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The Chemical Plant Contractor and the Plant User

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THE CHEMICAL PLANT CONTRACTOR AND THE MANUFACTURER

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THE CHEMICAL PLANT CONTRACTOR AND THE MANUFACTURER

PART I

How contractor and manufacturer can successfully work together and an analysis of activity between "work units" is made

by M. DAVIDMANN, B.Sc.

THE relationships between the chemical plant contractor and his customer, the chemical manufacturer, at first sight appear to be complex. In one case the contractor may offer advice, in another a complete chemical plant embracing a number of unit operations and services. He may carry out work on a manufacturer's process, from the initial idea, through process research, to the handing over of the production unit, or he may be concerned with site erection only. He may operate or maintain the plant he has built, or both, and be paid for his efforts in a number of ways.

The contractor fabricates plant items in his works and the manufacturer produces and sells the products of the completed plant. In between lies the provision of chemical plants, and it is in this field that the activity of contractor and manufacturer overlaps.

A "chemical plant" is a production unit which converts one or more raw materials to one or more marketable products. The marketable product from one chemical plant may be the raw material for the next. Chemical plants are built up from "unit chemical plants". A unit chemical plant is one in which a unit operation is carried out, so that chemical plants consist of one or more unit chemical plants. For convenience we here refer to "plants" and "unit plants".

The difference between one plant and another lies not in the pipes and shells, but in what takes place inside them and how it takes place. It thus lies in the types and sequence of unit plants used, and the operating conditions.

It follows that we can distinguish between plant constructors and plant contractors. Of the functions listed in Fig. 1, the plant constructor is concerned solely with functions such as mechanical design, fabrication, buying and site erection, whilst the plant contractor includes in his work chemical engineering design and commissioning.

No distinction is drawn here between manufacturers and those Government work units which are concerned with the provision and/or use of plants in general. The same arguments apply to both.

What is said here to apply between manufacturer and contractor in general applies equally well between contractor and sub-contractor.

Types of Contract

When the contractor offers unit plants or plants, based on a process which he owns or on one which is generally available and of which he has experience, he quotes a firm price. His responsibilities can be and are defined with respect to operation and performance. For the larger projects, the so-called "turnkey" projects, the unsuccessful contractors may expect[4] some recompense for quoting, or else decline to quote at all. The extent of the customer's capital expenditure and of the work required from the contractor is known in advance. Whether or not a price variation clause is included depends on the customer's requirements and on policy recommended by the contractor's trade association. The customer may be a manufacturer or another contractor.

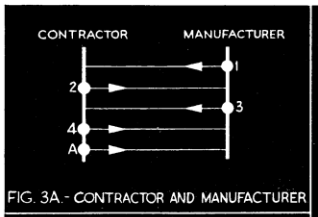


FIG. 3A.- CONTRACTOR AND MANUFACTURER

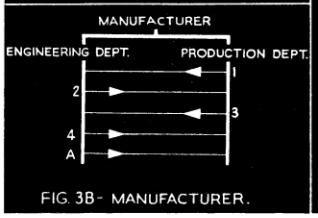


FIG. 3B - MANUFACTURER.

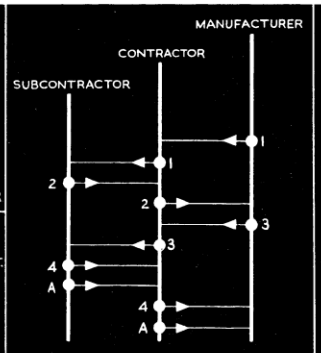


FIG. 4A - SUBCONTRACTING. CONTRACTOR AND SUBCONTRACTOR.

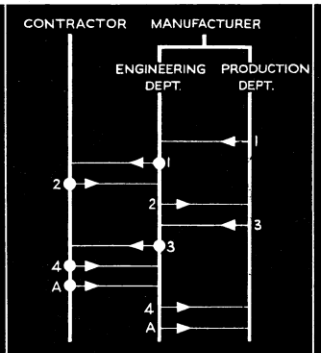


FIG. 4B.- SUBCONTRACTING. MANUFACTURER AND CONTRACTOR

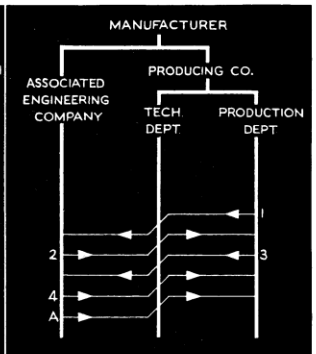


FIG. 5A. - CONTRACTING. LARGE MANUFACTURER.

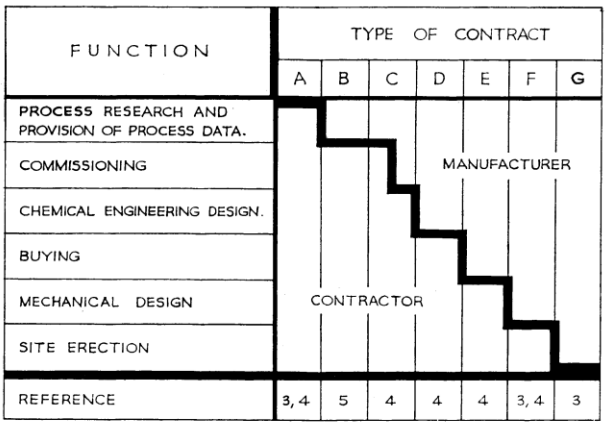


Fig. 1. Division of work.

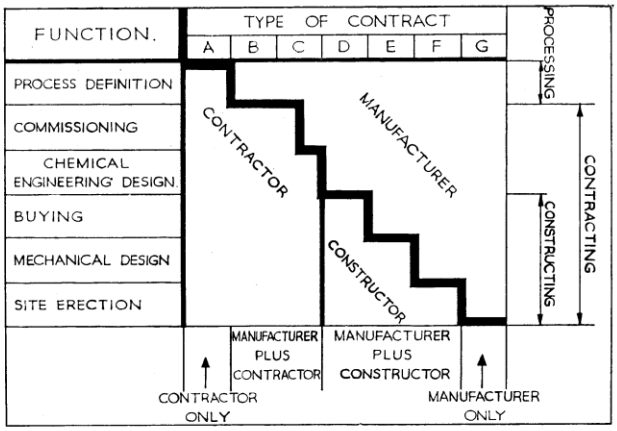


Fig. 2. Field of activity.

The contractor may also enter into a contract with a manufacturer when the extent of work required is not known. Here the manufacturer, in addition to paying for the cost of the work, also pays a fee. It is this type of contract which is used when the contractor assists the manufacturer by designing a plant for a new process which belongs to the manufacturer. It involves closer supervision by the manufacturer of the contractor's work. The fee is paid for the contractor's services and experience and thus includes his profit. Whether the fee is a fixed sum or a percentage of the cost depends on the degree to which the extent of work required from the contractor is known at the time the contract is prepared. A contractor who assists a manufacturer with design work on a new process up to the point where an estimate can be given, having been paid a fee for this work, may expect[4] to be given the contract on a negotiated basis, without competition, should the manufacturer decide to install such a plant, and may expect a further fee in the event of the manufacturer deciding not to proceed with the process.

Demand for Plants

A market exists for a new chemical product, the market for an existing chemical expands or a new market is found, or present methods of production are obsolete. As a result, the potential or present manufacturer requires new production facilities, that is, plants.[2] These may be provided solely by the manufacturer's engineering organisation, by an independent contractor, or by the manufacturer's engineering organisation assisted by contractors. Sub-contractors provide unit plants and plants to contractors, and also to the manufacturer's engineering organisation.

Relationship between Contractor and Manufacturer

A fundamental relationship exists between manufacturer and contractor. The manufacturer's task is to produce and the contractor is the specialist who provides him with the plant for doing this. The manufacturer exercises his choice, as regards type, form and quality of product, size of production unit, process and contractor and is responsible for the consequences. The contractor offers a specialist service and prescribes.

The fundamental relationship between them is functional and this is illustrated by the usual penalty clauses. The contractor may lose part or all of his profit, without necessarily suffering direct loss even when having to make good the defects, should the plant he has supplied not perform in accordance with his guarantee. The manufacturer, responsible for the consequences of his choice, bears the resulting losses such as those caused by loss of production due to initial malfunctioning or through a delayed start-up.

A similar functional relationship exists between the manufacturer's producing and engineering organisations, as well as between contractors and sub-contractors.

Division of Work

A number of authors have given examples of the division of work between manufacturer and contractor. As seen from Fig. 1, both the manufacturer and the contractor may provide complete plants, each carrying through the work from process research to the commissioned and operating production plant. They either do this work entirely on their own or it may be divided in varying ways between them. Contractors have been known[4] to carry out under contract

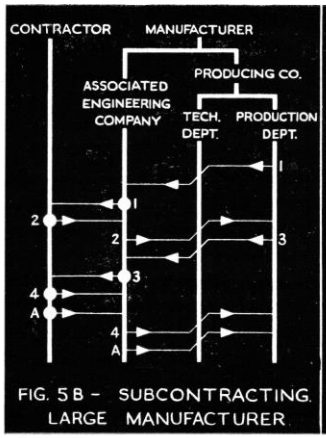


FIG. 5B - SUBCONTRACTING. LARGE MANUFACTURER.

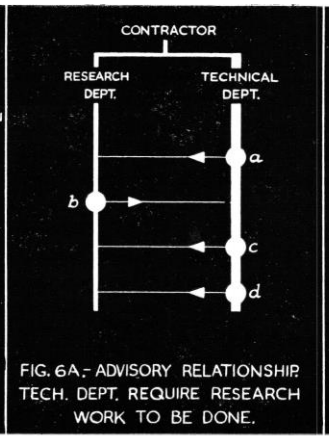


FIG. 6A.- ADVISORY RELATIONSHIP. TECH. DEPT. REQUIRE RESEARCH WORK TO BE DONE.

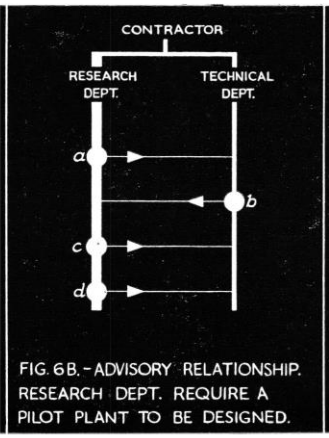


FIG. 6B.- ADVISORY RELATIONSHIP. RESEARCH DEPT. REQUIRE A PILOT PLANT TO BE DESIGNED.

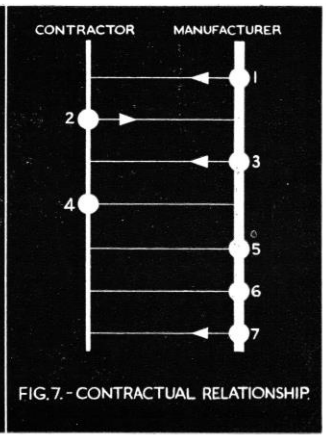


FIG. 7.- CONTRACTUAL RELATIONSHIP.

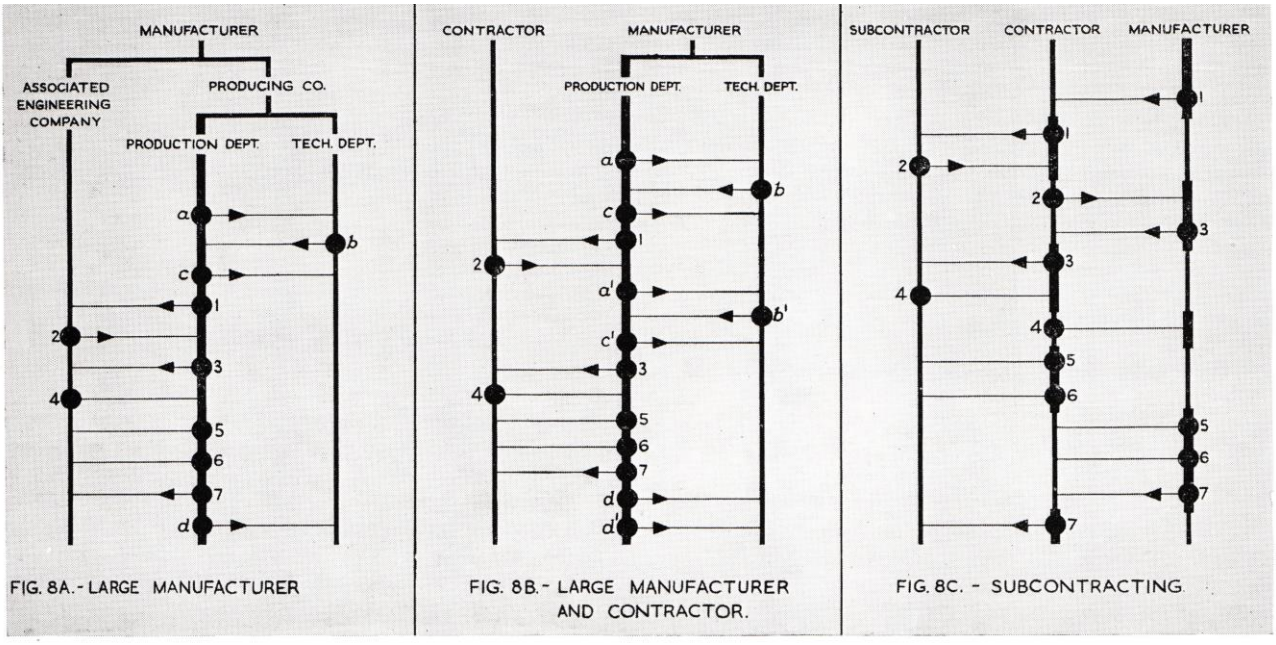


FIG. 8A.- LARGE MANUFACTURER

FIG. 8B.- LARGE MANUFACTURER AND CONTRACTOR.

FIG. 8C. - SUBCONTRACTING

the operation and maintenance of the plants they have designed and installed. The diagonal line in Fig. 1 defines the division of work between them for the cases illustrated.

The contractor provides unit plants and plants, based on his own or on generally available processes or based on processes for which he has taken out a licence. It is the contractor who is in general concerned with research into design methods and design data.

It is seen from Fig. 2 that the manufacturer may provide the plant himself, or sub-contract work to constructors, or use contractors. The contractor may sub-contract work to constructors but, in general, does not do this.

Activity

The actions which take place between contractor and manufacturer can be recorded as shown by Fig. 3. The vertical lines represent the work units concerned, an action is recorded as a horizontal line, the disc indicating the work unit which carries out the action. An arrow indicates the direction in which the action takes place. Each action is identified by a reference number or letter, thus:

1. Defining requirements, e.g., sending inquiry.
2. Prescribing, e.g., sending quotation with performance guarantee.
3. Deciding, e.g., sending order.
4. Commissioning.

A. Proving, e.g., carrying out of guarantee test.

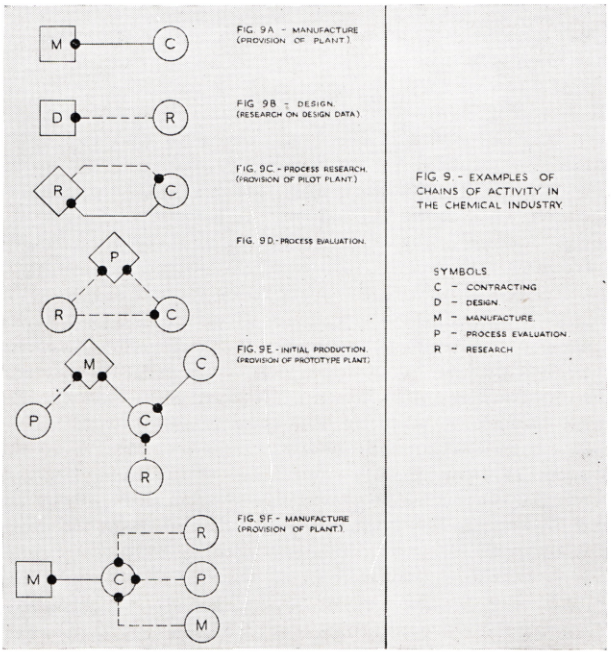
Fig. 3 shows the normal contracting activity, for an established process. Fig. 3 (a) shows the activity between contractor and manufacturer, Fig. 3 (b) that between a manufacturer's engineering and production departments. As regards contractor and manufacturer, the activity is not affected by whose process it is, the difference lying in the amount of information contained in the inquiry to the contractor rather than in the activity. In case 3B, however, the process belongs to the manufacturer. In case 3A process data are disclosed by one organisation to another; in case 3B this does not matter as both work units are part of the same organisation. Action in case 3B would be by agreement between the two work units rather than following a decision made by one or the other, and thus it may be difficult to assign responsibility. Basically, the activity for cases 3A and 3B is the same, the manufacturer's engineering department being a contracting organisation, that is, a contractor. In each case it is assumed that the contractor has to carry out a guarantee test so as to prove the performance of the plant to his customer.

Fig. 4 shows normal sub-contracting activity for established processes. Activity between sub-contractor and contractor is the same as that between contractor and manufacturer. The sub-contractor, however, deals with only part of the complete process or plant, and there is now exchange of process and design information between two contractors who are potential competitors. The same would seem to apply, although perhaps not obviously so, to the activity between the contractor and the manufacturer's engineering department.

Activity between contractor and the engineering department is similar to that between the engineering and production departments. There is then no difference in sub-contracting activity between cases 4A and 4B and the function of the engineering department is again that of plant contracting, but the manufacturer has kept confidential within his own organisation a considerable amount of process and design data.

However, the manufacturer's engineering department has now accepted some responsibility as regards the contractor to whom part of its work is sub-contracted. It has to state requirements and select a suitable sub-contractor, and to that extent it is now vulnerable. Having to make decisions, it may be blamed for consequences which, as likely as not, may have been caused in the first place by divided responsibility within the manufacturer's organisation. It is again the plant supplier who proves to his customer that his guarantee has been maintained.

The larger manufacturing organisation further subdivides its work, as illustrated by Fig. 5, again for established processes. The manufacturer's organisation may now consist of two associated companies, one of which provides the plants, while the other operates them. The producing company, in addition, has now its own technical department to give technical advice to the production department. Again, the contracting activity is the same as that found before and the same comments apply. In addition, responsibility is now likely to be divided threefold as shown, and the technical department may be interposed between the production department and the associated engineering company. Decisions are likely to be made by committee meeting and, as responsibility is divided, difficulties are likely to occur; they will occur repeatedly because they



are more likely to be explained away instead of their cause being established and the lesson learned. Process information is thus kept confidential and restricted to within the manufacturer's organisation at some considerable cost.

The manufacturer's associated engineering organisation, no matter whether this is an engineering department or an engineering company, has no competition to meet. On the other hand, the manufacturer who discloses his process data to independent contractors has to disclose them to at least two of them, should he require competitive tenders, thus increasing the chances of these data being disclosed to others to his disadvantage.

Analysis of Activity

The activity between a number of related work units has been illustrated and analysed previously.[6] Here we are concerned with analysing the activity between a number of work units in a functional relationship to each other. Considering two work units at a time, we can build up a picture of how contractor and manufacturer actually work, and how together they should work.

Functional relationships between executives in different work units have also been previously defined.[1] Of two executives in a functional relationship, one is the "responsible" executive, the other is the "prescribing" executive. Each executive is responsible to his own executive superior, and to no one else. The "responsible" executive is responsible also for obtaining specialist advice, for accepting or rejecting it, and for reporting useful results back to the specialist. The "prescribing" executive carries responsibility for giving specialist advice, that is, for prescribing, and for the quality of his prescription.

The advisory functional relationship between two executives in different work units is thus characterised by the following sequence of actions:

(a) *Defining requirements.* Request for service, from responsible executive to prescribing executive.
(b) *Prescribing.* Advice from prescribing executive to responsible executive.
(c) *Deciding.* Responsible executive accepts or rejects prescription.
(d) *Reporting useful results.* From responsible executive to prescribing executive.

The division of work and the functional relationships between work units carrying out design and research work were analysed and defined in reference 8. The contractor's technical department is responsible for design work. It is assisted in this work by the research department which prescribes. The research department is responsible for research work on new processes and here it is the technical department which prescribes.

These functional relationships between the contractor's research and technical departments are illustrated by Fig. 6, on the basis of the actions which occur. Vertical lines indicate the work units and horizontal lines represent actions. To indicate that the actions occur between two work units in a functional relationship, the "responsible" work unit is indicated by a thick vertical line. The direction in which the action takes place is also shown.

Further actions enter into a functional relationship when an order is placed, the "prescribing" executive guaranteeing his prescription. In the course of comparing actual with predicted results, he then has to ensure that actual results are equal to, or better than, predicted results, as he is responsible to his own executive superior for the guarantee he has given. Further, the "responsible" executive may wish to prove to the "prescribing" executive, by carrying out a guarantee test, that the guarantee has not been maintained.

Each of the two executives in a functional relationship is responsible also for the quality of his work to his own executive superior. Therefore, each is responsible for comparing predicted with actual results and for correlating the conclusions so as to improve the quality of his work. The "responsible" executive, who has predicted requirements, has to find out the extent to which his prediction, and his decision to accept one prescription rather than another, satisfies actual requirements. The "prescribing" executive, whose prescription has been accepted, has to find out how actual results compare with predicted results.

In addition, the "responsible" executive exercises his choice, accepting or rejecting the prescription; for example, choosing between competing contractors, being fully responsible to his own executive superior for the consequences of his decision.

Allowing for these additional actions, the contractual functional relationship between the two executives is then characterised by this sequence of actions:

(1) *Defining requirements.* Responsible executive requests a service from prescribing executive, defining his requirements.
(2) *Prescribing.* Prescribing executive gives advice to responsible executive, guaranteeing results.
(3) *Deciding.* Responsible executive accepts or rejects the prescribing executive's prescription.
(4) *Comparing with prescription.* Prescribing executive compares actual against predicted results and ensures that his guarantee is maintained.
(5) *Comparing with requirements.* Responsible executive compares the extent to which actual requirements are satisfied as a result of his prediction of requirements and of his decision.
(6) *Proving.* Responsible executive proves to the prescribing executive that the guarantee has not been maintained.
(7) *Reporting useful results.* Responsible executive reports to prescribing executive any results which may be of use to the prescribing executive.

This sequence of actions is the complete sequence, but not all the actions need occur in any particular case. For example, action 6 should occur only when it is thought unlikely that the guarantee will be maintained or when it has not been maintained.

We refer to work units as being "responsible" and as "prescribing". It is individuals who are "responsible" and who "prescribe". When reference is made to work units as "responsible" or as "prescribing", this is merely a con-

venient way of referring to an executive in a work unit. For example, the statement "technical department is responsible" is a shortened version of "in the functional relationship between an executive in the technical department and an executive in the other work unit, it is the executive in the technical department who is the 'responsible' executive".

Fig. 7 illustrates the complete sequence of actions, as it ought to take place, for a contract between contractor and manufacturer. The work unit which carries out the action is indicated, for each action, by the disc.

The contractor "prescribes", gives a performance guarantee, and an order is placed. Within the contracting organisation there should then be executives responsible to their executive superiors for giving prescriptions to the manufacturer, and for the quality of the prescriptions. In so far as this analysis is concerned, these executives would then be responsible to their executive superiors for the design of the plant, for giving the performance guarantee, and for ensuring that this is maintained, as illustrated on Fig. 7 by actions 2 and 4.

The manufacturer is "responsible". There should then be executives within the manufacturing organisation who are responsible, to their executive superiors, for obtaining specialist advice while stating their requirements (action 1); for accepting or rejecting this while being fully responsible for their decision (action 3); and for reporting useful results to the contractor (action 7). Such executives should similarly be responsible for determining the extent to which actions 1 and 3 have satisfied the organisation's requirements (action 5). They should also be responsible for proving to the contractor, should the need arise, that the guarantee has not been maintained.

There are thus two types of functional relationship. In the first, the expert advises, to the best of his ability, and an example of this is illustrated by Fig. 6. In the second the expert prescribes, guarantees results, the prescription is accepted and an order is placed for the service, an example of this being illustrated by Fig. 7. These two types of functional relationship are the basic building blocks from which we can assemble the various ways in which plants can be provided, responsibility being clearly defined at each step, so that the work is done without duplication of effort and without division of responsibility. We can then compare the chain of activity with that occurring in practice.

Fig. 8 shows the actions which take place when the two types of functional relationship combine in particular cases. Fig. 8 (a) illustrates the manufacturer's internal organisation when it consists of associated engineering and producing companies. It is, however, appreciated that the technical department's function is that of advising the production department, who are thus "responsible". Let us assume that the technical department advises on overall process economics. The production department receives the technical department's advice and makes its decision; then the associated engineering company is asked to provide the plant. Should the production department also ask the technical department to assist in comparing competitive tenders, then the activity would be as illustrated in Fig. 8 (b), which gives the general case irrespective of whether the contractor is tied or independent. Fig. 8 (c) illustrates the activity when contracting and sub-contracting, and again this applies irrespective of whether the contractor is independent or tied. The contractor bears a similar responsibility to the sub-contractor as the manufacturer does to the contractor.

To show the more complex chains of activity, simplification is necessary. In each case we are considering one specific function, and the work unit which is responsible for carrying it out is shown by a square. Supplying and advising work units are shown by circles. They, in turn, may need supplies or advice from other work units and these units are also indicated by circles. Contractual and advisory relationships are represented by continuous and broken lines respectively. The work unit which is "responsible" is marked by the usual disc in each functional relationship.

Just a few of these chains of activity are shown in Fig. 9. Of these, Fig. 9 (a) shows the contractual functional relationship between manufacturer and contractor and Fig. 9 (b) the advisory functional relationship between a design group and a research work unit, when the design group requires research work to be carried out on basic design data and design methods. Fig. 9 (c) illustrates the activity between a research unit which requires a pilot plant, the contracting unit requiring research work to be carried out on some aspect of its own work. Fig. 9 (d) illustrates the case where a work unit such as a manufacturer's technical department evaluates process economics. Here both the research and the contracting units act in an advisory capacity, the contracting unit, in turn, requiring research work to be done in connection with the advice it has to give to the process evaluating work unit. Fig. 9 (e) shows how a prototype plant may be provided, including sub-contracting, and Fig. 9 (f) how a contractor may obtain advice from one manufacturer so as to provide a plant to another.

It is seen that activity is in no way affected by the contractor's independence or of dependence upon a particular manufacturing organisation. It is also seen (Fig. 9 (d)) that the contractor may be providing to a manufacturer advice only, in the form of quotations. To summarise:

(1) The contractor's customer has to test the extent to which his requirements have been met. To a considerable extent this is now being done by the contractor.

(2) The contractor's customer has to prove that a guarantee has not been maintained. It would appear that in general it is the contractor who is being asked to prove that it has been maintained.

(3) In the contractual functional relationship between contractor and sub-contractor, it is the contractor who is "responsible". When quoting to his customer, the contractor must then accept the consequences of his decision to choose one sub-contractor rather than another. It is thus up to the contractor to ensure that his sub-contractor offers a guarantee equal to, or better than, that given by the contractor to his customer.

(4) The manufacturer's associated engineering organisation, no matter whether it is an engineering department or an engineering company, is a contractor and thus a potential competitor of the independent contractor. Any process or design information disclosed by an independent to a tied contractor is likely to be used by the tied contractor to the disadvantage of the independent contractor. This would also seem to apply between contractor and sub-contractor.

(5) Some contractors are tied to one particular manufacturing organisation; others are independent.

(6) The independent contractor has to sell the plants he provides in competition with other contractors. The tied contractor meets no such competition and his manufacturing organisation may have organised its work in such a way that plants are unlikely to be provided effectively for this reason alone.

(7) The tied contractor's purpose is not to provide plants effectively, but to prevent process information from leaving the parent manufacturing organisation.

(8) The customer does not report useful results to the contractor. The tied contractor clearly will not pass useful results to a sub-contractor. There is thus a decided lack of communication and this would indicate conflict, the indications being that it is caused by disclosure of process and design information.

(9) Two relationships exist between manufacturer and contractor, dependent on whether or not an order is placed. The first is contractual; the second, advisory.

To be continued

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THE CHEMICAL PLANT CONTRACTOR AND THE MANUFACTURER

PART II*

Commissioning, testing and proving of plant and its operation are discussed by the author

by M. DAVIDMANN, B.Sc.

Commissioning, Testing, Proving

BY commissioning is meant work carried out by the contractor's staff in putting the plant into operation, in ensuring that teething troubles are kept to a minimum and in overcoming them. Testing refers to tests carried out by the manufacturer's staff to show that the plant meets the manufacturer's requirements. A guarantee test, at times misleadingly called acceptance test, is carried out when the manufacturer suspects that the contractor is not capable of maintaining his guarantee, or that he has failed to do so, and this we call "proving".

When giving a performance guarantee, the contractor tells the manufacturer what the plant will do and under what circumstances it will do this. The contractor, in the course of commissioning, ensures that the plant operates properly, and satisfies himself that performance is as expected, or better. If performance is worse than expected and does not fulfil the guarantee, a policy decision is made by the contractor; namely, whether corrective action should be taken before the plant is handed over, or whether the manufacturer be asked to accept the plant subject to corrective action before a specified later date. Also the manufacturer may be asked to accept the plant as it stands, the short-comings being pointed out to him. Which of these alternatives is chosen depends not only on the extent of corrective action required but also on how important it is to the manufacturer to start production immediately. The policy decision with subsequent formal approach to the manufacturer is therefore made only after preliminary informal discussions between contractor and manufacturer.

Once the plant has been commissioned and handed over as an operating unit, we may take it, at least as far as the United Kingdom is concerned, that its performance is as guaranteed by the contractor, unless this be proved otherwise by the manufacturer.

The manufacturer cannot start production without operating the plant. Hence as soon as the plant is handed over to the manufacturer, as an operating unit, the plant should be deemed accepted, even should the manufacturer decide not to use the plant until some later date.

Sub-contractors may dispatch a prefabricated unit plant which the contractor mounts on prepared foundations and to which he connects the various process streams and services. As contractors and sub-contractors, during commissioning, prove to themselves that their guarantee has been maintained, their executives are at liberty to decide in any particular case that for the standard plant supplied no check on performance is required. In the case of the sub-contractor's prefabricated unit plant, for example, this implies that it may be deemed accepted on delivery to site. However, the manufacturer or contractor may prove, within a reasonable time from the plant having been handed over or delivered, that the contractor or sub-contractor, respectively, has not maintained his guarantee. This period is usually limited to six months or one year and it is during this period that contractors and sub-contractors generally supply, free of charge, replacement parts proved defective because of faulty workmanship or faulty materials.

It is the manufacturer who tests the plant to find out whether it meets his requirements. The initial process definition given to the contractor may have been inadequate and certain aspects of the process may not have been appreciated earlier on. Hence the manufacturer tests the plant and determines subsequent policy. He may decide to have the plant modified at his expense, to use it as it stands, or to carry out a guarantee test. The manufacturer arranges, and pays for, the supply and disposal of the necessary materials and services, in the quantities and at the rates and purities he requires. These need not be related to the contractor's guarantee, as it is the plant's ability to meet actual requirements that is being tested. For example, the manufacturer may now wish to operate at half the design output, or he may now wish to vary the purity of the product, or to determine the range of output and product purity over which the plant can be operated most economically. One of the contractor's executives would in general be present, at least during the early stages, to advise the manufacturer how he can best achieve his requirements, for example, by various changes in operating techniques. It is further possible that the manufacturer may consider, as a result of his testing, that the contractor has not met his guarantee. A further test, namely a guarantee test, would then have to be carried out, probably dislocating production and duplicating a test run. This is another reason for testing while one of the contractor's executives is present, since he can assist in locating any difficulty.

As regards testing, the contractor provides a service to the manufacturer and he therefore has to be paid for this work.

A guarantee test is carried out by the manufacturer to prove to the contractor, who is represented, that he has

* Part 1 was published in the April issue, p. 264.

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fallen down on his guarantee. The manufacturer again arranges and pays for all necessary materials and services to be provided, this time at the specified and agreed conditions, and operates the plant. The contractor's representative assists in locating the cause of the discrepancy, perhaps caused by circumstances beyond the contractor's control such as lack of maintenance or faulty operation of the plant by the manufacturer's labour. The proving run is carried out over an agreed period of time. In the event of performance being limited by the manufacturer's inability to supply materials and services at the specified conditions, then performance cannot be questioned and the manufacturer has failed to prove his point. The contractor's representative, however, may conclude that, even for this case, sufficient evidence has been presented to show that the contractor has a problem to solve.

Because it is the manufacturer who has to prove that a guarantee has not been maintained, the contractor has to be paid for work he does in proving; that is, for guarantee testing. A possible exception may be when it is proved that the guarantee has not been maintained, the work entailed in the proving run then assisting him in locating and eliminating the difficulty.

The contractor determines the extent of commissioning required and also the extent to which he has to satisfy himself that the guaranteed performance has been achieved. In general, the work he will do in this respect is stated in his quotation. Any assistance required by the manufacturer in connection with training of operators, testing and proving, when these are not specifically defined and stated in the quotation, is an additional expense which the manufacturer has to meet.

When a contract contains penalty clauses related to guarantees of performance and delivery, it is again the manufacturer who has to prove default. The delivery period may be taken to commence on the date the order is acknowledged unless the contractor's quotation clearly states that it commences from receipt of full and final instructions. These permit the contractor to proceed without further alteration of requirements on the part of the manufacturer. When penalty clauses are accepted by the contractor, they should be balanced by bonus clauses, the contractor earning a premium when performance and delivery are better than guaranteed. As the manufacturer is responsible for producing, the contractor does not indemnify the manufacturer against loss resulting from inadequate performance or from late delivery.

The points made here as applying between manufacturer and contractor appear to apply equally well between contractor and sub-contractor.

Manufacturer's Contracting Activity

The manufacturer's engineering organisation provides a specialist service to his producing organisation. The engineering department serves the production department and the associated engineering company serves the parent producing company. The manufacturer's engineering organisation, rather than independent contractors, provides plants so as to prevent know-how from leaving the organisation. The function of the manufacturer's engineering organisation is the provision of plants and it is, therefore, a contractor.

The manufacturer's engineering organisation need not make a profit, its success being more often judged by output and quality of product from the plants it provides. There is thus a tendency to overdesign, a contributory factor being that no competing bids are received by the producing organisation. Without competition there is no criterion by which the effectiveness of the engineering organisation's work can be judged. Success of product produced is not a criterion, as it might have been greater had the work been done more effectively. The engineering organisation has a considerable measure of security, since it is assured of both orders and financial backing from the associated producing organisation.

The contractor has to make a profit while competing with other contractors. He has every incentive to reduce costs, to improve his designs, methods and the processes he offers. While in his case the incentive to improve stems from the need to survive competition, in the case of the manufacturer's engineering organisation some drive to improve would come from the associated producing organisation, who may feel that their engineering organisation is not doing its work as well as it might. However, this may result not in the engineering organisation becoming more effective, but in some of their work being duplicated by the producing organisation, who consider that they can do it better. When this happens the producing organisation has lost sight of the main function of the associated engineering organisation, which is not that of successfully providing plants but that of retaining process information within the parent organisation.

The contractor's competitive position is shown by his annual profit and turnover compared with that of his competitors. There is generally no similar criterion of survival or effectiveness applied to the manufacturer's engineering organisation.

Sometimes it is apparent that the manufacturer keeps his know-how to his own organisation at some considerable cost to himself, and, as a result, plants are not likely to be provided effectively. This undoubtedly affects his position

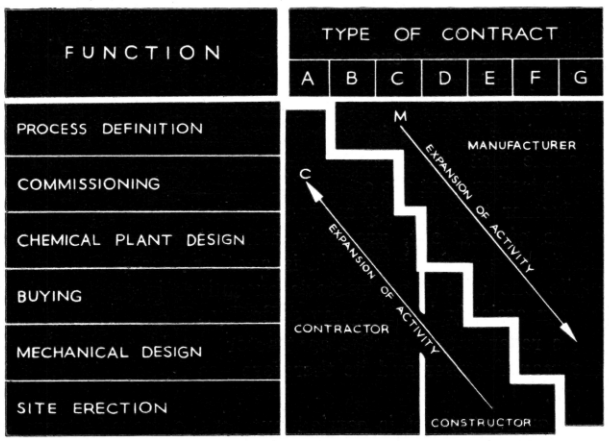

Fig. 10. Chart showing field of activity (dynamic).

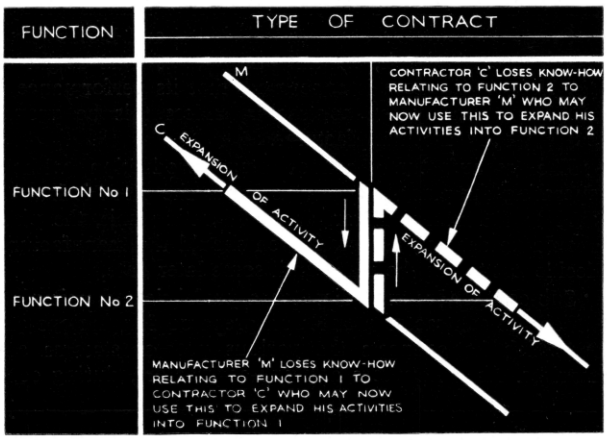

Fig. 11. Disclosure of "know-how" (conflicting interests).

compared with that of his competitors unless, of course, their plants are also being provided by an associated engineering organisation.

When the manufacturer enters the field of contracting, there then exists the possibility that the manufacturer's engineering organisation may use know-how relating to plants built by independent contractors, in order to design and construct similar plants. A parallel situation exists between contractors and sub-contractors.

As regards the provision of plants, the conflicting interests of contractor and manufacturer are illustrated by Fig. 10. It is seen from the way in which the diagonal line, which indicates the division of work, divides the field that the manufacturer's contracting work is an extension of his work on processes, and that the contractor's process work is an extension of his contracting activity. The constructor, as he grows, expands into contracting, and thence through activities concerned with processes to the providing of specific complete process plants. The manufacturer expands his activities through chemical engineering design, whilst using constructors, until in the end he provides the specific complete process plant himself.

The opposing interests of manufacturer and contractor are further illustrated by Fig. 11, the field of activity being that of Fig. 10. The diagonal lines represent manufacturers and contractors respectively. As vectors on a field of activity, the diagonal lines also state the direction of expansion along both axes. The division of work for the particular contract illustrated occurs between functions 1 and 2, this defining the type of contract on the field. The illustration shows how know-how obtained in the course of a contract by a manufacturer from a contractor may be used by the manufacturer to extend his activity to embrace that of the contractor. The manufacturer then takes over some of the contractor's work, thus becoming a competitor. This process continues until, in the end, the manufacturer even erects his own plants. Similarly, the constructor, who was initially concerned with field erection only, finally extends his activities so that they include the search for new processes.

However, the sequence is not yet ended. The manufacturer's engineering organisation in the first place supplies plants only to his own producing organisation. Eventually, it supplies unit plants and plants to other manufacturers as well, in open competition with contractors. While doing so it may still not have to show a profit, because of the strong backing it receives from the parent organisation, by direct or indirect subsidy.

As against this the author knows of no case where the contractor has developed a process, built the plant, and then proceeded to operate it at his own risk so as to sell the products for profit.

Both contractors and manufacturers must prevent their respective know-how from becoming known to their competitors by either party to a contract. The manufacturer may not appreciate the value of the contractor's know-how to the contractor, or indeed may not appreciate just what constitutes this know-how. In addition, the manufacturer may consider that the contractor's know-how becomes his when he buys a single plant. As a result, the manufacturer cannot be relied upon to protect the contractor's interests. As a consequence, the contractor has entered the manufacturer's field of processing, but only in so far as he obtains licences for processes, develops processes and offers plants in which a specific process is carried out. Such process plants are obtainable only from a restricted number of contractors until the time arrives when the process and the corresponding process know-how have become available to other contractors. On the other side the manufacturer, to protect his own know-how, sets up engineering organisations which, in so far as they are contractors, compete with independent contractors by taking work away from them. In the end the manufacturer's engineering organisation enters into open competition with the contractor.

Whilst the contractor does not compete with the manufacturer in producing, the manufacturer competes with the contractor in the provision of plants. Hence it appears that the manufacturer's preoccupation with competition amongst manufacturers has created a situation in which, almost whenever an order for a unit plant or plant is placed, the contractor's know-how is disclosed to his customer who is at the same time a potential competitor; at the same time it is more than likely that it will be disclosed to existing competitors.

Since the relationship between contractor and manufacturer is a functional one, the two ought to work together as a team. On the contrary, both fear, and occasionally suffer from, disclosure of know-how to competitors. When this happens the contractor has taken no effective steps to prevent such disclosure, relying as he does on the manufacturer to provide his livelihood. Manufacturers for their part have formed associated engineering organisations to protect themselves, which results in conflicting interests instead of team-work.

Processes and Plants

Here we are considering a hypothetical example which is, however, typical. A manufacturer improves a process and, should he wish to apply for a patent, he would have to give the process improvement and to describe how it can be effected. Let us assume that the process improvement consists of adding a comparatively small quantity of a chemical to one of the process streams and that this results in an increased rate of mass transfer in an adsorber and in a reduced temperature of reactivation elsewhere. The higher mass-transfer rate means a better product or increased recovery and, alternatively, a smaller and therefore cheaper adsorber. In addition, the reduced reactivation temperature implies that reactivation costs can be reduced in a number of different ways, using different materials of construction, various sources of low-grade or low-cost heat and various arrangements of exchangers. The manufacturer might well consider that the main advantage would be the economies resulting from the lower reactivation temperature, and may consequently file a patent application for the process as a whole whenever low-grade, low-cost heat is used in various exchanger combinations. He would then have covered both the process and the plant in which it takes place.

All advantages stem from the addition of a relatively small quantity of a chemical to one of the process streams and this is a process improvement, unrelated to the already known plant in which it takes place. The improvement consists of adding a certain chemical in defined proportions or quantities to one of the process streams, the means consist of a way of introducing the chemical in the required amounts into the process stream, and the advantage lies in the consequent economies, that is, in a cheaper product. Hence it would appear that a process is a matter entirely distinct from the plant in which it takes place.

The actual arrangement of exchangers and the source and cost of low-grade heat that would be used would depend, in each particular application, both on the customer's requirements and on the experience and ingenuity of the designer. In so far as they depend on a manufacturer's requirements, they would be determined by process considerations, that is, by considerations peculiar to the manufacturer. To the extent to which they depend on the contractor's choice they would be a matter of design, that is, they would concern the plant. Hence the manufacturer's requirements define the process and the contractor's freedom of choice concerns the plant.

We can consider in more detail the distinction between

process and plant with the help of a further example; namely, some of those processes which are concerned mainly with the unit operation of adsorption, more particularly with adsorption from gases.

The manufacturer names the process in accordance with his requirements. It is a "recovery" process when a valuable constituent is being recovered, "purification" when an undesirable constituent is being removed, and "filtration" and "drying" when it is oil vapour and moisture, respectively, which are being removed. The name he gives to the process thus gives some idea of his requirements. In addition, the manufacturer determines whether operation should be continuous, intermittent, manual, semi-automatic or automatic, the permissible overall pressure drop and the cycle time, the required inlet and outlet concentrations, operating conditions such as temperature and pressure, as well as the rate of flow of the process gas. He further determines the extent to which process gas has to be used for reactivation, considering the value and the required purity of the process gas. To the extent that the reactivation circuit depends on the manufacturer's requirements, it is a process consideration, as is the type of heating medium used for reactivation, and the maximum available quantity, and the quality, of the process stream which is available for any necessary cooling. These, then, are the process considerations for this case, and assistance is rendered to the manufacturer, in the form of quotations, to enable him to choose, for example, the most economic process conditions. In this connection it has to be remembered that the manufacturer has in addition to decide whether "adsorption" or some other unit operation best meets his requirements.

The contractor designs the adsorber, determines the number of adsorbers to be used and the type of adsorbent, the way the gas flows through the adsorbers, individually and collectively, during the various stages of the cycle, decides requirements of, or designs, the auxiliary equipment such as fans, heaters, coolers and separators, sizes pipelines and valves, designs the indicating and control instrumentation; he lays out the plant and does the necessary drawing, fabricating, procuring, carries out erection and delivers the plant. He guarantees that the performance of the plant meets the process requirements stated to him; in other words, he guarantees that the work he has undertaken will be done satisfactorily, stating the performance of the plant and the services required, all this being conditional upon the manufacturer having correctly and completely defined his requirements to the contractor in so far as process, process requirements and process conditions are concerned.

A clear line of demarcation can be drawn, for each case, between the matters which are decided by the manufacturer, and those which are decided by the contractor. Or put otherwise, a clear distinction can be drawn, in each case, between the process and the plant in which it takes place.

The following points arise:

(1) In each case it is possible to differentiate clearly between a process and the plant in which it takes place.

(2) Processes are the concern of manufacturers, and of manufacturers only, and process data should not be disclosed by a contractor to any other party without the agreement of the manufacturer from whom it was obtained in the first place, irrespective of whether or not an order is placed.

(3) Plants are the concern of contractors, and of contractors only. Manufacturers should not disclose design or plant data without the agreement of the contractor who supplied the data or the plant in the first place. It is implied that the contractor should not be asked unnecessarily to disclose data which he considers confidential. These points apply whether an order is placed or not.

(4) It seems necessary to oppose patent applications which confuse processes and plants, or processes and plant items. A patent application should cover either a process or a plant, but not both.

(5) It would appear that any process improvement which arises during the course of a contract should belong to the manufacturer. Similarly, any design or plant improvement should belong to the contractor. The improvement could not have been made had the relevant basic data not been disclosed. For example, useful test results on the plant should in any case be reported back to the contractor who supplied the plant in the first place. A specified time interval could be agreed between manufacturer and contractor, after which know-how may be disclosed.

(6) These various points applying to manufacturer and contractor apply with equal force to contractor and sub-contractor. For example, with the larger projects such as nuclear power station projects, the manufacturer states his process requirements to the contractor whose freedom of choice then covers a number of alternatives of plants, plant units and arrangements of them.

Processes and Treatments, Plants and Operations

The manufacturer processes raw materials to obtain saleable products. These products may be the raw materials which, in turn, may be converted to yet other products. It is the overall change, and the treatments applied to produce this change, which constitute the process.

One manufacturer may convert raw material A to product B which is transferred elsewhere to be converted to product E. Writing, for example, AB when we mean "conversion of raw material A to product B", we can relate the individual processes with the overall process:

$$AB + BE = AE \qquad \ldots . (1)$$

Another manufacturer may consider that, in his case, it is more economic to convert A to another product, C, which, in turn, is converted to E. His processes can then be represented by AC and CE, and the overall process is:

$$AC + CE = AE \qquad \ldots . (2)$$

Yet another manufacturer may convert A to E by three consecutive processes, extending his production facilities in stages, installing one plant at a time:

$$AC + CD + DE = AE \qquad \ldots . (3)$$

Equations (1), (2) and (3) and the processes they contain represent groups of processes in so far as only the treatment is specified. Raw materials may differ in form and analysis and different manufacturers may require the products to be in various forms and of different purities. Denoting such differences by suffixes, we can write down just a few of the possible processes which take place when A is converted to E, for the groups of processes represented by Equations (1) and (2), thus:

$$A_1B + BE_1 = A_1E_1 \qquad \ldots . (1a)$$
$$A_2B + BE_1 = A_2E_1 \qquad \ldots . (1b)$$
$$A_1B + BE_2 = A_1E_2 \qquad \ldots . (1c)$$
$$A_2B + BE_2 = A_2E_2 \qquad \ldots . (1d)$$
$$A_1C + CE_1 = A_1E_1 \qquad \ldots . (2a)$$
$$A_2C + CE_1 = A_2E_1 \qquad \ldots . (2b)$$
$$A_1C + CE_2 = A_1E_2 \qquad \ldots . (2c)$$
$$A_2C + CE_2 = A_2E_2 \qquad \ldots . (2d)$$

The number of alternatives shown are a very small sample. For example, the intermediate products B and C are assumed to have constant form and purity. Their form and purity are important factors when considering the profitability of further conversion, and each manufacturer is likely to have his own specific requirements. Thus there exist a very great number of different processes.

The manufacturer divides his process into what one might call "unit processes", but which are more clearly defined as "treatments". Examples are purification, recovery, filtration, drying, hydrogenation, conversion, and so on. This terminology enables the manufacturer to describe his particular requirements, that is his process. For example, a raw material may have to be purified and then filtered, the filter cake having to be dried and a constituent being recovered from the filtrate. No particular significance can be attached to the subdivision of processes into treatments. The same treatment may be "purification" to one manufacturer and "recovery" to another.

It is seen that treatments and processes may vary from manufacturer to manufacturer, and that they are no more than descriptions of how a particular manufacturer converts, or intends to convert, a raw material into a product. Bearing in mind that processes consist of at least one treatment, and that it is in the terminal conditions that plant and process meet, the contractor may then expect to get inquiries for plants for a large number of processes, examples being A_1E_1, A_2E_2, A_1B, BE_2 and C_1D_1. If one process differs from another only in the purity of raw material and product, he provides plants which may be similar. But as a plant is provided so that a particular process can take place in it, a plant is designed to meet the requirements of the particular customer. Because of the large number of processes, and so that plants can be provided effectively, the contractor divides the plant functionally into a number of unit plants. Each unit plant carries out a unit operation, and only in so far as these are independent of processes can plants be assembled from unit plants.

A gas drying treatment is carried out not in a unit plant but in a plant which is made up of a number of unit plants, examples being the adsorber and the heat exchanger. The unit operation of adsorption is carried out in a unit plant called the adsorber and heat exchange is carried out in a heat exchanger. A drying installation is thus a plant, differing from other plants in the number, type and arrangement of unit plants. This illustrates that there is in general no correspondence between the manufacturer's "treatment" and the contractor's "unit operation". As process and plant are separate and distinct matters, one should not expect such correspondence. Further, a number of different types or arrangements of unit operations may be available for carrying out the one treatment.

It has been said that a process is made up of unit operations in their proper sequence. Manufacturers, however, do not describe processes in terms of unit operations, as this would be far too cumbersome. Plants are assembled from unit plants in which unit operations are carried out and from the point of view of the chemical engineer and contractor the essential characteristic of a unit operation is that it is independent of the processes for which it is used.

This being so, one may classify unit operations accordingly. In addition, when it is seen that a plant is distinct and separate from the process which takes place in it, then it can be appreciated that the training of the chemical engineer should emphasise the engineering aspects rather than the chemical aspects.

(To be continued)

66.013: 658.22.003.2

THE CHEMICAL PLANT CONTRACTOR AND THE MANUFACTURER

PART III*

A discussion of the problem of releasing commercially valuable information during the execution of a project

by M. DAVIDMANN, B.Sc.†

Disclosure of Know-how

THE manufacturer is concerned with maintaining and improving his competitive position relative to other suppliers of the same or of competitive products. He is likely to originate process improvements which result in a cheaper or a better product. His research department is looking for new outlets and may find new products and methods of making them. He may, for a substantial fee, obtain a licence to produce a given product. His income depends on his output and price in relation to demand and his competitor's output and price. Hence his process data and process improvements constitute his stock-in-trade, his know-how, not to be disclosed to present or potential competitors unless they are penalised by a licensing fee.

The manufacturer is not alone in encountering competition. The contractor also is concerned with maintaining his competitive position; in this case, that relative to other contractors. His research department is searching for new processes and how to improve existing processes. He may own and acquire process data, obtained at some considerable cost to himself. Given effective mechanical design, fabrication, procurement and erection, that is, given that construction is carried out effectively, his income depends on his chemical engineering design data and methods, and on his processes and process data.

Difficulties clearly arise when manufacturer and contractor jointly take a process from research through design to producing plant. The contractor may later on offer suitable plant to the manufacturer's present or potential competitors, or he may use process information gained during the course of the contract to the manufacturer's disadvantage by disclosing it to the manufacturer's competitors. The same difficulties arise whenever a plant is provided by a contractor to a manufacturer.

In the same way the manufacturer may disclose the contractor's know-how to the contractor's competitors when asking for tenders for, or when buying, another similar plant from another contractor, or by publishing test results together with design information.

A similar situation exists when an independent research organisation is employed. Here the danger is that work paid for by one customer may be sold a second time to another at greatly increased profit, the work having been paid for already by the first customer.

It is for reasons such as these given here that the manufacturer prefers to have his plants designed and installed, or modified, by his own engineering organisation.

The disclosure of know-how to competitors is shown in Fig. 12. The field of activity on which it is based is that of Fig. 10 (see page 336, May issue) and the diagonal lines represent competing contractors and competing manufacturers. It applies as well to manufacturers and contractors as to manufacturers and constructors. The division of work for the particular contract illustrated is such that it occurs between functions 1 and 2, this defining the type of contract on the field.

Know-how

Know-how is correlated, recorded and applied experience. Suppose that a manufacturer finds that specific materials of construction are required to obtain a reasonable working life from a given type of valve on a particular process stream. Suppose also that he orders such valves, stating both the process stream and the materials of construction. It is then possible that the supplier who provided the valves in due course offers valves suitable for this particular process stream to chemical industry at large. The open sale of these valves, incorporating the specific materials, may amount to a disclosure of know-how to the manufacturer's competitors.

If the valve supplier guaranteed the first set of valves, which failed consistently, as suitable for their purpose, and then continued to replace them at his own cost until satisfactory materials had been found, then the know-how would belong to the valve supplier, irrespective of losses incurred by the manufacturer as a result of interrupted production. The supplier could then offer his valves to anyone, as proved suitable for this particular process stream.

Should the manufacturer require further valves, the know-how belonging to the supplier, the manufacturer should not disclose it to the supplier's competitors when calling for quotations. The manufacturer should call for quotations without disclosing the materials, and in deciding with whom to place the order should weigh his knowledge that this supplier's valves are proved against guarantees given by his competitors. When the supplier guarantees the valves as suitable for the particular process, he need not disclose the materials of construction he is supplying.

Should the replacement costs have been paid by the

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manufacturer, then the know-how belongs to him and it may not be used by the supplier. Should the supplier receive an inquiry from a prospective customer for a valve suitable for the same, or a similar, process stream, he should offer a valve made up from his standard materials of construction, leaving it to his prospective customer to decide whether these valves are suitable or not. Even his ability to supply the specific alternative materials should not be disclosed, but he may state that any other alternative materials could be supplied at extra cost and at customer's request. In short, the choice of materials should be left entirely to the prospective customer.

On the other hand, the valve supplier may approach the manufacturer whose know-how he would like to use, disclose the prospective customer, and obtain agreement to use the special materials of construction so as to guarantee his valves suitable for the particular process stream. The manufacturer may agree and charge a fee. This fee would, in effect, be paid by the supplier's customer to the manufacturer. It therefore suffers from all the disadvantages given later in this article for such a case.

The valve supplier thus has to put forward standard materials of construction, as stated in his quotation, leaving it to his customer to specify special materials or other special requirements. He may, of course, introduce the prospective customer to the experienced manufacturer, if both parties agree to this, leaving them to sell or license know-how to each other.

In each case one can decide to whom know-how, that is experience, belongs, not only for the simple example given here but whenever process and plant meet, that is, whenever contractor and manufacturer come together. The ownership of know-how should be clearly defined in each contract, design know-how belonging to the contractor and process know-how belonging to the manufacturer. Any one party may not disclose the second party's know-how to a third. The manufacturer should not disclose design know-how; the contractor should not disclose process know-how.

Where the customer requires information to enable him to carry out maintenance work, the disclosure of information should be restricted to the minimum, spare parts being obtained from the contractor at the contractor's discretion, drawings and design remaining the contractor's property.

Know-how is of value to the recipient only if he uses it, and such use cannot but be detrimental to the interests of the contractor who supplied the information in the first place. It follows that the contractor should refuse to disclose design information to the customer. In general, each drawing should clearly specify the ownership of the information it contains with respect to process, chemical engineering and mechanical design information.

Licensing

In general it is the manufacturer who develops, improves and patents processes. He may then offer these, under licence, to contractors. The contractor may have to pay a fee so as to obtain only an option to enable him, at considerable cost, to acquaint himself with the process, in order to decide whether he wishes to take out a licence. Should he decide to take up the process, he obtains the licence at additional cost. Both the option and the licence are likely to contain secrecy clauses. The contractor, now a licensee, proceeds to advertise so as to obtain inquiries in order to sell the specific plants in which this process is carried out. It will cost the contractor a considerable amount of money to prepare quotations for the various manufacturers who may be interested. Assuming that the contractor obtains an order, he may then have to pay a further fee to the manufacturer who originated the process or process improvement, that is, to the licensor. This fee may be based on the number and size of plants sold.

If the licensor has patented the process, a good deal of the process know-how is contained in the patent. In any case, the contractor is likely to obtain only process know-how from the licensor, having to contribute his own design knowledge and experience. Any design data disclosed by the licensor is likely to be based on the plant in which the process is being carried out at the licensor's works and would thus belong to the contractor who designed the plant in the first place. Any fee for design data should thus be paid to the contractor who designed the plant and not to the licensor. Indeed, such design data should not be disclosed by a manufacturer without the agreement of the contractor who designed the plant.

When a process is offered to a contractor at the laboratory stage, by a manufacturer, there is no doubt that the contractor has to contribute design know-how before a plant can be provided.

A manufacturer would be interested in selling licences for a particular process to as many contractors as possible, to obtain the highest income. A contractor would prefer to restrict the number of licensees so as to restrict competition in order to obtain a reasonable return from the money he has invested in taking out the licence.

When a contractor takes out a process licence, the sequence of events is then as follows:

(1) A manufacturer invents or improves a process. Licences are offered to contractors for building plants for carrying out the specific process.
(2) The contractor pays the manufacturer a fee, for an option to take out a licence, to enable him to investigate the process.
(3) The contractor evaluates the process at considerable cost to himself. He receives process data, but has to contribute design know-how.
(4) Deciding that this process is more economic, or results in a better product than others, from the point of view of his prospective customers, or that there is a need for the process, the contractor takes out a licence, agreeing to pay the licensor further fees in accordance with, say, the number and size of plants ordered. Other contractors will obtain licences for the same process at similar cost to themselves.
(5) The contractor now submits quotations to prospective customers for plants in which this process is carried out. Each quotation can cost the contractor a good deal of money.
(6) The prospective customer, another manufacturer, who is concerned about using the most economic process, chooses between alternative processes on the basis of quotations received from a number of contractors.
(7) Let us assume the licensee receives an order. His price includes the fees he has had, and still has, to pay to the licensor, and the cost of previous unsuccessful quotations to other prospective customers, who are also manufacturers.

The sum total of points (1) to (7) above is that a manufacturer has invented or improved a process and has licensed this, by a very circuitous route, to another manufacturer. The contractor invests money in evaluating a process which, in the end, he may decide not to take up. He invests more money when he takes out a licence and still more money while he quotes to interested manufacturers. The licensor cannot lose, the prospective customer receives free advice on particular processes in the form of technical discussions with, and quotations from, contractors. The contractor risks his money and the manufacturer who orders a plant pays for quotations prepared for other manufacturers.

From the manufacturer's point of view:

(a) A process is licensed by one manufacturer to another.
(b) Manufacturers evaluate alternative processes on the basis of quotations received from contractors.

(c) A manufacturer places an order for a plant in which the preferred process is carried out, on the basis of competitive quotations received from contractors.

One fails to see why contractors should take any risk whatsoever as regards item (a) and why the contractor provides a free process advisory service in connection with item (b). A manufacturer may at the moment ask contractors to do work costing £1000 for the possibility of saving £100. Further, a manufacturer who places an order pays for advice given to other manufacturers who may even be his competitors.

We saw earlier on that two relationships exist between contractor and manufacturer: namely, an advisory and a contractual relationship. These correspond to items (b) and (c) above, respectively, the unsuccessful contractors [item (c)] remaining in the advisory relationship.

The contractor thus offers two distinct and separate services. The first is advisory and assists the manufacturer in selecting the most suitable process for that particular manufacturer's special needs, as the manufacturer cannot do this without quotations. The second is the provision of plants. Hence we conclude:

(1) Processes are the concern of manufacturers, and of manufacturers only.

(2) Processes should be licensed by one manufacturer to another. The contractor who investigates a process at his own cost, or who takes out a process licence at his own cost, is taking a risk which is clearly one which only the manufacturer should take.

(3) No fees should be paid by contractor to manufacturer for process information. Such fees should be paid only by one manufacturer to another.

(4) The contractor who advises in the form of technical discussions and quotations in connection with processes—in other words, who assists the manufacturer in selecting one process rather than another—is offering a specialist service, quite distinct from that of plant contracting, and should be paid for his work in this connection. The manufacturer who receives the advice should pay and not the customer who orders a plant. This means that a fee should be paid for each quotation, being paid by the manufacturer to the contractor, and by the contractor to the subcontractor.

Contractor's Process Activities

Contractors provide plants for processes for which they have taken out a licence, or of which they have experience, or which are generally available. At times the contractor carries out process research, at least in so far as he evaluates processes so as to decide whether to apply for a licence to supply plants in which a particular process takes place.

The manufacturer chooses the product he intends to market, its form and shape as well as its quality, and the raw material. He decides the size of plant to be installed and the degree of continuity of operation, i.e., the standby facilities, he requires. This is the manufacturer's process definition.

A number of alternative processes may appear attractive or be available and the manufacturer has to compare them before he can decide on one or the other. The manufacturer bases his decision on the cost of the product, allowing for capital and operating costs, in the prevailing or anticipated circumstances. He thus calls for quotations from a number of contractors to evaluate alternative processes.

Contractors who do not realise that processes are a matter concerning their customers rather than themselves tend to regard know-how as consisting of process experience. As long as a contractor concentrates his attention on processes rather than on plant design, it is unlikely that he can bring to bear on any particular process the design experience gained on other processes. The division of his design work into specialist sections concerned with processes underlines the manufacturer's concern about his know-how being disclosed to his competitors by the contractor. The contractor's chemical engineers, now called process designers, are not likely to have the time, nor is it their responsibility, to accumulate and correlate knowledge and experience concerned with any particular unit operation. From the point of view of chemical engineering design, the contractor's experience on any particular unit operation is then scattered throughout process files. Process know-how is likely to be developed at the expense of chemical engineering design know-how.

The contractor who provides unit plants for one or two operations, and plants for one or two treatments, is likely to do this effectively. His equipment and plants (for example, direct coolers, scrubbers and driers) are comparatively uncomplicated. He supplies these to chemical industry at large, irrespective of process.

The somewhat larger contractor, once he divides his work according to processes, feels the limitations. In due course he is likely to lose his lead in design know-how but his knowledge of particular processes increases. As there are very many processes, he may in due course supply but a few of the plants required for carrying out processes in general, concentrating on supplying particular branches of the chemical industry. His preoccupation with processes may thus limit his activities to the processes of which he has experience or for which he can obtain a licence.

In due course he expands his process activities, at the expense of his design know-how, until he ceases to be competitive in designing, fabricating and providing the unit plants and plants for single treatments in which he specialised initially. This, then, may result in the creation of the so-called contractor who is entirely concerned with process evaluation, his plants being designed and provided by subcontractors. This is not a contracting organisation, but one which investigates, recommends and sells particular processes. It provides a specialist advisory service to those manufacturers who need advice on available processes and how they compare with one another.

The smaller contractor is concerned with equipment and plants in which unit operations and single treatments take place. These he provides to the chemical industry at large, irrespective of process. As the contractor grows and tackles larger projects, he finds that a larger number of specialists have to work together and that team-work is ineffective. This is perhaps recognised, but instead of organising so as to obtain effective team-work the design work is divided according to the requirements of different customers, that is, according to processes. This obscures the functional division of work between manufacturer and contractor, and a manufacturer may now consider that any process information he discloses is likely to find its way to his competitors, and he may consequently begin to provide his own plants. The contractor, preoccupied with process rather than with plant design, limits his field of activity to comparatively few processes and the quality of his design work suffers. As he grows still further he ends up by providing an unpaid and limited process advisory service to manufacturers, making a living by buying and reselling plants.

To improve this situation the contractor should clearly differentiate between the process and the plant. His function is to provide plants and his work is characterised by chemical engineering design work. This design work should be subdivided into separate work units, each of which is responsible for work on one particular unit operation. The work is then divided functionally and plants are designed by teams. He may then provide unit plants and plants made up of many unit plants, competing with other contractors in each case. The contractor should expand not by concerning himself with processes, but by extending his activity in the unit operations he already knows and into other types of

unit operations. He should provide plants which include his own unit plants and those of sub-contractors, the plants being provided irrespective of process.

The contractor's activity appears then to be limited, as far as this analysis is concerned, only by the extent to which he can organise his work effectively so as to remain competitive despite the size of his organisation, and by the extent to which his organisation achieves team-work between specialists. The main problem in the provision of major plants, at present, is perhaps that of obtaining team-work. Problems in organisation,[6] in functional division of work and in obtaining team-work,[8] as well as in work planning,[7] are discussed elsewhere.

The Environment

In an industrial civilisation many needs arise for a large number of different products and services. These needs are satisfied by a correspondingly large number of specialised work units. Competition between work units ensures that needs are satisfied effectively. Individuals and work units work in harmony together to satisfy the society's needs.

This system of organisation, in which reward is in proportion to the urgency of the need satisfied, and to the service rendered, will succeed in meeting the society's needs only if all the following requirements are satisfied:

(1) The society's effort has to be divided into separate and distinct activities carried out in work units. Each work unit carries out an activity essential to the completion of the work, determined by the work undertaken. This division of work, to be effective, has to be functional.
(2) Free competition is required between work units carrying out the same functional activity.
(3) Individuals and work units need to co-operate with each othe to complete the work undertaken.

If any one of these requirements is not met, then difficulties can be expected. For example, to enable a work unit to operate, not only has the work to be done, but capital is required in addition. Shareholders and employees thus form a team, co-operating with each other in the carrying out of the work unit's task. When the work unit is a company, then it is the responsibility of the board of directors to ensure that shareholders' and employees' respective responsibilities, and the functional relationships between them, are clearly defined and understood, and to apportion reward between shareholders and employees, taking into account the total situation as it is seen at the time. It is not enough for this apportioning of reward to be fair, it must also appear to be fair; that is, those concerned have to understand that it is fair. Where responsibilities, or functional relationships, or fairness of reward are not clearly defined and understood, conflict results between those who should be working together.

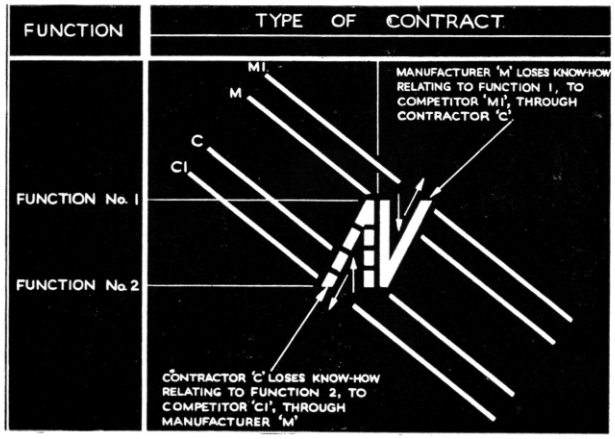

Fig. 12. Disclosure of know-how to competitors.

Processes and plants are the concern of manufacturers and contractors respectively. However, the manufacturer provides plants and the contractor concerns himself with processes so that to that extent we see conflicting interests instead of team-work.

It seems that a useful purpose could be served by a code of practice, concerning, for example, know-how and its disclosure, prepared by representative bodies such as the Association of British Chemical Manufacturers and the British Chemical Plant Manufacturers Association, each for their own part of the industry and then jointly for the industry as a whole, initially at a national, and then at an international level. Another point that could be taken up in a similar manner, and of at least the same importance, is that a fee should be paid for each quotation by the recipient. Such representative bodies, agreeing and acting jointly, accept responsibility for the industry as a whole in very much the same way in which, in the previous example, responsibility is accepted by a board of directors.

Conclusions and Recommendations

The contractor carries out chemical engineering design and provides plants, the manufacturer produces, and this would be a functional division of work. However, manufacturers also provide their own plants and contractors are concerned with manufacturing processes. This results in conflicting interests instead of team-work and in plants not being provided effectively. Hence to that extent the manufacturer does not produce effectively.

Processes should be licensed by one manufacturer to another and not to a contractor. No fee should be paid by contractor to manufacturer for process information, as such fees should be paid by one manufacturer to another.

As regards any inquiry or contract, process improvements should belong to the manufacturer, design or plant improvements to the contractor. Manufacturers should, as a rule, report useful results to the contractor.

The contractor commissions the plant, but it is the manufacturer who should test and prove it. The contractor should be paid when assisting in testing and proving.

The contractor not only provides plants, but in addition advises in connection with manufacturing processes, by means of technical discussions and in the form of quotations. He should be paid for his work in this connection. The manufacturer who receives the advice should pay instead of the manufacturer who places an order. This means that a fee should be paid for each quotation, by manufacturer to contractor, and by contractor to sub-contractor.

Contractors appear to have experienced difficulties in obtaining team-work between specialists when designing plants of some complexity and have consequently divided their work according to processes. This limits their activity to but a part of the chemical industry. The contractor should divide his chemical engineering design work, functionally, according to unit operations, plants being designed by teams irrespective of the processes which take place. He then has to organise so as to ensure team-work and so that the work is done effectively. His field of activity is then limited only by the extent to which this is done successfully.

Finally, a code of practice, for the industry as a whole, would serve a useful purpose.

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