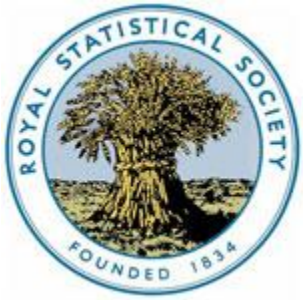

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QUALITY CONTROL IN THE USA

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Quality control is usually regarded in Great Britain as a statistical subject, but Mr van Rest found in the USA a tendency to regard it as a branch of management concerned with the control of quality, control involving not only manufacture to a specification but also a satisfaction of the consumer's needs.

I WENT to the USA as a member* of a specialist team brought together by the Anglo-American Council on Productivity (now British Productivity Council) to study inspection methods and organisation in the light engineering industry.[1] This article describes present practice in this field in the USA as we saw it and discusses the changes in outlook that have occurred in the last few years together with their significance, especially in relation to the drive for greater productivity which is going on both here and there. Some twenty visits were made, some of these by part of the team only, in the 42 days' stay. Admittedly the firms visited were chosen, by a consultant in this field, from among those who are using the most modern practices in the control of quality, so that the picture obtained is not necessarily representative of all American industry. There is evidence, however, particularly in the membership figures of the American Society for Quality Control, that these practices are fairly widespread.

Broadened Meaning of the Words 'Quality Control'

To the statistician the most striking development is the wide meaning given to the words 'quality control.' Over here, and indeed there, the name was for long reserved for the statistical technique involved in controlling a manufacturing process by sample inspection at the time of manufacture. The new conception of the meaning and scope of quality control accepts this as one of the tools but applies the name to the wider management function of ensuring that what is made by a manufacturing organisation is what was intended.

This broadened conception of quality control as a new branch of management has been reported before, but it needed a visit to make me realise the full implications of the change. The management of a manufacturing organisation needs, in order to manage, information on costs, on quantity, and on quality. The first two of these have long been generally accepted as essential; the third has usually been left to

* Nominated by the Royal Statistical Society and seconded by the Ministry of Supply.

a section of limited scope working mainly within the production department. What is being done in America and by some firms in the United Kingdom is to lift the question of quality on to a level with the other two, to make it a major concern of management and, in doing so, to study and state the principles that should indicate the methods to be used in each part of the organisation. The result is a more efficient management, a clearer appreciation on the part of members of the management team of what is expected of them, a reduction in the friction which has often been the outcome of the absence of that clear definition, and a product which, in serving the user better, releases capacity and energy on a national scale.

The Scope of Quality Management

Quality control seen in this way as a new branch of management requires to be organised to do at least three things. It needs, first, to put itself in a position to assure top management about the current quality of the products; second, it must inspect in order to prevent faulty articles passing at certain critical stages of manufacture; third, it must pass the information it has obtained to those departments which will use it to prevent further faulty production.

A little thought will show that these functions are akin to those of other branches of management. The costing branch, for example, must be in a position to inform top management of the current level of costs in order that benefit from changes may be assessed. It must continually be making assessment of costs at various points of the organisation and it must inform others of any untoward variation in order that the cause may be removed as quickly as possible.

It is not only within the manufacturing organisation that the scope of quality control has been extended; producers also recognise that the external influences must be allowed full play if the product is to be successful in a competitive field. These influences express themselves sometimes positively as complaints by customers, sometimes less positively by a falling off in sales. Market research may reveal features of design which influence demand; sometimes such features must be sought by field experiment or life test. Whatever their source they cannot operate successfully on the manufacturing organisation unless channels are provided for the interpreted information to flow to the appropriate departments. The quality department is recognised as the appropriate one to provide these channels. Broadly speaking, the operation of these external influences is very similar to that of inspection within the factory, for just as an operator in charge of a machine makes his article, tests or measures it, and adjusts his machine accordingly, so the whole manufacturing organisation must be ready and provided with the means to carry through this same cycle of making—testing—adjusting. The ideal firm will, for example, be constantly measuring the reaction of the market to its product rather than waiting to do so until the sales fall off.

It is this rather broad conception of quality control, a conception which includes outside influences which should be allowed to modify the specification as well as that internal control which ensures conformity with specification, which is characteristic of American practice today. The methods and techniques employed are not very different from those we are accustomed to in the United Kingdom, but the organisation required is different.

The Organisation for Quality Control

This broadening of the field of operation of quality control requires a quality control department to undertake tasks additional to the ones usually assigned to inspection within the factory. But since these tasks are directed to the same end as inspection, namely the control of quality, it is natural for quality control and inspection to be co-ordinated. The results of work in the new field, however, are to be used to modify design and specification, things which should be the firm foundation for the manufacturing part of an organisation. Thus the new quality control department must take its place alongside 'design and methods' and on an equality with them and with 'production.' It is not, however, solely for this reason that the new organisation requires a head in the first rank of the management hierarchy; it is also because top management have also a duty to check the operation of the organisation it has set up, a duty it can delegate to the quality control section but only if that section is directly responsible to it. Thus the need is for an organisation with its head free from the day-to-day difficulties of production yet with parts permeating the whole. Such a requirement is not unique; it is that, for example, of the accounting service and of the personnel department. The manner in which such a functional organisation can exist in parallel with an executive one like the production organisation has been discussed by Mr W. B. D. Brown.[2]

One of the early tendencies when mass-production techniques were new was the separation of the two functions of production and inspection. The two were regarded as incompatible and not to be exercised by the same person. In fact, it has been the deliberate policy of some to set the producer against the inspector so that one could press for greater production while the other opposed this as far as was necessary to maintain quality. Such conflict cannot be productive. There can be no escaping the fact that good quality is only achieved if everyone is working to that end without conflict. The American realisation of this is summed up in the slogans used in the factory: 'Quality is everybody's business' and 'Quality depends on me.' The type of organisation adopted by American management gives back to the production departments the responsibility for quality while still keeping the functions of inspection and production separate. A shop superintendent pressed to keep to a schedule may be tempted to relax his standard of quality in a particular instance; but he is less likely to do so if the exercise of

the inspection function by another person, reporting to him the result of the inspection, leaves him still with the responsibility for quality.

A typical form of the organisation network is shown in the chart of Fig. 1; where there are several plants in the same manufacturing organisation it is even more important that the central administration shall contain a quality control organisation with its own links with the inspectorates of the separate plants.

In these new quality control departments it was interesting to come across the new designation of 'quality control engineer' or 'quality engineer.' Those who employ them are emphatic that they should be engineers who have gained a knowledge of statistics rather than statisticians with a secondary knowledge of engineering. As many as six were encountered in one firm. They were employed on the analysis of the reports on quality from the various sources, on the solution of production problems, and in the instruction of foremen. Not infrequently their statistical knowledge is gained from a short, intensive course at a neighbouring university; it is rare that a man will go to the firm fully equipped in both engineering and statistics.

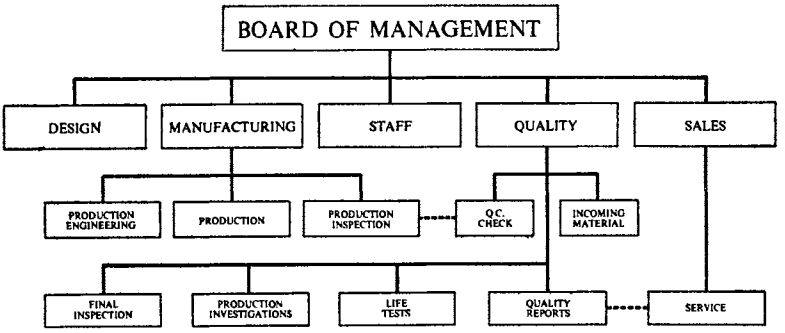

FIG. 1. Organisation chart showing the position of the quality control department.

The Activities of a Quality Control Department

In America, quality control like most other topics has been the subject of many lecture courses and has consequently been methodically dissected and its basic principles stated. This scientific approach is of value, of course, in enabling consistent applications in differing situations. On several occasions the writer was shown how certain parts of an organisation satisfied these basic principles that were being taught.

For example, in each of its fields of activity a quality control department can be thought of as fulfilling in varying degrees the three functions already mentioned, of accepting or passing good articles, preventing bad articles from being made, and reporting on the levels of quality achieved. The reporting forms an assurance to the management that its aims are being fulfilled and to the consumer that the goods are suitable.

Of these three functions it is acceptance that has been predominant hitherto. The others are called into play only by the broader view now taken of the duties of a quality control department. The exercise of the acceptance function makes the department the arbiter of what is good or bad, that is, the interpreter of the specification. Such interpretations can naturally be most effectively made by a department that also has as one of its duties the analysis of faults found at later stages of manufacture and in the working life of the article after it has passed to the user.

The prevention function calls for experiment and investigation into materials and processes which are beyond what may ordinarily be expected of a production department. Long-term improvements in production processes and the tracing of causes of production troubles can also be listed under this function.

The assurance function is given great importance in the newer fields allotted to quality control. The department is thought of as exercising the delegated checking function of top management and so must make reports which form a kind of audit for management. Such reports are in fact essential if management is to keep any control over quality. They can be as detailed or as summary as is desired, but when detailed they have the further use of promoting some rivalry in the field of quality between plants or between shops. For this purpose there is no reason why some general measure, a quality index, should not be used for comparative purposes. If the reports give the amounts of scrap they form a means for management to check efficiency as well as quality. The assurance afforded by the activities of a quality control department extends to the user, and this fact is often used in sales publicity.

The four main fields of activity in which these functions are exercised are (*a*) the inspection of incoming materials, (*b*) inspection during production, (*c*) final or functional inspection, and (*d*) the collection, analysis, and interpretation of service reports, life tests, and customer complaints.

Incoming Materials. Most manufacturing organisations need to keep some check on the quality of their raw material. When the 'raw' material consists of finished parts which are to be assembled the work can assume great proportions, and the help of special methods is extremely desirable both to reduce the cost of inspection and to save the cost of holding and storing between delivery and use.

The inspection work on these 'bought out' goods is often duplicated, since the supplier also needs to inspect in order to control his own quality. Further, the purchaser's inspection must often be carried out on a large scale because information about order of production and state of control of the manufacturing process is not available to him. These two major causes of wasteful expenditure have naturally received attention and the larger firms especially have achieved a large measure of co-operation with their suppliers. This co-operation may consist of a record in the form of a statistical quality control chart covering

production before, during, and after the production of the batch, or of visits by the purchasing company's inspector to see these charts from time to time. The initiative to install the statistical quality control system has usually come from the purchaser, but one supplier met with was in the habit of sending the equivalent of a sample frequency distribution with each batch of goods.

In this field of inspection the acceptance function is obviously very much to the fore, but the new development just described is of the nature of defect prevention. The records kept of each supplier and the remainder of the activity in general form an assurance to the rest of the purchaser's organisation that the articles purchased will be suitable.

Inspection during Production. In keeping with the principle that the producer is responsible for the quality of the work he does, the main work of inspection in this field was found to be carried out in very close touch with the production department. Where there is a strong quality control department actively engaged in the other fields described, it is not unusual for production inspection to be managed by the production department itself with the quality control department acting as advisers and making their own check on the inspection from time to time. In view of the very strong responsibility for quality required to be carried by the head of a production department this is a very good arrangement. The production head can be assured of a rapid redeployment of his inspection force when circumstances require it, and a lot of the old antagonism between 'inspection' and 'production,' especially at the operator level, disappears.

The break which is thus made in the vertical chain of functional authority represented in Fig. 1 need have no adverse effect on standards of quality, since the quality control department still retains a measure of supervision and especially since the final inspection is then usually left entirely in its hands. The production inspectorate gains by having its long-term production difficulties investigated by a staff trained in statistical analysis, a training which is required for the other activities of the quality control department but which might be considered unnecessary for production inspection staff.

Final Testing or Acceptance Inspection. Where the production inspectorate and the quality control department are divorced in the way just described it is usual for the final testing to be carried out by the quality control department, who are then able to report on the quality of the articles actually emerging from the factory. They thus exercise their assurance function to top management besides intercepting any faulty articles before they reach the customer. As receivers of the articles from 'production,' and being independent of 'production,' they are able to take the customer's point of view and report accordingly. The information they can pass back can also be used to improve the quality of production.

According to the nature of the product this stage of inspection is carried out either by sampling or by total inspection. The fact that

this is the last stage before the article reaches the customer leads many firms to make a very thorough and total inspection. If sampling is used it must usually be the rather large-scale sampling used for batches, although in some cases the readily available knowledge about the order of production and about the control during production enables the sampling to be reduced to the proportion needed for statistical quality control charts.

Final testing often consists of, or is combined with, a functional test, especially of such complicated articles as refrigerators, motor cars, and radio sets. The information gained during a functional test is of importance to design and methods departments as well as to the production department, so is more properly the sphere of the more widely based quality control department rather than the production inspectorate.

Outgoing Goods. By the time the manufactured articles are packed and on their way out of the factory there should be very little that has escaped the inspection net. What there is, however, could be important in terms of time and work required to make corrections after the articles have gone out of the factory into the hands of the ultimate consumer. It was not unusual, therefore, to find the quality control department taking a small sample of the outgoing goods, unpacking them, perhaps after simulating the treatment received by the package during a journey, and giving them a thorough examination and test. In addition to checking on what is happening in the packing department much can be learned by such a practice. Where a reputation is at stake it is not uncommon for the manufacturer to make purchases of his own products in the open market in order to make a similar check at a still later stage.

In the Field. The work of the quality control department in the field, that is outside the factory, consists of the collection and analysis of customers' complaints and of reports from the sales organisation and from the service engineers. The recognition of these as potential guides on quality and their channelling through a department having intimate contacts with the departments concerned with design and specification are major factors in reducing the lengths of the periods when the quality is, as it were, 'out of adjustment.'

Statistical Techniques in Use

Bearing in mind that the firms visited were chosen as leading in the latest practices it was not surprising to find sampling methods in extensive use; what was surprising was to hear them sometimes described as new. The history of the development of statistical methods was, of course, well known to the few, but there, as here, must exist many firms to whom they are new or even unknown.

Total inspection was by no means abandoned, but economies had been effected by passing to the sorting room only those batches judged on a preliminary sample to be below a given quality. Incoming stores

in particular were dealt with in this way, the irregular load on the inspecting staff being evened out by supplementing with non-urgent work of a routine character. One firm had gone to an unusual amount of trouble over the randomness of its samples. The inspectors were supplied with lists of random numbers suitable for various batch sizes. They had, too, a table marked out in numbered squares on which a batch of small articles could be spread as a preliminary stratification.

The same firm had developed the 'lot-plot,' a sampling method of delineating a frequency distribution and of calculating confidence limits for the quality of the lot.[3] This 'lot-plot' had been reduced to a standardised routine, so that in addition to its regular use it can be called for by a quality engineer studying a special problem to provide him with the data he requires without having to give detailed instructions.

The Munitions Board has published a Standard[4] containing a selection of sampling schemes suitable for quotation in military inspection specifications. This standard was frequently referred to by firms as the source of their sampling schemes. In fact it appeared that government inspection had played quite a large part in spreading knowledge of sampling techniques; it was recalled, too, that many of the study groups which later formed nuclei for the American Society for Quality Control had their origin in government-sponsored lecture courses during the 1939–45 war.

The extent to which control charts were used was variable. In some plants they were prominently exhibited on almost every machine as an incentive to the worker; in others they were in use only on troublesome processes and might only be used for a limited period. The firms visited were mostly fully aware of the advantage of measurement over go/not-go gauging in detecting changes in any process. The additional cost of the measuring instruments compared with gauges was considered well worth while, though this opinion must of course be considered against the background of their usually large production. On the other hand, go/not-go gauges have to be made specially for each job, whereas sensitive measuring gauges are now standard articles.

The Inspection Specification

Within the factory the word 'quality' can refer only to degree of conformity with specification; the absolute or specified quality of the article being made has already been decided by the manufacturing policy of the firm. Great importance seemed to be attached to the completeness of this specification, since anything lacking in this gives an opportunity for the misunderstandings and deviations which produce the unwanted variations in the final product. In particular, the specification or one copy of it will include the detailed instructions for inspection, the special properties to be looked for, the gauges needed, or the sample size to be used on batches.

Publicity for Quality

It appeared that in most of the firms visited the organisation for controlling quality had been installed to the accompaniment of much publicity within the plant. The opportunity would be taken of a major reorganisation such as occurred at the end of the war contracts to seek out the latest techniques in each branch of management. Having decided on a quality organisation and chosen the head and his assistants the management would let its interest in quality be known in no uncertain terms. One firm was reported to have engaged an advertising firm to plan the introduction of a quality 'programme.' A special number of the house magazine would be devoted to the subject, posters would be displayed, and competitions would be organised for slogans. More important still, some such evidence of interest on the part of management was planned to be continued.

At the back of this policy of publicity was the realisation that the inspection and quality departments by themselves cannot produce the desired result. Quality must ultimately be the responsibility of the production department, of the individual operators; all that inspection can do is to assist by providing the information. Its function of refusing to pass on the bad-quality goods does not in itself produce quality. The quality publicity was therefore, with reason, directed at the operators and all directly concerned with production.

It was not as a rule found feasible to relate bonus schemes to quality, though group bonus schemes might be so related. The difficulty was that so many operators were involved in the production process that any assessment of blame involved much argument and it was considered worth while avoiding the consequent friction by basing the bonus only on group quality.

The American Society for Quality Control

The real evidence of the upsurge of interest in quality in manufacture which is taking place at this time in America comes from the activities of the American Society for Quality Control.

Nothing quite like this society exists in the United Kingdom. Membership is open to all interested in the activities of the society. It issues a monthly magazine, *Industrial Quality Control*, available only to members and to libraries, containing news of section activities and members together with articles on the subject of quality control. The membership is over 4 500 in 53 local sections, including one in Canada and one in Mexico. These local sections were formed as a result of the government-sponsored lecture courses on statistical quality control given in the industrial centres during the war. In many cases a discussion group continued as a local quality control society; it was not until 1946 that a move was made to unite them into one society.

More recently a decision had to be made whether or not to become a section of the American Statistical Association. It is significant that the decision not to do so was made on the grounds that the subject of

quality control is a wider one than the statistical techniques known by that name and that to join forces with an avowedly statistical body would restrict the membership. The decision has been justified by the large increase of membership which has resulted from a statement of these wider aims, and by the large attendances at section meetings and society conferences. It is evident that, all ranks of industry being eligible to join, a new source of membership has been tapped.

Many of the sections or local chapters of the society offer instruction, in the form of either 'clinics' held just before chapter meetings or an instruction course preceding a conference jointly arranged by several sections. At a 'clinic' members' problems, usually matters of actual experience arising from their work, are discussed by a panel of the more knowledgeable members of the section, often including a member of the teaching staff of the local university.

I attended one session of a 'two-day intensive training course in elementary statistical quality control' arranged to precede the Sixth Mid-west Quality Control Conference of the fourteen mid-west sections of the ASQC. For this a large ballroom of a Chicago hotel had been equipped with a public address system and desks for the 120 or so students. A printed manual gave full notes and diagrams for the twelve lectures given by lecturers drawn from the four universities of the area. The active co-operation of the Chicago Association of Commerce and Industry in both the conference and training course had no doubt done much to bring about the large attendance. The time-table and titles of the sessions are given to show the scope of the course.

Monday

9.00– 9.50	What is statistical quality control?
10.00–10.50	Interpreting industrial data
11.00–11.50	Construction of average and range charts
1.30– 2.20	Using an average and range chart for process control
2.30– 3.20	Frequency distributions and control charts. Process *vs* product. The normal distribution
3.30– 4.20	The control chart for fraction defective—what it is and where it applies

Tuesday

9.00– 9.50	Using fraction defective charts in industry
10.00–10.50	Other attribute charts and their use in industry (number defective, defects/unit, and average defects/unit)
11.00–11.50	Fundamentals of acceptance sampling
1.30– 2.20	How and why modern sampling plans work
2.30– 3.20	Choice of sampling plan—single, double, multiple; how they compare
3.30– 4.20	Available standard sampling plans: Dodge-Romig, Military Standard 105A

It was not clear what class of person would benefit from such a course. It was much too condensed to serve as the training for the quality engineers referred to earlier; yet it might serve as a means of recruiting to this new profession, since many, though already made curious by hearsay, might not without some short introduction such as this ever be tempted to go more deeply into the subject.

This new profession of quality engineer cannot yet be said to be firmly established. The larger firms who can afford to have men engaged full time on problems of quality employ them under this name or as 'analysts,' but as far as I could ascertain they are not trained as such but as engineers with a short added training in statistics, often received after joining the firm. The fact that the name is used is, however, a strong indication of the need for men with this compound training.

Conclusions

As a result of making such a visit as this and seeing for oneself the enthusiasm with which the task of controlling quality has been taken up by some of the larger firms one is inclined to say that the subject is comparatively neglected over here. Second thoughts, however, incline one to the view that the neglect is apparent rather than real. Here and there in the United Kingdom are to be found firms applying these principles, in part at least, and deriving much benefit. What is missing is the methodical study and enthusiastic application by the younger staff which come from discussion, lectures, and the exchange of experience. This may be the reason why more firms are not found following the lead given.

In its current form, quality control is a management subject even though its techniques may be statistical. Enough has been said above to show that successful application does not necessarily require students of statistical method; in fact the participation of practitioners in all branches of management is required. It follows that the opportunity for and the encouragement of this exchange of experience must come not from a statistical body but from one interested in management and whose membership is not limited to any one class of worker. In fact the question arises 'Should there be a British Quality Control Society?' The answer must come from industry itself.

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