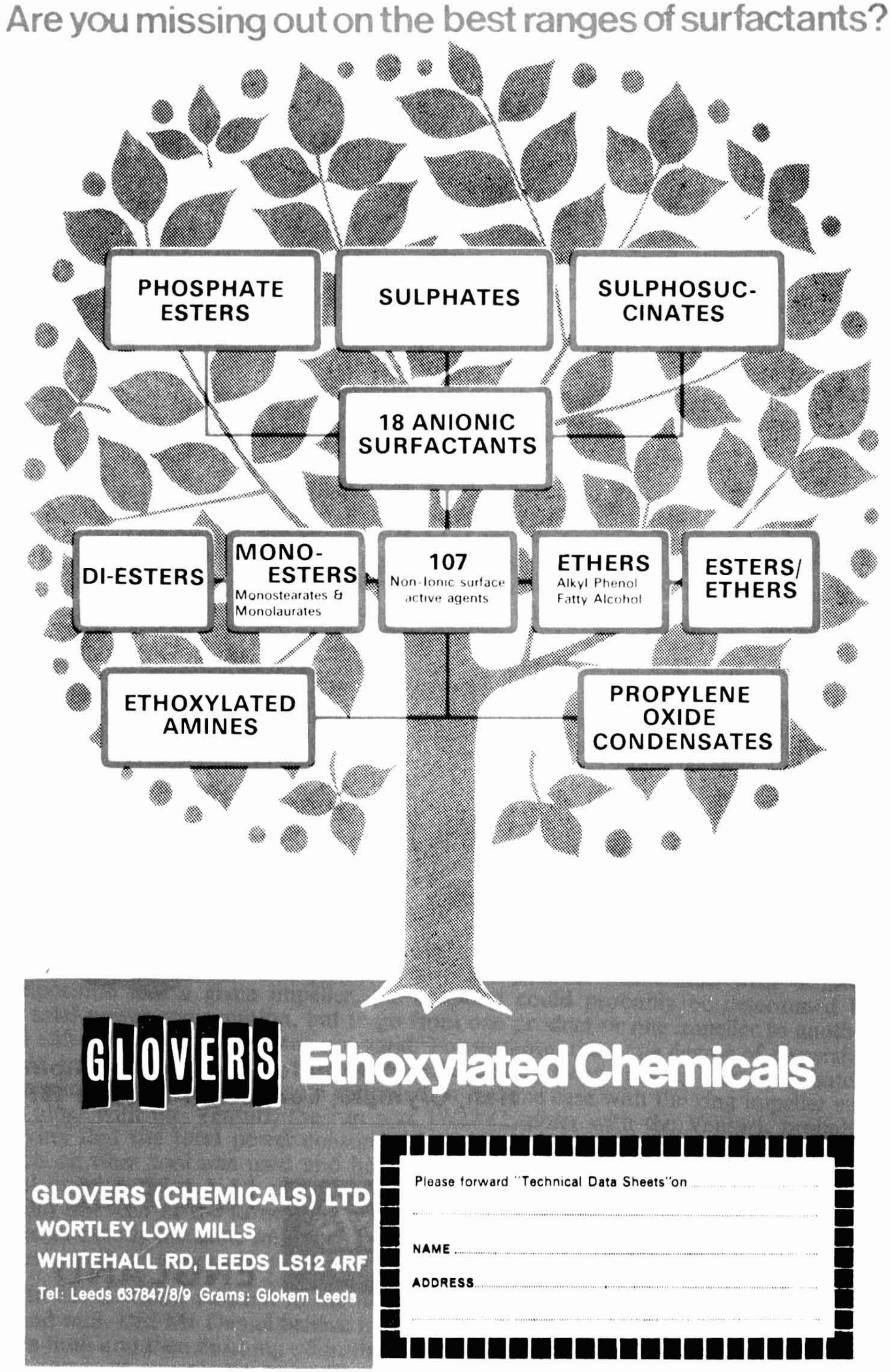
MR DANIEL replied that the Venturi type gave predominantly laminar flow. The circulation it produced resulted mainly from the laminar stream emerging from the Venturi openings, which was then bounced off the tank, whereas in the sawtooth there was a lot of turbulence at the impeller periphery. There was therefore quite a difference in the type of flow, and proof of this was that one could obtain good dispersion and complete, smooth, circulation of highly pseudoplastic materials, for instance using Bentone, with the Venturi impeller but not with the sawtooth impeller, no matter how it was used.

MR F. J. OWEN asked if Mr Daniel would differentiate between turbulent and laminar flow, as he felt these were normally defined in terms of Reynolds numbers. Did Mr Daniel consider the flow was laminar up to a certain reading in Reynolds numbers and above that was turbulent flow, or was the assessment purely subjective—it looked laminar or it looked turbulent?

MR DANIEL said that the Reynolds number determined at what point the laminar flow could not be maintained, and became turbulent. Obviously to maintain laminar flow, one must stay below the Reynolds number, but how this could be achieved depended very much on the construction of the impeller. With the Venturi impeller it seemed difficult to go above the Reynolds number because there was exceptionally orderly flow. The centrifugal force made the mill base converge very smoothly and gradually. There was a stationary layer at the metal surfaces and progressively faster flow towards the centre, so the ideal flow profile was attained. Much higher pressures than available would be required to destroy the Venturi effect and get turbulence. On the other hand, if a sawtooth impeller was used, it was extremely easy to set up turbulence; in fact, there was really no way to avoid turbulence in a low viscosity system.

MR OWEN said that his definition of the Reynolds number was the product of the square of the diameter of the impeller, the rpm, the density, and the viscosity of the mill base, so that as the viscosity decreased for a constant speed and constant diameter of any turbine, the Reynolds number was then solely dependent on the viscosity; so for any one impeller it could only be dependent on viscosity.

MR DANIEL replied that he did not think that it was that simple; there were many more variables. Valid comparisons could only be made if the impellers were basically the same design; the Reynolds numbers could then be determined. As paints were not Newtonian systems, and had very complex rheologies, theoretical approaches to the problem were beset with many difficulties and uncertainties. He would seriously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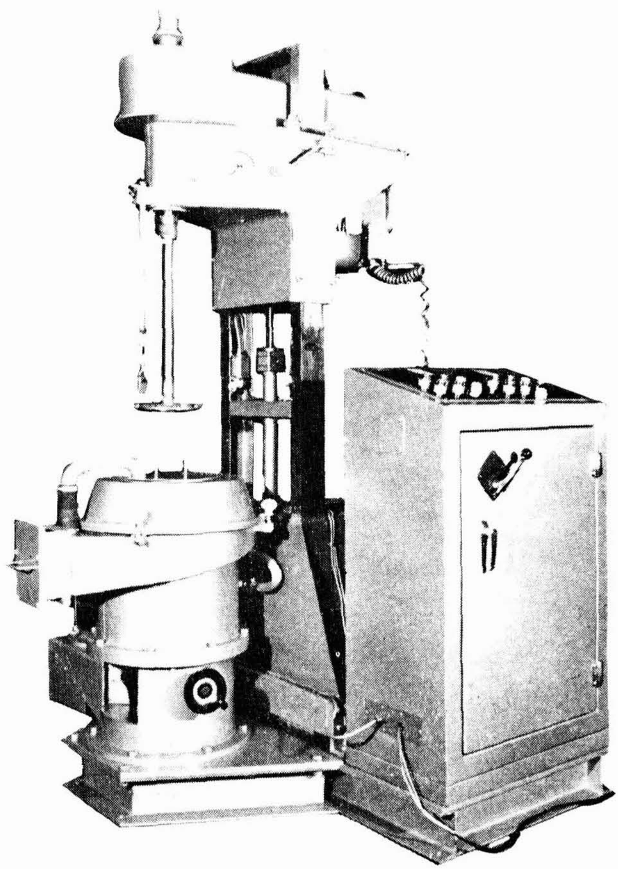

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doubt whether this theoretical approach by Reynolds numbers could be used for any system that was as non-Newtonian as a mill base.

MR OWEN said that he wondered how one related the statements that at one stage turbulent flow was needed for wetting and laminar flow was needed for dispersion, and what criterion was used to distinguish between these flows. Did one just look and say "that looks like turbulence" and later "that looks laminar?"

MR DANIEL agreed that this was the case.

MR J. BRAVEY asked if Mr Daniel envisaged experimenting with about half a dozen consecutive batches to determine the correlation between lab and production operating conditions.

MR DANIEL said that this raised a very important point. At present there was no tool that he knew of that allowed one to determine in the lab the behavior in the plant. If one scaled down operation in a quart can in the lab, an impeller approximately 1in to 1¼in in diameter would be required, and in order to create the necessary peripheral speeds, it had to run at 18,000 to 20,000 rpm. A shaft running at this speed would always cause spitting and create a deep vortex. Also a half horsepower motor was required, and this was more than most lab mixers had. On the other hand, to experiment in the plant with relatively large batches of the order of 100 gallons was really awkward. The gentleman who invented the Venturi impeller had spent the last six months trying to develop the design for a lab unit that really correlated in all impellers with plant operations, and, in all his years of experience had never come up against a seemingly simple scaling down problem which had proved to be so difficult. He claimed to have solved the problem, but the instrument was not yet available. This would be a wonderful tool to put into easy practice the correlation of lab and plant.

MR W. A. ALLMAN asked, if one graphed current consumptions against time, what sort of curve could be expected. Did this curve indicate incorrect and defective manufacturing methods and would one expect a similar sort of curve for different types of paint?

MR DANIEL replied that this would be the case if total power consumption were plotted against time, and the same type of mill base was run. He had seen a plant in the US which was plotting the power demand throughout the operation, not the total power consumption; but thought that, in general, it had little merit, because if a much higher fraction of the power was wasted by converting it to heat with one impeller or with one mill base consistency than with another, it could at best be consistent within itself. Every time the same product was made with a given composition and a given impeller, the endpoint could probably be determined by the total power consumption, but to go from one product or one impeller to another and still expect correlation was not valid. For instance, the same degree of dispersion could be obtained at totally different temperatures; when making the same batch, dispersing it to exactly the same endpoint, in the one case with the ring impeller and the other with the Venturi, the run was 17-22°C cooler with the Venturi, probably proving that the total power consumption could not be the same. It depended very much on what tool was used and how, i.e. how deep the impeller was set, what the total operating time was, etc. If the operator did not control every variable, i.e. if he did not feed at the same rate, if he did not bring the speed up to the dispersion speed in exactly the same way, then it was hard to see how one could use such broad criteria as those the questioner had mentioned.

MR H. G. COOK referred to the use of a high speed disperser in conjunction with a sand mill. Did Mr Daniel believe in operating the high speed disperser more or less to its limit and then finishing off in the sand mill, or vice-versa?

Mr Daniel said that whatever could be achieved easily with good operating technique by the high speed disperser was all to the good.

If the correct impeller, mill base composition, and technique were used, it did not take any extra time to achieve good dispersion and what had already been accomplished in the high speed disperser would cut down the work load on the sand mill. So a much better through-put would be achieved by ensuring a good predispersion in the high speed disperser, using the sand mill almost as a refining tool. This was exactly the same situation as in using the pony mixer and roller mill combination: the better the premix that was fed to the roller mills, the fewer passes that were needed.

Discussion at the Trent Valley Branch

The First Questioner asked if it would not have been more appropriate to discuss high *shear* dispersion rather than high *speed* dispersion, since low speeds gave satisfactory results in a dilatant system.

Mr F. K. Daniel replied that the term "high shear" would be more misleading than "high speed." It would imply that the shear *stress* generated by the impeller was high, but it was not—certainly not as compared to the stress generated by roller mills. Impellers dispersed best at medium to low shear stress but fairly high shear *rates*, i.e. high fluid velocity or speed. Good dispersion usually required peripheral speeds of 4,000 to 5,000 ft/min. True, strongly dilatant systems must be dispersed at somewhat lower speeds such as 2,500 to 3,000 ft/min but that was still relatively high speed. Besides, such dilatant mill bases were not typical; in fact, strong dilatancy should be avoided because such systems were so sensitive to minor changes in operating conditions.

The Second Questioner referred to the Venturi impeller and asked about the slide illustrating a worn impeller showing deflecting teeth.

Mr Daniel said that the lower the mill base viscosity, the lower was the dispersing efficiency of the sawtooth impeller and the greater the wear on the teeth. At higher consistencies, the teeth caused less turbulence, hence they wore only moderately. The Venturi rings, on the other hand, wore hardly at all because they suppressed turbulent flow, even in low viscosity fluids.

The Third Questioner asked what the advantage of feeding pigment into the vortex was.

Mr Daniel replied that it saved wetting time and also kept the temperature down. Sifting the pigment into the vortex, rather than dumping it by the bagful, would be most advantageous.

The Fourth Questioner enquired as to which pigments should be selected to give a good grind.

Mr Daniel commented that it was preferable to reverse this question. All pigments forming tough aggregates and agglomerates would be unsuitable. A hiding or tinting test was more sensitive than a grinding test.

The Fifth Questioner asked it there was any difference in tooth and disc techniques and any difference in temperatures.

Mr Daniel said that the mill base was 17-22°C cooler with a Venturi impeller, using correct mill base consistency.

The Sixth Questioner asked if there was an ideal shape for the container.

Mr Daniel replied that a round, dish-bottomed tank was most ideal.

The Seventh Questioner asked if there were any limitations on batch size.

Mr Daniel said there were none.

The Eighth Questioner dealt with the possibility of using two-shaft units with the same motor and asked for comment on the use of the Varikinetic type.

Mr Daniel said that two-shaft units were useful where mill bases had insufficient flow to maintain good circulation with a single impeller. They acted somewhat like the old pony mixer. The Varikinetic disperser used a single speed motor without speed contols. Proper flow could be maintained by adjustment of the vanes. However, the vanes produced high turbulence and could wear badly in abrasive systems. In other words, the Varikinetic too had its limitations.

The Ninth Questioner asked if mill design was more important than mill base formulation.

Mr Daniel replied that both were important; in fact, they were interdependent.

Next month's issue

The Honorary Editor has accepted the following papers for publication and these are expected to appear in the February issue:

"Dispersion in aqueous media," *by W. Carr*

"The influence of non-aqueous media on dispersions," *by K. Pond*

"Polyurethane finishes for the coil coating process," *by F. Blowmeyer*

"The fibre optics colorimeter and its application in paint manufacture," *by I. G. H. Ishak*

Correspondence

Sir,—Looking through some old school books, I came across the following gem which I had copied from an American journal (identity long forgotten) around the mid-1930s.

The Chemists

Whose interest is to ferret out the last minute constituent
And hazard veiled opinions as to types of groups substituent
Who scrutinises all results in manner supercritical
The filter washing, beaker tossing, chemist analytical.

Who doubts e'en known reactions when he doesn't know conditions
Whose temperature and pressure rules upset our best traditions
Who looks on all but van der Waals with naught but deep suspicion
The phase-rule hampered, ego pampered, chemist who is physical.

Who makes unholy messes that he cannot crystallise
Who generates foul vapours which contaminate the skies
Who builds up complex molecules whose structures are titanic
The work bedizened, wan and wizened, chemica organic.

Who extracts dope from berry leaves and venom out of snakes
Gets alkaloids from kidney beans and weeds that grow in brakes
Whose cheap two-bit cosmetics are a cinch to wreck the cuticle
The drug besotted, fever rotted, chemist pharmaceutical.

Whose iron-carbon diagrams at best are merely boring
Who looks on smelter refuse dumps with attitude adoring
Who ever seeks to make alloys by methods scarce chemurgical
The metal etching, test piece stretching, chemist metallurgical.

Who seeks to make it evident he's versed in any subject
Whose hastily formed judgement spells ruin to your project
Who fakes up specious arguments about the woes resulting
The pencil pushing, error shushing, chemist who's consulting.

To whom is everything composed of just whorls in the ether
Who looks on force and matter play as befitting neither
Whose principles and precepts are for ever hypothetical
The quantum chasing, law erasing, chemist theoretical.

Whose life is just a tedium of motors, pumps and tanks
Distilling columns, colloid mills and heater tubes in banks
Whose outlook economically is scarcely ever cheering
The hybrid chemist-physicist who deals in engineering.

It occurs to me that your readers may care to amuse themselves by composing additional stanzas appropriate to our branch of the profession.

Yours faithfully,
A. R. H. Tawn
24 November 1970

34, Crest View Drive,
Petts Wood, Kent. BR5 1BY

(*How about*—

Whose overall is stained with colours kaleidoscopic
Who searches ceaselessly for systems thixotropic
Whose endless efforts are to stop the damned thing floating
That unfortunate of science—the chemist, surface coating.

—*Hon. Editor*)

Reviews

SURFACTANT BIODEGRADATION

By R. D. SWISHER, New York: Marcel Dekker Inc., 1970. Pp. xxiii + 496. Price £15.95

The problem of surfactant biodegradation was found to be serious in the 1950s when excessive foaming was occurring at sewage works and in the environment of sewage effluents. This resulted from the widespread replacement of soap for domestic and laundry use by synthetic detergents, which retain their foaming properties down to 1 p.p.m. Intensive study indicated that the principal cause of the trouble was the branched alkyl chain in the dodecyl benzene sulphonate derived from propylene tetramer, which rendered the surfactant highly resistant to biodegradation. By the late 1960s the nuisance had largely been avoided by the substitution of alkyl benezene sulphonates of straighter chain configuration. Some individual problems with industrial surfactants, particularly the non-ionics, however, still remain.

The whole subject is young enough to be reviewed in its entirety in this single volume. An exhaustive bibliography of over 1,000 references covers every significant work on the subject to 1969. Comprehensive tables record the comparative biodegradability of all important surfactants. While it may not be necessary for this book to be on the shelf of every paint library, it should be readily available for consultation.

L. A. O'NEILL

MARINE CHEMISTRY

VOLUME II. THEORY AND APPLICATIONS

By D. F. MARTIN. New York: Marcel Dekker Inc. 1970. Pp. x + 451. Price £4.50.

It is unlikely that a chemist concerned with the protection of ship bottoms and marine structures will ever find the whole of a book dealing broadly with the subject of the oceans to have a direct bearing on his particular concern. Nevertheless there is a sense in which information about the environment with which he is involved must be of considerable help, even if only to condition his mode of thinking. This volume, described as a preliminary edition, gives a convincing picture of what happens or probably happens in the oceans, and particularly of the relationship between physical and chemical factors of air, land and ocean, and marine ecology. The danger in having a limited professional interest is that the book leads one into fascinating but, from the paint chemist's point of view, unnecessary paths.

Of particular interest to this reviewer were the sections dealing with the rôle of silicates in the metabolism of marine organisms, with the synthesis of complex silicates by sea water, and with the control of pH, in the short term by carbonates and in the long term by the silicates. This is covered by chapter 4 entitled "The model ocean". Also in chapter 4, the chemistry of iron in sea water is considered at some length and your reviewer could not help wondering whether there is an analogy with other metals such as copper. It is suggested that chelates between the metal and humic acid are of importance.

The cycles involving the principal elements of importance to nutrition; carbon, nitrogen, sulphur and phosphorus are described and the contribution of anoxic bacteria deep on the ocean floor or in estuarial muds is outlined. It would seem that the limiting factor in growth is the availability of phosphorus, which varies both seasonally and geographically.

The short section on food and drugs from the sea stimulates thought on the possibility of extracting marine biotoxins for possible use to discourage marine growths attaching to surface coatings.

The book is clearly printed, easy to read and well provided with references. The practice of including a summary with notes at the end of each chapter is useful and could well be adopted in other similar reviews. Obvious printing errors are few with only minor slips such as $Al(CH)_3$ for $Al(OH)_3$ on page 114.

P. J. GAY

Manchester Section

Some aspects of paint formulation

The second meeting for Student Members of the Manchester Section was held in the Manchester Literary and Philosophical Society's Lecture Theatre on Wednesday 14 October 1970. Mr J. E. Mitchell was in the chair and 63 students and guests attended the meeting.

Mr Mitchell began by apologising for the absence of Mr T. W. Wilkinson of Laporte Industries Limited, who was unable to give the lecture as planned owing to an important business commitment. Mr B. Howells of Laporte was introduced and he proceeded with the lecture on "Some aspects of paint formulation".

Mr Howells started by touching on the historical background of paint formulation, pointing out that writing paint recipes on a percentage basis was useful for costing formulations, and that referring to paint formulations by giving pigment to binder ratios did give an indication of the type of paint, i.e. gloss, eggshell or matt.

Referring to the dangers of formulation collecting, it was said that although a handy, well-tried, formulation was useful, the continued use of old formulations could make the paint chemist lazy and inhibit the development and trials of new products.

Mr Howells developed the lecture by going into the aspects of successful paint formulation. Owing to conflicting property requirements, everybody was aware that it was virtually impossible to produce a paint incorporating every desirable property at low cost, and the essence of successful paint formulation is in arriving at the correct compromise of properties. Therefore, before starting to formulate a paint a clear aim or target must be established and, bearing in mind the end use of the product, definite property requirements must be laid down. To assist in arriving at the required paint formulation quickly some knowledge of statistical testing could be a great help, and any effort spent by the paint chemist in acquiring such knowledge would not be wasted.

The importance of correct raw material selection was stressed, not only from the technical point but also from the point of view of using versatile products so that the stocking of several products for similar uses could be minimised. Here the raw material suppliers were complimented on the provision of useful data relating to their products, thereby making the correct selection of raw materials much easier. It was pointed out that extenders were not added to paints just to cut costs, but were in fact necessary for improving certain properties such as flow, opacity, brushing, filling, etc.

Correct formulation of mill bases was also considered important with a view to cutting processing time to a minimum to obtain maximum output of paint with the required properties.

Some very interesting tables and graphs were presented illustrating how formulations should be costed, and others showing the relationship between cost and pigment volume concentration of TiO_2 in paints in which whiting was used as the common extender. A graph showing the effect of PVC on such properties as gloss, blistering and hiding was also shown. The relevant properties such as contrast ratio (brushed and coated), colour, etc., of extenders such as natural and synthetic calcium carbonate, Talc, Barytes and Blanc Fixe, calcined and natural China Clay were presented in tabular form.

After question time a vote of thanks was proposed by Mr A. Gerrard and carried with acclamation.

D.A.P.

Information Received

(In case of difficulty regarding addresses, members and subscribers to the JOURNAL *should apply for details to Director & Secretary of the Association at the address shown on the front cover.)*

It has recently been announced that **Ciba United Kingdom Limited** and **Geigy (UK) Limited** have agreed to merge to form a single company in the UK. The merger, which is expected to take place early in 1971, follows the acceptance of the proposals to merge **Ciba Limited** and **J. R. Geigy SA** by shareholders of the parent companies in Basle earlier this year. It is said that the merging of the two UK companies will be a logical extension of the joining of the Swiss parents and essential to the research activities of both companies for future developments and diversification of their interests.

The UK organisation will take the form of a combined holding and operating company which it is anticipated will be called **Ciba-Geigy (UK) Limited.** The Head Office will be at 42, Berkeley Square, London. **Ilford Limited** will continue to operate as a separate company.

Columbian International (Great Britain) Limited has recently announced that it is now working on the development of furnace blacks which are intended to replace the existing channel blacks used in paint and printing inks. This is of particular importance in view of the decision by The Texas Air Control Board that no channel black manufacture will be allowed, for pollution reasons, after the end of 1972. By this date the United States channel black industry will have shut down. Some work in this field has already been carried out, owing to the rising costs of importing channel blacks into this country. Columbian's two high colour furnace blacks, *Raven 1000* and *Raven 1200*, are said to be first in a new family of such products.

It has recently been announced that **Unilever NV** and **Resinas Sinteticas SA** are discussing the possibility of the acquisition by Unilever of 100 per cent of the equity of Resinas Sinteticas. The latter company is a long established synthetic resin producer whose products include alkyds, amino resins, phenolics and unsaturated polyesters, production facilities being situated near Barcelona. Any agreement reached will be subject to the approval of the Spanish Government.

Cray Valley Products Limited has extended its range of curing agents for epoxy resins by the introduction *of Synolide 968*. Developed primarily as a low temperature accelerator for the *Versamid* range of polyamide hardeners, *Synolide 968* is claimed to be equally effective as an accelerator of many other types. Low toxicity and economy in use are also claimed.

A new leaflet giving details of a range of synthetic resin plants, including computer programmed units, has been issued by **Chemical and Thermal Engineering Limited.** Copies of the four-page booklet are obtainable from Chemical and Thermal Engineering.

It has recently been announced that **Southern Instruments Holdings Limited** has acquired **Shandon Scientific Industries Limited.** Shandon will be merged with the Southern Instruments and Southern Analytical subsidiaries at Camberley, thus forming a new company to be called **Shandon Southern Instruments Limited.** It is believed that the combination of Southern's strength in production expertise and technical innovation, allied with the marketing ability of Shandon, will strengthen the overall position of the new company.

ICI Limited is to offer for sale a safety system for use in hydrocarbon plants. From its experience over nearly 20 years of operating these plants, the company has developed a firewall steam curtain, which, it is claimed, can be installed for less than 1 per cent of the cost of a large olefine plant.

The steam curtain is automatically triggered off when sensors inside the firewall detect escaping vapour, thus preventing clouds of inflammable vapour reaching sources of ignition. Full details of the system, together with a manual giving detailed guidance on how to calculate when and where hazards can occur in olefine plants, is offered, and ICI experts will be available for consultation.

Trirad, a new solid state radiometer for measurement of illuminance sources, has been introduced by **Kollmorgen Color Systems.** Completely automatic, *Trirad* measures the light source and displays the CIE chromaticity co-ordinates after a delay of approximately 20 seconds. Illuminance (Y) is displayed in lumens per sq ft. The measuring head can be used direct with control unit, or by means of an extension cable up to 10ft away.

Hoechst-Cassella Dyestuffs Limited has recently issued a technical data sheet on *Madurit OP Powder*, a new melamine resin for surface finishing of paper and cardboard.

A new prefabrication primer for structural steelwork, *Weldalloy*, has been introduced by **Southern Imperial Coatings Corporation.** Based on heat tolerant, corrosion inhibitive metallic alloys, *Weldalloy* is said to provide protection before, during and after construction, and to accommodate burning, heating and shaping at full production speeds, without any arc instability, weld porosity or gas production. A 28-page booklet describing the new product, and giving details of practical usages and tests, is available from Southern Imperial Coatings.

A new range of gas fired infra-red ovens is now being produced by **Mechanical Coatings Limited.** Based on *Type AL* emitters and with a burner face temperature of 1,010°C, the new oven is said to offer extreme time saving compared to convection stoving. A wide range of oven configurations is available, including the normal hexagon as well as horizontally positioned ovens firing both upwards and downwards. Burners for town gas, natural gas, or liquid propane gas can be supplied.

Vincit P482 is a new general purpose adhesive recently introduced by **The Carborundum Company Limited.** Usability with a wide range of surfaces, high initial tack and bond strength, and good shear stability are claimed for the new product.

Two new products manufactured by the **Newcastle Company** of Pennsylvania are to be marketed in this country.

The *Newcastle Model 57* case packer is a semi-automatic, pneumatically controlled unit designed for those wishing to package in a wide range of containers. It is claimed that the packer will deal with virtually any size or shape container at a line speed of 240 containers per minute, and that metal, glass or plastic containers can be used.

A new floor level semi-automatic palletiser, *Model 1-57 Palavator*, is also offered by the Newcastle Company. Operating at floor level with no platform, the new machine, it is claimed, can handle cartons, bags and bundles with rated line speeds up to 20/30 cases per minute.

Blythe Colours Limited has recently issued a 4-page booklet entitled "Progress in colour . . . 1870-1970" commemorating Blythe's establishment 100 years ago. A full list of Blythe's inorganic pigment products is included.

A new plant for the manufacture of *Flammex* flame retardants has recently been commissioned by **Berk Limited.** Owing to the increase in regulations regarding flame resistance of plastics, the plant has become very much larger than was envisaged when its development was announced 12 months ago. Two production lines are now in operation: one for the *Flammex T23P* and *LV T23P* retardants which are manufactured under licence from **Michigan Chemical Corporation,** and one for Berk's own bromine-based *Flammex* compounds.

A new fluoroelastomer with significantly improved compression set resistance has been developed by the **Du Pont Company (UK) Limited.** Optimum compression set values using the new product, *Viton E-60 C*, are obtained by curing at 232°C. All other properties of *E-60 C* are said to be similar to the other *Viton* types.

Du Pont has also recently announced that the analytical instruments business of **Bell and Howell Limited** has been transferred to the Instrument Products Division of **Du Pont (UK) Limited.** This follows the announcement in the United States that Du Pont has purchased the business and assets of **Bell and Howell Company's** analytical instruments products line.

A new high-speed vibration mill, the *Op-Po Mill*, has recently been introduced by **Podmore & Sons Limited.** Based on a patented drive unit that transmits horizontal vibrations claimed to be of higher frequency and amplitude than other conventional vibration mills, the *Op-Po* operates two or four grinding containers up to 700ml. capacity. These containers are constructed in steel, ceramics, or other suitable materials, and it is recommended that they are filled to 60 per cent volume with grinding media and 30 per cent with the material to be processed. It is claimed that great time savings in laboratory grinding, dispersion and blending processes are possible using the new mill. Reduction of particle size to less than 1 micron is possible.

Coates Brothers Inks Limited has announced that it has acquired a controlling interest in **Lorilleux-Lefranc (West Indies) Limited.** The name of the company has been changed to **Coates Brothers (Jamaica) Limited,** and will be operated as a joint venture with **Lewis Berger (West Indies) Limited,** which will remain a substantial shareholder and will also take a small shareholding in **Coates Brothers (Caribbean) Limited.** It is envisaged, say Coates, that these new arrangements will improve still further services to the printers in the North Caribbean area.

A new red oxide primer for use on polyester glass fibre moulds has been developed by **Ault and Wiborg Industrial Finishes Limited.** The new primer, *Alcobond*, comprises a red oxide primer base and special catalyst in a mixing ratio of 2:1, and is applied to the mould before application of the release agent. When the moulded item is removed, the Alcobond is present in the surface of the gelcoat, providing a primer that can be covered with most types of conventional paint.

A portable pH meter has recently been produced by **Pye Unicam Limited.** Designed to bring on site the stability and accuracy of laboratory models, the *Model 293 Portable pH meter* is claimed to operate for more than 2,000 hours between battery changes and to be of a rugged construction which will allow years of use without loss of repeatability or accuracy. The ranges are 0-14 pH and 700-0 to 700mV with manual temperature compensation from 0—100°C. Automatic temperature compensation from -5—100°C is also available by use of a resistance thermometer.

Alkydal F 41 is a new vegetable fatty acid modified medium oil alkyd produced by **Farbenfabriken Bayer AG.** The new resin, which is primarily for use in the formulation of coatings having reduced drying times and curing within the range 20-80°C, is available in this country from **Bayer Chemicals Limited.**

The new **Degussa-Antwerpen NV** chemicals plant in Antwerp was recently opened in the presence of representatives of the Belgian Government. The new plant, which is in a 270 acre site, is the most modern and largest of Degussa's production units, and will have an annual capacity of 4,000 tons of *Aerosil* (with possibilities for doubling in the near future) as well as 10,000 tons cyanuric chloride, 17,000 tons calcium ferrocyanide, 3,000 tons sodium cyanide, 36,000 tons hydrogen peroxide, and 60,000 tons sodium perborate.

Hull

Protective coatings for gas pipe lines and storage vessels

The second meeting of the present session was held at the Technical College, Hull, on 2 November. The Section Chairman, Mr N. F. Lythgoe, introduced Dr J. T. Harrison of the Gas Council, who gave a lecture with the above title.

Dr Harrison described the growth of the national grid for the storage and transmission of natural gas and then discussed the reasons for coating pipes and storage vessels, e.g. to improve resistance to corrosion, to assist gas flow by reducing wall friction and to facilitate inspection. Choice of pretreatment and of coating system was discussed in some detail, as were the several methods of joint coating after welding.

An account of a similar lecture given by Dr Harrison has appeared previously in the Journal (*JOCCA* 1969, **52**, 464) and it is unnecessary to give greater detail here. Dr Harrison's lecture was nevertheless most interesting and was followed by the usual discussion period in which questions were asked by Messrs. Tasker, Gilroy, Gibson, Harrison, Brown and Lythgoe. Finally, a vote of thanks was proposed by the Chairman; 19 members and 3 visitors were present.

J.A.H.

Irish

The role of chlorinated rubber in modern anti-corrosive systems, including its use in printing inks

A lecture was given on Friday 16 October, at the Clarence Hotel, by Mr P. A. Herbert of Imperial Chemical Industries Ltd. His subject was "The role of chlorinated rubber in modern anti-corrosive systems, including its use in printing inks." Two films and several slides were shown to augment Mr Herbert's very interesting talk. Thirty members and 12 visitors were present.

A.R.

London

The significance of glass transition temperatures of paint films

A meeting was held on 11 November 1970 at Borough Polytechnic, London SE1, when Mr J. L. Prosser of the Paint Research Station gave a paper with the above title. In the absence of the Section Chairman, Mr R. H. E. Munn took the chair.

Mr Prosser commenced by posing the question "What is a glass transition temperature?" Basically a change in physical properties occurred, such as specific volume or refractive index; it was perhaps from a practical point of view more important that there was a change in the mechanical properties at the T_g. Unfortunately there was often a difference of up to 20°C between T_g's derived from mechanical measurements and those obtained from optical or volume measurements, and most of the T_g figures quoted in the literature came from the latter. In practice, there was a region of transition rather than a sharp change; the T_g was obtained by the intersection of two tangents.

A paint film was laid down on a substrate from solution; at a certain stage of film formation rigidity developed, and on further evaporation of the solvent intermolecular porosity developed. On releasing stresses by increasing the temperature some relaxation occurred, leading to a change in volume. Three methods of measurement had been used in the PRS work, (a) the sonic pulse method, (b) dilatometry, and (c) a more practical bend test on a mandrel. A wide range of paints had been examined, all pigmented with titanium dioxide; these were epoxy polyamide, vinyl toluenated alkyd, linseed epoxy ester, soya/penta alkyd, polybutyl methacrylate, linseed/tung phenolic, vinyl chloride/acetate/maleic acid, and an aliphatic NCO polyurethane. These paints had all been laid down to form 25μ films, and conditioned in a standard manner.

The procedure used was to measure the T_g of the film when fresh; the film was then subjected to artificial weathering and removed, dried out for 24 hours, and then measured again. This was repeated as required. The original measurements had been made by the sonic pulse method. Most films showed a rapid initial rise in T_g in the first few weeks, followed by a gradual levelling out or sometimes a slight fall. After about 15 weeks' artificial weathering, the T_g's of a wide variety of films were very similar, in the range of 40-50°C. It was found that soya/penta alkyd films always showed two values for T_g, while other alkyds did not; there was no adequate explanation. It had been suggested in the literature that pigmentation of films could increase the T_g markedly. This effect had not been observed; a paint film with 15 per cent titanium dioxide showed a difference of only 2-3°C compared with a clear film.

In order to see whether the unexpected results obtained were caused by the sonic pulse method of measurement, the dilatometer technique had been used. Some differences were found in individual cases, but generally there was good agreement between the results with the dilatometer and sonic pulse methods.

It was then decided to develop a method which could be used generally in a normal paint laboratory based on the measurement of a mechanical property. A bend test using a conical mandrel was chosen. Soft aluminium panels were pretreated and then painted. These were cooled in a refrigerator, at intervals of 5°C, and then subjected to an extensibility test on the conical mandrel. The limitation of the method was that only about 9 per cent elongation could be achieved, whereas 30-40 per cent was really necessary for complete utility. It was found that the rate of extension had an important effect.

Mr Prosser concluded by saying that it was possible that there were two kinds of transition temperature, (a) one such as is shown by sonic pulse or volume change methods, and (b) one where the paint film was strained at the same time as the measurement was made. The paper was followed by a lively and extensive discussion, after which a vote of thanks to the speaker was proposed by Mr P. Whiteley.

V.T.C.

Midlands

Polymer developments in the 70's and beyond

A meeting of the Midlands Section was held on 16 October in the Chamber of Commerce, Birmingham, when 45 members and guests, under the chairmanship of Mr H. Griffiths, the Section Chairman, heard Mr A. R. H. Tawn give a lecture entitled "Polymer developments in the 70's and beyond."

Mr Tawn opened with a quotation from Louis Pasteur as a text, "Chance favours the prepared mind." His main purpose of the evening was to prepare the minds of the audience for the great deal of change likely in the state of polymer development over the next few years. Although the rate of change in the polymer field was high and this was reflected in the progress with plastics, rubber, adhesives and textiles, the paint industry did not keep step; the growth of the paint industry just about kept pace with the gross national product. Mr Tawn's solution to the problem was to find new uses for surface coatings, giving paint-on central heating developed at the P.R.S. as an example.

Three facets of materials science were frequently studied in isolation, structure was studied by the chemist, properties were measured by the physicist and applications were dealt with by a technologist or engineer. It was important that cross-discipline work and liaison was encouraged and one could foresee the emergence of the materials scientist, able to specialise but equipped to deal with any facet as appropriate.

Mr Tawn gave several examples of mutual interest between technologies. Crystallinity in plastics led to superb mechanical properties but was avoided in paints because of solubility problems. It was therefore necessary to modify the technology for transference to the surface. With both the areas of vitreous and organic coatings well established, startling developments could be expected in the hinterland between the two pure types. It has been known for very many years that discrete particles of foreign material dispersed in a metal could enhance its strength, similarly this two phase system operated to advantage in ABS and GRP plastics.

Five important breakthroughs in polymer science in recent years were listed.

In 1953 Ziegler and Natta introduced a new tool for polymerisation, namely ionic stereospecific propagation.

A very great increase in the understanding of ionic polymerisation was taking place.

Recently there had been great refinements in block and graft copolymerisation so as to exclude homopolymers.

Polymer scientists were now able to control cross-link distribution as well as density.

A recent innovation was stereoregular free radical polymerisation.

Mr Tawn went on to discuss in more detail developments in anionic polymerisation and polymer growth at pigment surfaces. Anionic initiation using alkali metal aryl compounds caused an initial dimerisation of the monomer to give a bifunctional ionic radical which could grow in both directions. Stereoregular polymerisation resulted when the diluent did not solvate. As the generation of reactive sites was immediate, such polymers were practically monodisperse. As common contaminants such as oxygen, carbon dioxide and water would all terminate this growth, conditions needed to be practically aseptic. This led to the fascinating concept of "living polymers" where polymerisation continued until all the monomer was used up, leaving polymer chains with "live" ends; it only required the addition of a second monomer to produce a perfect block copolymer.

Anionic polymerisation involving phthalic anhydride and ethylene oxide had recently produced the first stereoregular polyester. By use of peroxides of transition metals, particularly nickel, stereoregular free radical polymerisation had also been achieved. A number of other recent processes were reported in Mr Tawn's paper (*JOCCA* 1969 **53** 600) originally presented to the London Section in September 1968.

Finally, Mr Tawn warned that if projected figures for the growth in polymer usage, such as three million pounds weight in the year 2000, sounded unrealistic, it should be borne in mind that such forecasts were invariably low. Also, if the surface coatings industry did not develop new technology to take advantage of polymer development, then someone else would. He ended with the exhortation, quoted from Cardinal Neumann, "A man would do nothing if he waited so long that no one could find fault with what he had done."

The audience, although slightly stunned by the complexity of the subject matter and the eloquence of the address, recovered sufficiently to enter into a lively discussion. A vote of thanks was proposed by Mr D. E. Hopper and endorsed by the assembled gathering.

R.J.K.

Scottish

Some aspects of coil coating

The first meeting of the new session was held on Thursday 15 October, at the St. Enoch Hotel, Glasgow, when Mr J. Hortensius of Synres International N.V. and Mr L. Tasker of Laporte-Synres Ltd., presented a paper entitled "Some aspects of coil coating."

Mr Hortensius began by describing the problems and incentives, both economic and practical, which had led to the adoption of the coil coating system for the protection and decoration of sheet steel, aluminium and other metals prior to their fabrication into furniture, building components, household equipment and other industrial products.

The processes and equipment involved in coil coating were described and illustrated with many slides, and many of the problems inherent were discussed.

Many examples of the uses to which pre-coated metal was put were illustrated, the biggest consumer being the building industry, though slides showing furniture and domestic articles were included. From these examples, the combination of hardness, adhesion, elasticity and "slip" which determined the formability of a satisfactory paint system were apparent.

Mr Hortensius said that the measurement of hardness, smoothness and mar resistance were straightforward but difficulties were encountered when elasticity and adhesion were measured. Several tests were available, such as those of the ECCA (European Coil Coating Association) and the ASTM test No. D.1737-62, which used cylindrical steel mandrels, but as the minimum mandrel used was $\frac{1}{8}$in they could not be truly indicative of performance where a zero bend was being produced. Mr Hortensius described his work in conjunction with Mr F. Sjoukes of N.V. Plaatwerkerij En Verzinkenij V/H P. Bammens & ZN using bends of O-T, 1-T and 2-T. Small pieces of the formed material were embedded in polyamide/epoxy compounds or in polyacrylate compounds, and part of the cast piece was cut off in a lathe until the metal was at the surface and could be sanded and polished ready for microscopic examination and photographing using polarised light. The resulting photographs, showing film performance on inside bends, outside bends and stretching, were most illuminating, especially where the coating was over a galvanised surface where cracking of the zinc layer could give rise to problems.

A short survey of the types of paints used followed. The oldest and probably still the most used was the alkyd/melamine enamel for metal for inside use. The so-called polyester or oil-free alkyd/melamine combinations, which yellowed less and had better forming properties, were often preferred. Thermosetting acrylics of the acrylamide type were being used more and more, as they gave better results at higher band speeds. The siliconised acrylic and polyester resins were used for sidings for which very good weather resistance was required, though the best weather resistance was obtained with paints based on polyvinylidene fluoride.

Besides paints, polyvinylchloride and polyvinylfluoride were used, applied mainly as films laminated on the metal band.

During the discussion that followed, several important points were brought out.

Research on the problem of cracking of the film on severe bending was in progress and it might be that specialised acrylics, polyesters, or even isocyanates would be the eventual answer.

Epoxy type coatings were only being used as primers at present.

The maximum bend that could be allowed for to give reasonable freedom from cracking was 2-T.

Polyethylene waxes and sometimes lanolin were occasionally incorporated in the paint to facilitate mechanical forming but care must be taken to ensure that the mar resistance of the film was not impaired.

The "guaranteed" life of coated panelling used outside in America was quoted as: polyvinylidene fluoride—20 years; siliconised types—5-10 years; acrylics—about 5 years.

The growth rate of usage of coated panelling in America was about 30 per cent per annum and in Europe about 10 per cent per annum. The latter figure was the growth rate which obtained in the U.S. about 5 years ago, but usage there had expanded considerably over the past 4 years. The UK was lagging behind Europe in this field, with pvc being the main coating used. Whilst in America the main outlet was for building cladding, in Europe the tendency was to expand in refrigerator, washing machine, and heater casings, venetian blind slats and other household articles.

The vote of thanks was proposed by Mr A. Maclean.

H.A.M.

South African

Third National Convention

During the week-end of 11—13 September 1970, the South African Section held a very successful and enjoyable Convention at Cathedral Peak Hotel in the Drakensberg Mountains in Natal.

The Convention was attended by 58 members of the South African Section, mainly from the Transvaal and Natal, indicating the popularity and topicality of the theme chosen. The popularity of the choice of venue was indicated by the fact that nearly all delegates were accompanied by their wives and that a fair proportion also brought their children.

The theme, "Electrophoresis," was well covered by the five speakers, who discussed all the aspects of the subject.

After an opening lecture by Professor J. W. Bayles, of the University of Natal, on the theoretical aspects of electrodeposition, entitled "The physical chemistry of electrophoresis," Mr H. R. Crawford, of Cray Valley Products, lectured on "The design of resins for electrodeposition." Mr Crawford outlined the historical development of resins designed for electrophoretic deposition and then went on to describe the advantages to be gained by paint deposition by this method. He then highlighted, at some length, the underlying principles which give the particular advantages of the process and examined these basic features under varying environmental conditions to optimise the resin performance.

The morning session was concluded with a talk by Mr T. Entwistle, of S. A. Titan Products, who reviewed the literature concerning the pigmentation of paints suitable for electrodeposition in his paper entitled "Pigments and pigmentation of paints suitable for electrodeposition." He then made particular reference to the effect of different types of pigment and extender; different grades of the same pigment; and different quantities of pigment on paint deposition and film properties, noting points of agreement and disagreement between various workers.

Dr R. L. Nicolay, of Herbert Evans, opened the afternoon session with a lecture on "Equipment aspects and quality control of electropainting baths." His talk covered in some detail the plant and installation requirements for electropainting. Also covered was a description of operational sequence with attendant problems of pretreatment, jigging and methods of conveying. After dealing with quality control and testing of the paint in the tank, Dr Nicolay concluded with a discussion of the different electrical systems used.

The concluding paper of the Convention was entitled "Broad aspects of formulation and process control in electrophoretic deposition," and was presented by Mr R. E. Rouse, of Dulux Ltd. His paper dealt with the effects of the constituents of the paint on electrodeposition, and the effects of pigment volume concentration and pH. He then went on to deal with process controls in some detail and illustrated his arguments with examples of various paint formulae used for electrodeposition and their deposition characteristics.

The proceedings closed with a lively and interesting "Open forum" during which the delegates were given the opportunity of questioning the speakers on various points on which they required more detailed information.

L.P.B. DE G.

Thames Valley

Management principles and can the small firm survive?

The Thames Valley's 1970-71 winter session got off to a successful start when Mr Wansbrough-White of Booz-Allen & Hamilton International gave a lecture on the "Survival of the small company" on 24 September. The meeting was held at a new venue—The Beech Tree, Beaconsfield, where it is intended to hold the rest of the winter programme.

Mr Wansbrough-White began by saying that good management was a pre-condition of the successful business and that one could be sure that many companies would not survive in the seventies and eighties. Statistics showed that 97 per cent of all registered companies in the UK employed less than 500 workpeople and yet up to 50 per cent of all the work force was employed in these same companies. If the 8,000 smallest firms were to close, at least 2½ million people would lose their jobs.

The smaller company, particularly the family concern, had tended to suffer most in recent years from capital gains tax, SET, death duties, and so on, but the position was improving as management improved and the attitude of paternalism became less common. The speaker showed how time itself was no longer an aid to company health; the life cycle of products was getting shorter, the peak profit period was lessening, more rapid innovation was necessary and speedier decision processes were required. Companies were therefore in much more of a time compression sequence than hitherto and had to adapt themselves to it.

In surveying the attributes and weaknesses of small and large companies, Mr Wansbrough-White found it convenient to classify them into four main groups according to the size of the total work force: those with up to 25 employees, those with 25-300 employees, those with approximately 500 employees and, finally, the large concerns with upwards of 1,000 personnel.

In the group of smallest companies, there was a high degree of entrepreneurial skill and one man usually made all the vital decisions. Often there were problems of delegation and finance but there existed freedom from competitive anxiety.

In the second group as defined above, a company was at its most vigorous and it was particularly outstanding among all four groups because it easily achieved the highest rate of return on capital employed. However, difficulties of increasing size led, for example, to appearance of management strata, to more problems of delegation and usually, to a thirst for additional capital; company aims became muddled and required much deep discussion to be properly identified. As the company grew in size to the third group there were even more transitional problems; overheads could rocket, budgeting was a more difficult exercise, increased production seemed to increase overheads rather than diminish them. Often enough, the takeover loomed up, giving rise to more company instability and worker uncertainty with the possibility of strikes.

Further company growth to the fourth stage and beyond meant a sharp diminution on the rate of return on capital; time seemed to become even more an enemy; higher management now received too much advice, often conflicting; staff infighting occurred and status problems usually multiplied. Sound upward communication was rarely achieved, and management failed to comprehend the attitude of the rank and file. Another common failing was that too many competing products were liable to be introduced and the desirable goal of near 100 per cent efficiency in stock levels often enough was more than offset by the escalating costs of doing so.

In the operation of the more successful companies, the basic principles needed were fairly well understood, e.g. good production planning, sound engineering, reliable and relevant upline information, independent outside assessors to improve company efficiency and profitability, reduction in the volume of unnecessary paper, fewer ineffectual meetings, greater personal responsibility, and reduction in the number of layers of "management". In addition, further desirable features should include good financial control, an adequate cash flow, more flexibility in budgeting procedures, and close vetting of R & D expenditure with the possibility of a reduction by increasing use of consultancy. Again, information systems needed to be closely examined in case the right information was not flowing freely. Especially important was the more intelligent use of computers with programming designed to give more *relevant* information; training programmes ought to be encouraged among all ranks; upper management should try to be less remote and, finally, personnel policies should try to reflect more the feelings of the majority of the rank and file.

After some good questions which reflected the intense interest in the speaker's subject, Mr A. L. Bacon gave the vote of thanks.

R.E.G.

Obituary

R. P. L. Britton

Members of the Association will be saddened to learn of the death on 12 November 1970 of Mr R. P. L. Britton, a Founder Member of the Association.

Mr Britton's interest in the Association had remained constant throughout his life and in October he willingly agreed to propose the vote of thanks to the Lecturer on the occasion of the Foundation Lecture at the Painter Stainers Hall. In recent years Mr Britton had regularly attended the Annual Reunion Dinner of Founder Members, Past President and Past Honorary Officers and will be greatly missed for his pleasant and self-effacing personality. When the Association held its Annual General Meeting in Bristol in 1968 he and his wife met the coach which travelled in the afternoon across the Severn Bridge for tea at Speech House in the Forest of Dean and interested everyone with details of his hobby of wine-making and liqueur-making by freezing.

Mr Britton was one of the original members of the committee formed by the Government in 1916 to examine the use of linseed oil fatty acids to make a drying paint medium. This Committee brought together those who, two years later, were to found the Association. It is difficult to appreciate the courage which this took because in those days chemists in industry were not allowed to know one another, let alone talk about technical matters, but when the Committee disbanded the members thought it would be a pity to go back to the old situation and very courageously took steps which led to the formation of OCCA.

Mr Britton was one of the sixteen Founder Members, was a member of Council for the first few years and frequently took part in the discussions; he also read two papers at early meetings of the Association.

Technical Exhibition

21-25 June 1971

Largest Exhibition to date

The demand for space at the Twenty-Third Technical Exhibition, to be held for the second time at the Empire Hall, Olympia, London, W14, has exceeded that of any previous Exhibition.

Applications have been received from 11 overseas countries—Belgium, Canada, Denmark, Finland, France, Germany, Holland, Italy, Norway, Switzerland and the United States of America. Of the applications made, 12 of the companies have never shown at previous Exhibitions whilst 28 did not show at the 1970 Exhibition. A list of exhibitors, as at the closing date (1 December 1970), is given below.

The "Official Guide" to the Exhibition, 17,500 copies of which will be printed, is now being prepared and all orders for advertising space must be received by **29 January**. Copies of the "Official Guide" will be posted to members in the New Zealand and South African Sections in March and thereafter to the members in all other Sections.

Any non-members wishing to receive a copy of the "Official Guide," which is free of charge, should apply to the Association's Offices, Wax Chandlers' Hall, Gresham Street, EC2V 7AB, or telephone (01) 606-1439 (Ext. 3).

The admission of visitors to the Exhibition is also without charge, in pursuance of the Association's policy of encouraging the widest possible dissemination of knowledge concerning technical developments. As the Exhibitions afford an excellent opportunity for the technical men in the supplying and consuming industries to discuss their common technical problems, this important occasion in the calendar of the surface coatings industries has been known for many years as "The Forum for Technical Display and Discussion."

Further details will be appearing in this Journal in the coming months.

Alphabetical List of Exhibitors—OCCA 23

Albright & Wilson Ltd
Amoco Chemicals Europe
Anchor Chemical Co. Ltd
August's Limited
Baker Castor Oil Company, The
BASF United Kingdom Ltd
Berk Limited
BIP Chemicals Ltd
† Blagden, Victor, & Co. Ltd
† Boulton, William, Limited
† BP Chemicals (UK) Limited
British Titan Products Co. Ltd, with Titanium Intermediates Ltd
† Buckman Laboratories Inc
Buhler Brothers (England) Ltd
Bush Beach & Segner Bayley
Cabot Carbon Limited
**** Cal/Ink Chemical Co. of Canada Ltd

Alphabetical List of Exhibitors—OCCA 23—*Continued*

† Campbell, Rex, & Co. Ltd
**** CdF Chimie
Ciba-Geigy (UK) Ltd
Chemical Industry of the Federal Republic of Germany
Chemische Werke Hüls AG
† Columbian International (Great Britain) Ltd
Cornelius Chemical Co. Ltd
Cox's Machinery Ltd
**** CPC (United Kingdom) Ltd
Crosfield, Joseph, & Sons Limited
† Croxton & Garry Ltd
Daniel Products Company
Degussa
D.H. Industries Ltd
Diaf A/S
**** Dorr-Oliver Co. Ltd
† Draiswerke
Eastman Chemical International AG
Elcometer Instruments Ltd
† Esso Chemical SA
Farbenfabriken Bayer AG
Ferranti Ltd
**** Francaise des Matieres Colorantes
**** General Electric Plastics NV
† Hardman & Holden Limited
† Hercules Powder Company Limited
Hoechst UK Limited
Hygrotherm Engineering Ltd
Imperial Chemical Industries Limited
Imperial Smelting Corporation (Alloys) Limited
† Industrial Colours Limited
Instrumental Colour Systems Ltd
Jenag Equipment Ltd
Kingsley & Keith (Chemicals) Ltd
† Køge Chemical Works Ltd
Kronos Titanium Pigments Ltd
Laporte Industries Limited
Lennig Chemicals Limited
Marchant Brothers Ltd
Mastermix Engineering Co. Ltd, The
Meijer's, Rudolph, Inc
Microscal Ltd
† Millroom Accessories & Chemicals Ltd
† Mitchell, W. A. & Smith Ltd
Molteni Off. Mecc. of Milan
† Montecatini Edison SpA
† Norsk Spraengstofindustri A/S
A/S Norwegian Talc
† Noury & Van der Lande, NV
**** Oulu Oy
Paint Manufacture (Morgan Grampian (Publishers) Ltd)
Paint, Oil & Colour Journal (Industrial Newspapers Ltd)
Paint Research Association
Paint Technology (Sawell Publications Ltd)
† Plastanol Limited
Polyvinyl Chemie Holland
† Pyrene Company Limited
Research Equipment (London) Ltd
† Rosinous Chemical Products
Rhone-Poulenc/Redis
**** Rohm & Haas GmbH
Sachtleben AG
Sandoz Limited
Scado-Archer-Daniels NV
† SCC Colours Limited
**** Schering AG
Sheen Instruments (Sales) Ltd
Shell International Chemical Co. Ltd
Silver, Peter, & Sons (Engineers) Ltd
Silverson Machines Limited
† Spelthorne Metals Ltd
† Swada (London) Ltd
**** Swan, Thomas, & Co. Ltd
**** Synres International NV
† Synthese NV
Synthetic Resins Limited
**** Technessen NV
† Tin Research Institute
Torrance & Sons Limited
Torsion Balance Co
Unilever-Emery NV
Union Carbide Europe SA
Veba Chemie AG
Vuorikemia Oy
VVB Lacke und Farben
Wacker Chemie
Winkworth Machinery Limited
Winn and Coales
† Wolf, Victor, Limited
† Younghusband Stephens & Co. Ltd

**** Denotes Companies who have not previously exhibited at OCCA Exhibitions.
† Denotes Companies who did not exhibit at 1970 Exhibition.

Biennial Conference 1971

Surface Properties and Appearance

At the end of November copies of the Conference Brochure were despatched to all members of the Association and to non-members who had written requesting this information. The closing date for applications on this occasion will be **1 March 1971** and the attention of readers is directed to this date which is a month earlier than normal since the Conference itself will be held from 4-8 May at the Palace Hotel, Torquay.

Following the practice of previous Conferences, it is intended to despatch pre-prints of the papers, together with full details of accommodation allocated, badges, tickets etc. in the special Conference folder, at the beginning of April 1971.

Four technical sessions have been arranged under the title given above, together with a special session devoted to a management topic—"The management of innovation"—and three Workshop Sessions entitled:

How will pollution control affect the paint industry?

Is the gloss emulsion paint a myth?

Powder coatings—a threat to stoving enamels?

As well as the technical sessions there will be the usual social programme for ladies attending the Conference, together with a Civic Reception for all delegates on 5 May and the Association's Dinner and Dance at the conclusion of the Conference on the Friday evening, 7 May.

Council has fixed the registration fees at £15 for Members, £7 10s 0d for Wives and £25 for Non-members, with a concessionary rate for Student and Retired Members of £7 10s 0d. The Chemical & Allied Products Industry Training Board will consider the payment of grant, to firms within scope, for attendance at the Conference. Payment is subject to the content of the Conference being relevant to the needs of the sponsoring company and also to the development of the individual attending.

Readers wishing to receive the Conference Brochure and Registration form and/or synopses of the papers (as published in the October and November 1970 issues of *JOCCA*) are requested to apply to the Director & Secretary at the Association's office.

London Section

Half-Day Symposium

Surface coatings for structural steel—their use and abuse

A half-day Symposium will be held on Wednesday, 20 January 1971 commencing at 2.15 p.m. at the Polytechnic of the South Bank (formerly the Borough Polytechnic), Borough Road, London, SE1. Those contributing will be:

Mr R. Hullcoop, ICI Ltd., Paints Division—"Paint and painting specifications"

Mr J. Runham, J. D. and S. Tighe, Painting Contractors—"The industrial painting contractor"

Mr K. Harden, W. P. M. Paints Division—"Problems on site"

Mr J. Rogers, Shell International Petroleum Ltd.—"The customers' requirements"

Mr R. C. Dent, C. E. G. B., Civil Engineering Branch—"The architects' point of view."

Each speaker will be allocated up to 15 minutes to speak on his subject after which a short break will be taken for refreshments. The meeting will then be thrown open for general discussion.

Prices have been set as follows, which

includes afternoon refreshments: OCCA. Members 7s 6d. Non-Members £1, Student Members free of charge. Members from other Sections and non-members are welcome. Application should be made as quickly as possible to R. H. E. Munn, Cray Valley Products Ltd., St. Mary Cray, Orpington, Kent.

Ladies' Night

The London Section Ladies' Night was held on 20 November 1970 at the Criterion in Piccadilly, W1. The Guest of Honour, Mr A. R. H. Tawn, Hon. Research and Development Officer of the Association, proposed the toast of London Section. Mr Tawn referred to the achievements of the Section; it had provided several Presidents of OCCA; it initiated the annual Technical Exhibition, which had now developed into the premier exhibition in the world on paint technology; it had introduced the European Exchange lectures. All present were very conscious of the fact that the Chairman, Jack Pooley, was missing, through illness. He proposed the toast of London Section with the greatest pride and delight.

Mr D. Eddowes, the Vice-Chairman of the Section, in his reply, expressed his regrets that through illness Jack Pooley was not present and stated that the best wishes of all present would be sent to him. Mr Tawn had spoken of the London Section starting the annual exhibition at the Borough Polytechnic; the Section now held its technical meetings there in the splendid new building. He welcomed Mr and Mrs A. R. H. Tawn and the other official guests, Mr and Mrs B. A. Richardson, from the Southern Branch; Dr and Mrs F. M. Smith, from Manchester Section; Mr and Mrs H. J. Griffiths, from Midlands Section; Dr and Mrs L. J. Watkinson, from West Riding Section; and Mr R. H. Hamblin, Director & Secretary.

He also thanked those members of the Committee who had taken part in the organisation of the event, and proposed the toast of the Ladies and Guests.

Mrs J. E. A. Hedgecock, in her reply, expressed the thanks of all the guests for being invited to a very pleasant evening in the homely atmosphere of the Criterion; it was a real pleasure to have a meal served which one had not had to plan and prepare beforehand. Following the dinner, there was the excitement of the tombola, after which dancing continued until 1 a.m.

V.T.C.

Manchester Section

Annual Dinner Dance

The Annual Dinner Dance was again held in the Peacock Suite of the Piccadilly Hotel, Manchester, on 23 October, some 420 members, guests and their ladies attending.

The principal guests were Mr and Mrs J. Smethurst (Mr Smethurst being a former Section Chairman). The other Section guests were Mr A. S. Fraser (President) and Mrs Fraser, Mr D. H. Tate (Chairman, Newcastle Section) and Mrs Tate, Mr R. G. Gardiner (Chairman, Scottish Section) and Mrs Gardiner, Mr N. F. Lythgoe (Chairman, Hull Section) and Mrs Lythgoe, Mr R. H. Hamblin (Director & Secretary), together with Dr V. G. Jolly (a past Section Chairman) and Mrs Jolly, and Mr G. A. Campbell (an Honorary Member, past President, and Chairman of the Manchester Section) and Mrs Campbell.

At a separate ceremony before the dinner, Dr Smith completed the presentation of badges to past Section Chairmen by making the award to Mr Smethurst and Dr Jolly. Previous presentations were made at the Annual General Meeting and the Summer Committee Meeting earlier in the year.

The toast to the Manchester Section was proposed by Mr J. Smethurst, who, after remarking that he had been host on many similar occasions, now found

Seen at the Manchester Section Dinner Dance. Back row (left to right): Dr. F. M. Smith (Chairman, Manchester), Mr. S. Duckworth (Vice-Chairman, Manchester), Mrs Duckworth, Mr J. Smethurst, The President (Mr A. S. Fraser). Front row (left to right): Mrs Smith, Mrs Smethurst, Mrs Fraser

himself playing an unusual role. Having been instructed by his colleague, the Chairman, to be serious, he recommended the table punters not to bother to make books since his speech would not be a long one. His main theme, however, was a thoughtful one, in face of the dehumanising effect of bigger and bigger businesses (amalgamations were proceeding between suppliers, as well as between paint and ink manufacturers), he considered that OCCA Sections could help to preserve human rapport on occasions such as this, and in and after their meetings.

Dr Smith, in replying and proposing the toast to the guests, was making a reference to his principal guest's speech, when he was interrupted by either a popping champagne cork or a pistol shot. Fortunately, either missile went wide and he was able to continue. He welcomed individually each visiting Section Chairman and referred to the presentation of past Chairmen's badges. In conclusion, he thanked the Section Committee for their support and particularly Mr W. K. MacCallum (Hon. Social Secretary) for his strenuous efforts in organising the function.

After a short interval, dancing commenced to Don Mack and his Music, with the support of a gyratory girl vocalist, in fact from this time to the close, all was go-go-go.

D.A.P.

Scottish Section

Student Group

Programme 1971

All meetings will be held in the St Enoch Hotel, St Enoch Square, Glasgow, at 10.00 a.m.

Saturday 9 January

"How the alkyd resin replaced the drying oil" by G. H. Hutchinson of A. B. Fleming & Co. Ltd.

Saturday 13 February

"Organic pigments available to the paint chemist today" by M. A. Kerr of Geigy (UK) Ltd.

Saturday 13 March

A.G.M. followed by lecture on the Student Project by I. R. McCallum & R. F. Hill.

Association Notices

Applications for membership

It is felt that the members would like to be reminded of the standard of competence for the election of candidates to Ordinary Membership of the Association, as laid down by the Council, when they are sponsoring candidates for election. The qualifications for the granting of Ordinary Membership at the present time are:

1. A degree in a scientific subject or any generally accepted equivalent qualification; or an approved technological qualification in a subject covered by the Association.

2. Or where there is adequate evidence of the technical competence of the candidate other than the obtaining of the qualifications mentioned above, the qualifying period of practice in the industries covered by the Association shall be normally not less than seven years.

Associate Membership is open to those employed in the industries who do not qualify for Ordinary Membership.

The Council has further resolved that Student Membership should be open without restriction to the age of 21 years and may be extended to 25 years of age, where candidates are following courses of technical study to the satisfaction of their employers or technical college lecturers.

Retired members

Council also wishes it to be known widely that in 1962 it introduced a reduced membership subscription rate for members who have retired from business. This applies to a member who has completed 20 years as an Ordinary or Associate Member and has retired from business, and normally has reached the age of 60; he may apply for his name to be retained on the Register of Members at an annual subscription rate of £1.05 and he will retain the same rights of membership as the class of membership to which he was attached upon retirement.

Members wishing to avail themselves of this concession should write, in confidence, to the Director & Secretary at the address shown on the front cover of this *Journal*, giving the relevant information under the four headings: (*a*) name, address and Section, (*b*) date of election, (*c*) date of retirement, (*d*) age.

Change of address

Members changing their address are urged to inform the Association's office immediately so as to avoid any misdirection of mail. This is particularly important as far as the *Journal* is concerned.

Will members please note that since membership of the Association is entirely on an individual basis, if notification of the change of an address for a company is sent to the Association's office this will not necessarily guarantee the change of address in the Association's records of the member concerned unless the name of the member is stated on the communication.

Binding of the "Journal"

Members will be pleased to know that W. Heffer & Sons Ltd., Hills Road, Cambridge, will undertake the binding of back volumes of the Association's *Journal* sent in by individual members at a cost of £2 per volume.

Members wishing to avail themselves of this facility should send the parts direct to W. Heffer & Sons Ltd., enclosing a remittance of £2 and ensuring that notes bearing their names and addresses are enclosed with the parcels.

1971 members' subscriptions

Members are reminded that 1971 Membership subscriptions to the Association are payable on 1 January 1971. Forms were despatched to all members in October or November, depending upon address.

New members may like to know that the Commissioners of Inland Revenue have approved of the Association for the purpose of the Finance Act, 1958, Section 16, so that a member subject to United Kingdom income tax is entitled to a deduction from the amount of his emoluments assessable to income tax for the whole of his annual subscription to the Association, provided the subscription is defrayed out of the emoluments of his office or employment and that the interests covered by the objects of the Association are relevant to such office or employment.

Claims for adjustment of PAYE code numbers should be made on form P.358, copies of which may be obtained from local tax offices.

News of Members

Mr F. Lewis, an Ordinary Member attached to the Manchester Section, has been appointed managing director of WPM Colour and Adhesives Co. Ltd.

Mr R. Adam, an Ordinary Member attached to the Irish Section, and past-Chairman of that Section, is to leave Dublin to take up a position in Australia. Mr Adam was presented with a silver salver by the Irish Section in recognition of his hard work both for the Section and the Association.

Mr A. A. Harrison, an Ordinary Member attached to the London Section, has been appointed to the board of Coates Brothers & Company Limited, becoming group production director.

Dr W. Carr, an Ordinary Member attached to the Manchester Section, has been awarded the Roon Foundation Award for 1970. He received the award, which is given to the speaker adjudged to have given the best contribution to the Annual Meeting of the Federation of Societies for Paint Technology, in recognition of his paper "The flocculation of phthalocyanine blue—fact or fiction?" presented at the 1970 meeting in Boston. Dr Carr is also to present a paper at the Association's Conference at Torquay in May.

Amongst the six new directors appointed to the board of the Silver Paint & Lacquer Company Limited are the following Ordinary Members attached to West Riding Section:

Major Gordon Bentley

Mr Cecil Butler (Chairman West Riding Section 1959-61)

Mr David Morris (Hon. Secretary West Riding Section)

Mr Eric Smith

Register of Members

The following elections to membership have been approved by Council. The Section to which the new members are attached are given in italics.

Ordinary Members

DAVIES, BERTRAM MICHAEL, Woodhouse Court, 31 Woodhouse Road, London N12. (*London*)

FLEMING, JOHN MURRAY, BSc, 151 Hazelwell Crescent, Birmingham B30 2QE. (*Midlands*)

KHIDHER, ABDUL MONIM, BSc, Al Zahid Building, 15/3 25B Al Kuraada, Al Sharkiya, Aswad Street, Baghdad, Iraq. (*Overseas*)

STRUGAR, DANIEL, PhD, E. I. Du Pont De Nemours & Company, Marshall Research & Development Lab., 3,500 Grays Ferry Avenue, Philadelphia, Penna., USA. *(Overseas)*

WILSON, DAVID SMITH, 40 Dee Drive, Paisley, Renfrewshire. *(Scottish)*

YOUSUF, KHALID, BSc, c/o Modern Paint Ind. Corporation, PO Box 4994, Karachi, 2, West Pakistan. *(Overseas)*

Associate Members

HURLEY, RICHARD B., BA, Cabot Carbon Ltd., Carolyn House, Dingwall Road, Croydon CR9 2XS. *(London)*

Student Members

BROOKS, MICHAEL FRANK, 47 Cumberland Road, Plaistow, London E13. *(London)*

CHO, JOCK MIN, 94 York House, Idlethorp Way, Thorpe Edge, Idle, Bradford 2. *(West Riding)*

HILLMAN, ROBERT, 127 Charlton Road, Keynsham, Nr. Bristol. *(London)*

Forthcoming Events

Details are given of meetings in the United Kingdom up to the end of the month following publication, and in South Africa and the Commonwealth up to the end of the second month.

Monday 4 January

Hull Section. "The preservation and waterproofing of joinery timber prior to painting" by Mr R. R. Hill of the Timber Research and Development Association, to be held at the Bullock Lecture Theatre, Hull College of Technology, at 7.00 p.m.

Thursday 7 January

Newcastle Section. "Discounted cash flow and investment appraisal—a management technique" by Mr K. W. Blackburn of the Sunderland Polytechnic, to be held at the Royal Turks Head Hotel, Grey Street, Newcastle upon Tyne at 6.30 p.m.

Friday 8 January

Manchester Section. "Printing inks for web offset" by Mr D. F. Bisset of Coates Bros. (Inks) Limited, to be held at the Manchester Literary and Philosophical Society, 36 George Street, Manchester 1 at 6.30 p.m.

Saturday 9 January

Scottish Section—Student Group. G. H. Hutchinson, ARIC, A. B. Fleming & Co. Ltd. "How the alkyd resin replaced the drying oil" to be held at the St. Enoch Hotel, Glasgow at 10.00 a.m.

Tuesday 12 January

West Riding Section. "Two-pack epoxy coatings" by Mr A. McKay of CIBA (ARL) Limited, to be held at the Griffin Hotel, Boar Lane, Leeds at 7.30 p.m.

Wednesday 13 January

Manchester Section—Student Group. "The use of carbon black in paints, plastics and printing inks" by Mr B. E. Thomas of Columbian Industrial Ltd., to be held at the Manchester Literary and Philosophical Society, 36 George Street, Manchester at 4.30 p.m.

Newcastle—Student Group. "Modern management techniques" by Mr N. D. Harris of the Department of Management Studies, Newcastle Polytechnic, to be held at the Newcastle Polytechnic, Ellison Place, Newcastle upon Tyne at 3.00 p.m.

Friday 15 January

Irish Section. "Modern dispersion equipment" by Mr H. Wadham of Torrance & Sons, Ltd., to be held at the Clarence Hotel, Wellington Quay, Dublin at 8.00 p.m.

Midlands Section. Annual Dinner Lecture "Microscopic examination of pigment-vehicle interaction during film formation" by Dr Jettmar and Dr Apel of BASF, to be held at the Winston Restaurant, Birmingham 5, at 6.30 p.m.

Scottish Section. Annual Dinner Dance, to be held in the St. Enoch Hotel, Glasgow.

Wednesday 20 January

Scottish Section—Eastern Branch. "Money-go-round." A 30-minute film and talk on commercial practice by a speaker from the Scottish Stock Exchange, to be held at the Carlton Hotel, North Bridge, Edinburgh at 7.30 p.m.

London Section. Conversazione: "Surface coatings; their use and abuse for painting structural steel." Lecturers as follows: Mr R. Hullcoop (ICI Paints Division) Mr J. Runham (J. D. & S. Tighe) Mr K. Harden (WPM Paints Division) Mr J. Rodgers (Shell International Petroleum) Mr R. C. Dent (CEGB). To be held at the Borough Polytechnic, Borough Road, London SE1, at 2.15 p.m.

Thursday 21 January

Irish Section. Annual Dinner Dance to be held at the Clare Manor Hotel.

Midlands Section—Trent Valley Branch—"The future of water-thinnable coatings" by Mr A. J. Becalick of Lennig Chemicals Ltd., to be held at the British Rail School of Transport, London Road, Derby at 7.00 p.m.

Scottish Section. "Handling of solvents" by Mr I. M. Fotheringham of Shell Chemicals (UK) Ltd., and "Hazards of solvent fires" by AD Officer Clarke of the Fire Prevention Section, Glasgow Corporation Fire Department, to be held at the St. Enoch Hotel, Glasgow at 6.00 p.m.

Thames Valley Section. "Special problems of paints and mastics with reference to building techniques" by Mr E. L. French of Taylor Woodrow Construction Ltd., to be held at the Beech Tree Hotel, Beaconsfield, Bucks at 7.00 p.m.

Friday 29 January

Bristol Section. Ladies Evening. "Cosmetics" by Mr A. Foster of Revlon Overseas Corporation, to be held at the Royal Hotel, Bristol at 7.15 p.m.

Monday 1 February

Hull Section. "The use of instrumentation in the evaluation of paint performance" by Mr D. M. Bishop of British Railways, to be held at The Bullock Lecture Theatre, Hull College of Technology at 7.00 p.m.

Thursday 4 February

Newcastle Section. "Flooring compositions" by Mr A. C. Jolly and Mr E. Stanley of Synthetic Resins Limited, to be held at The Royal Turks Head Hotel, Grey Street, Newcastle upon Tyne at 6.30 p.m.

Friday 5 February

Thames Valley Section. Buffet Dance, to be held at "Great Fosters," Egham.

Tuesday 9 February

London Section—Southern Branch. "New developments in the field of shop and wash primers" by Herr Lampe, given by Dr Lehmann of Farbwerke Hoechst AG. To be held at the Pendragon Hotel, Clarence Parade, Southsea at 7.00 p.m.

West Riding Section. "Compositional changes of solvent mixtures during the film formation process" by Mr L. A. Tysall and Dr D. H. Shearer of Shell Research Limited, to be held at The Griffin Hotel, Boar Lane, Leeds at 7.30 p.m.

Wednesday 10 February

Newcastle Section—Student Group. "Modern methods of paint application" by Mr K. Baxter of British Paints Limited, to be held at the Newcastle Polytechnic, Ellison Place, Newcastle upon Tyne, at 3.00 p.m.

Thursday 11 February

Scottish Section. "Colour consiousness" by Dr F. M. Smith and Mr D. Malin of Geigy (UK) Ltd., to be held at the St. Enoch Hotel, Glasgow at 6.45 p.m. Joint meeting with the Plastics Institute and the British Paper and Board Makers Association.

Friday 12 February

Manchester Section. "Present and future trends in motor car finishing" by Mr H. L. Quick of Rootes Motors Limited, to be held at Manchester Literary and Philosophical Society, 36 George Street, Manchester 1 at 6.30 p.m.

Saturday 13 February

Scottish Section—Student Group. "Organic pigments available to the paint chemist today" by Mr M. A. Kerr, Geigy (UK) Ltd., to be held at St. Enoch Hotel, Glasgow at 10.00 a.m.

Wednesday 17 February

London Section. "Techniques of electrographic reproduction" by Mr J. Sloman of Ozalid Limited, to be held at the Borough Polytechnic, Borough Road, London SE1, at 7.00 p.m.

Scottish—Eastern Branch. "Layout of machinery and plant" by Mr D. P. Sullivan of DH Industries Limited, to be held at the Carlton Hotel, North Bridge, Edinburgh at 7.30 p.m.

Thursday 18 February

Thames Valley Section. "Where paint and ink meet" by R. G. Kinsman of Winstones Ltd., to be held at the Beech Tree Hotel, Beaconsfield, Bucks at 7.00 p.m.

Friday 19 February

Irish Section. "Paper production" by Dr P. Sherry of Clondalkin Paper Mills Limited, to be held at the Clarence Hotel, Wellington Quay, Dublin at 8.00 p.m.

Midlands Section. "Developments in automobile finishing" by Mr H. L. Quick of Rootes Motors Limited, to be held at the Chamber of Commerce House, 75 Harbourne Road, Birmingham 15 at 6.30 p.m.

Newcastle Section. "Ladies Night" to be held at the Five Bridges Hotel, Gateshead.

Friday 26 February

Bristol Section. "The glass transition temperature of paint films" by Mr L. J. Prosser of the Paint Research Station, to be held at the Angel Hotel, Cardiff at 7.15 p.m.

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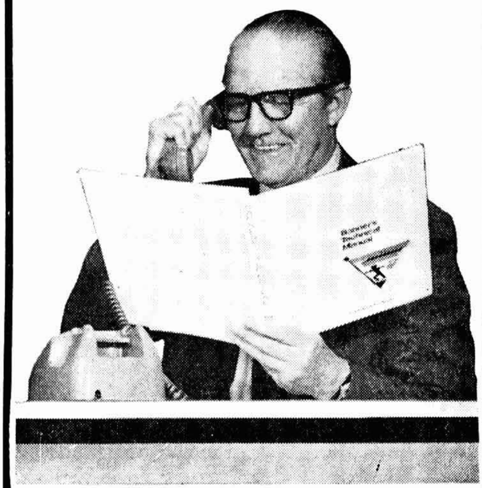

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LONDON SECTION SYMPOSIUM

"Surface coatings; their use and abuse for painting structural steel." Borough Polytechnic, 2.15 p.m., Wednesday 20 January.

For further details see page 121

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