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THE QUALITY ASSURANCE CYCLE

INTRODUCTION

THE DESIGN AND MANUFACTURE of electronic capital goods has long been recognized as a complex business, and particularly so when the range is as wide as that marketed by The Marconi Company. The quality assurance system necessary to maintain a high product performance and reliability reputation is, not surprisingly, complex in its own right, and must continually develop to meet the demands of new manufacturing processes, new materials, new product design and special customer requirements.

There is no one correct quality assurance system and the best for any business is that most suited to its overall organization, personnel, products, facilities and its business trends. In a large company, therefore, the quality assurance system must admit variations in detail according to the needs of the separate commercial divisions and manufacturing sources, whilst maintaining company policy overall.

This article indicates the cycle of events comprising the quality assurance system in force at that part of The Marconi Company primarily concerned with broadcasting, communications and radar equipment, and traces the main considerations and actions applicable to a typical proprietary product.

ORGANIZATION AND RESPONSIBILITIES

The phrase 'Quality is everybody's business' is these days a rather hackneyed one—but no less true for that. Development of quality consciousness in everyone concerned with a product, from start to finish, and from top to bottom, is always a major management objective: but even so few companies, if any, can achieve their quality objectives without quality engineering and verification specialists. The development of these specialists, integration of them with the other essential skills, and the delegation of quality responsibilities throughout the organizational structure, largely determine the product quality and reliability that will be achieved.

The product divisions and works quality control organizations combine with central services assistance to form a complete quality assurance system. Whilst the works has its own quality responsibilities for the control of basic manufacturing processes, supplies, production verification techniques and package design, it provides a product quality control service to the product division, which oversees this service during manufacture whilst exercising full quality control itself during the pre- and post-manufacturing stages.

Central company services provide the policy guidance, standards and codes of practice links across all product divisions and all works organizations.

The following chart shows where responsibility rests for primary and secondary quality defining data, and the main quality assurance interests of the three organizations.

Product Defining Specification

Quality assurance begins as soon as attempts are made to compose the product defining specification. This

WORKS	CENTRAL SERVICES	PRODUCT DIVISION	
Production methods instructions	Material and component standards specifications	Product defining specifications	Responsibility for primary and secondary quality defining data
Test and inspection methods instructions	Process specifications	Customer-invoked specifications	
Purchasing orders	Workmanship codes of practice	Manufacturing drawings	
Packaging specifications	Quality policy guidance	Purchased item specifications (non-standard)	
Quality control instructions	Design guidance manual	Product test specifications	
	Design office practice instructions	Sales specifications	
	Quality standards	Special quality control instructions	
		Manufacturing orders	
		Contract supply requisitions	
Manufacturing process control	Company quality policy	Defining specification preparation	Quality control responsibility fields
Product verification during production	Company quality standards	Reliability studies	
Product test programme	Maintenance of standard component and material qualification approvals	Component proving programme	
Package specification and verification	Maintenance of standard defining documentation	Equipment proving programme	
Measuring equipment calibration and maintenance	Quality training	Project evaluation and appraisal (design consideration meetings)	
Failure analysis and reporting (during manufacture)		Generation of manufacturing drawings, test and sales specifications	
Defect investigation and reporting (post-despatch)		Generation of non-standard purchased item specifications	
Supplier evaluation		Chairmanship of critical appraisal meetings around first production quantities	
Supplies quality planning		Design improvement, modification control and records	
Supplies verification (internal and external)		Analysis of performance, reliability and failure feedback	
Issue of purchase and sub-contract orders		Issue of manufacturing orders	
Provision of material and process laboratory services		Issue of contract purchase requisitions	
Provision of environmental test laboratory services		Spares ranging	
Maintenance of essential quality records and production batch identities		Field installation and commissioning	
Issue of quality assurance documentation		Quality training	
Quality audits (manufacture and supplies)		Asssurance that sales contract is satisfied	
Quality training		After-sales service	
Critical appraisal of first production quantity			
Modification state verification			
Assurance that manufacturing order requirements are satisfied			

Responsibility for primary and secondary quality defining data and quality control.

specification is the management brief for the design team, describing all essential characteristics and qualities which are judged to provide good value for the target selling price set. The product defining specification provides the design objectives and in stipulating performance, service environment, reliability, serviceability, etc. it substantially dictates the equipment and component proving programmes necessary.

Supplies Quality Control Starts Early

The development phase begins by identifying the new technical problems posed and finding solutions which are proven in principle by bread-board models and the like. These initial steps are important in the quality assurance sense because engineers begin to select and purchase materials and components, creating working mechanical, electrical and electronic systems, some of which will be evident in the final design. Amongst those materials and components selected will be new items about which the company knows no more than given by the supplier, which is often very little as far as precise identity, repeatability and reliability are concerned. Development engineers are

Fig. 1. CCU printed circuit board assembly area.

responsible for specifying and proving the suitability of new items, but, alerted by the first purchasing orders, the supplies quality department will press for identification and specification in precise terms. By the time production quantities are ordered, at least, new items will have the backing of an agreed quality control programme covering such aspects as qualification approval, 100% tests, tests subject to sampling plans, acceptable quality level and, if required, certificated guarantees. Where thought necessary, the suppliers' capacity to provide satisfactory articles is evaluated.

The activities of the quality engineering and quality verification groups, which form the supplies quality department, continue throughout the development and design phase with quality engineers in the supply department always working closely with design engineers. It is convenient to mention at this stage, that as experience of new items is gained, the supplies verification group will swing away from 100% goods inward checking on non-critical items and adopt control check procedures, either at the supplier's works or after delivery, according to the recorded supplier's quality performance.

Preproduction Considerations

Manufacturing specialists are allocated from the outset to every major new project. A senior preproduction engineer is assigned the task of assisting designers to employ existing plant and processes as far as possible, at the same time looking for opportunities to employ newly installed (and usually more productive) facilities to the utmost. A senior test project engineer is also assigned to every major new project. He has responsibilities akin to the preproduction engineer but is concerned with testing instead of production. He specializes in test methods, techniques and measuring equipment, and is concerned to see that production test specifications form a complete performance verification programme. In advising design engineers on testing matters, the test project engineer endeavours to introduce automatic testing opportunities and the high-quality confidence provided thereby. In so doing, he can significantly influence accessibility, connection and termination methods, and layout. He will design special test jigs and rigs; feed advance information to auto-test programmers; arrange for training of production test staff; participate in product-proving programmes, and liaise with works inspection and quality control staff. He will ultimately follow the product into production, continuing close liaison with the designers until all problems are resolved.

The preproduction and test project engineers play a large part in the critical examination and appraisal of first-off production equipments—carried out to ensure that the products of full manufacturing planning and engineering satisfactorily meet the sales or customer specification.

The co-ordination of all available resources during the development and design phase is a major project management problem. This task is often performed by a senior official in the product division outside the engineering department so that the engineering manager, who has particular responsibility for quality control, can concentrate on his design and quality assurance tasks.

As circuitry, mechanisms and units take shape, the performance, reliability and life expectations for critical elements need to be established. Engineered models are manufactured, and type-proving programmes planned and brought into being. Information is continuously collected, analysed and acted upon. Spares are delineated, packing is designed and proven for various transit and storage environments, new purchased item specifications and process specifications are prepared. The skills deployed are many and various including mathematicians, chemists and specialist engineers of all kinds, e.g mechanical, reliability, environmental, standards and so on. The engineering quality manager's task is therefore formidable, eased only by company standards and

practices which provide the basic disciplines within which individuals operate.

The design and quality status gradually grows until the final design consideration meeting allows the last drawings and specifications to be finalized, vetted and issued for manufacturing purposes. The engineering/quality manager can then concentrate on overseeing the product through its production, test, despatch and commissioning phases.

Production Quality Control Takes Over

When drawings and specifications are issued and manufacturing orders placed, the production control department analyses the works task, provisions materials required via the supplies division and plans the whole network of operations and movements in calendar time to meet the delivery date. Production and test engineering departments issue detailed methods and routing instructions, provision tooling

Fig. 2. CCU printed boards on test with semi-automatic a.c/d.c testers.

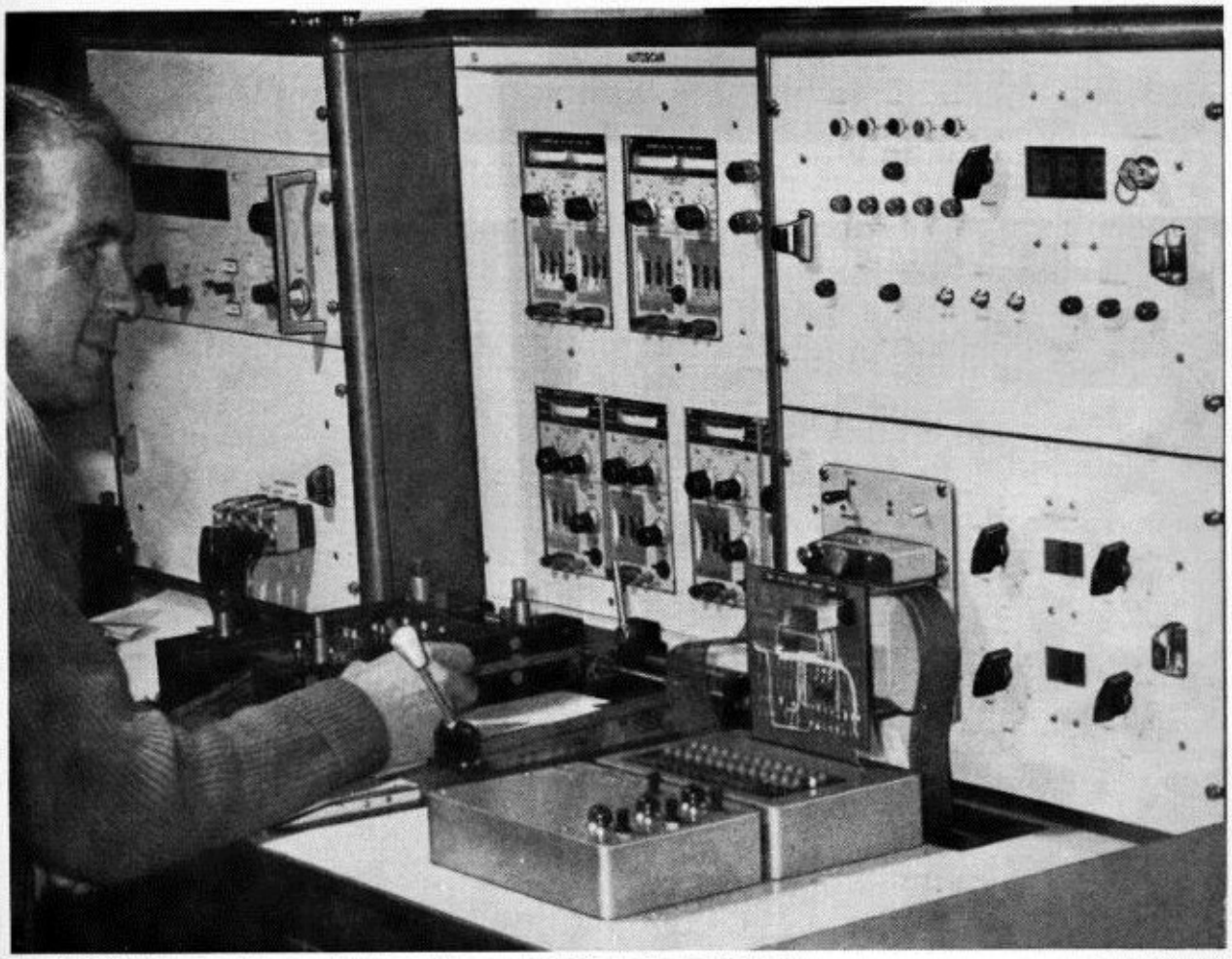

Fig. 3. Marconi designed and developed 'Autoscan' tape-controlled dynamic automatic tester.

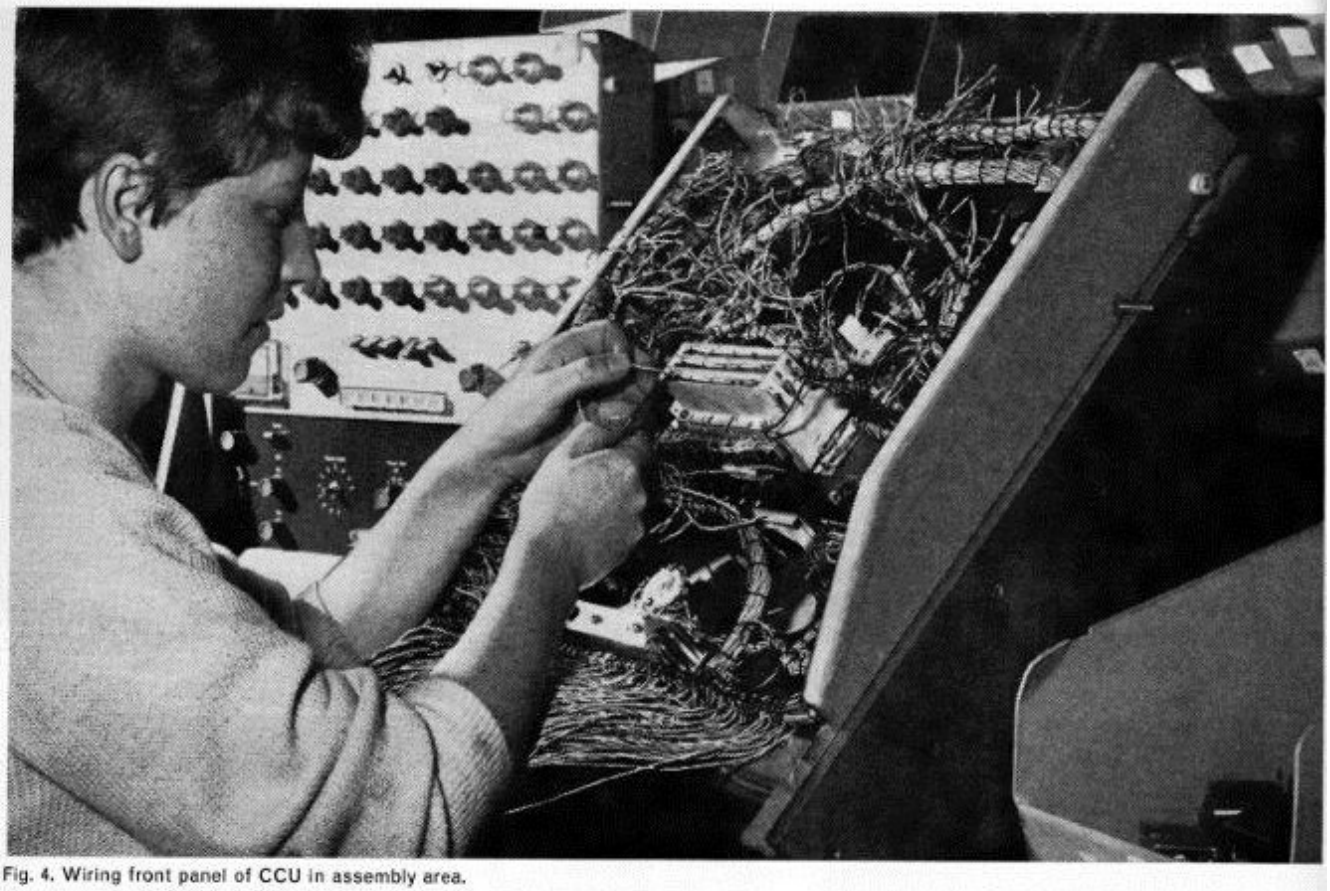

Fig. 4. Wiring front panel of CCU in assembly area.

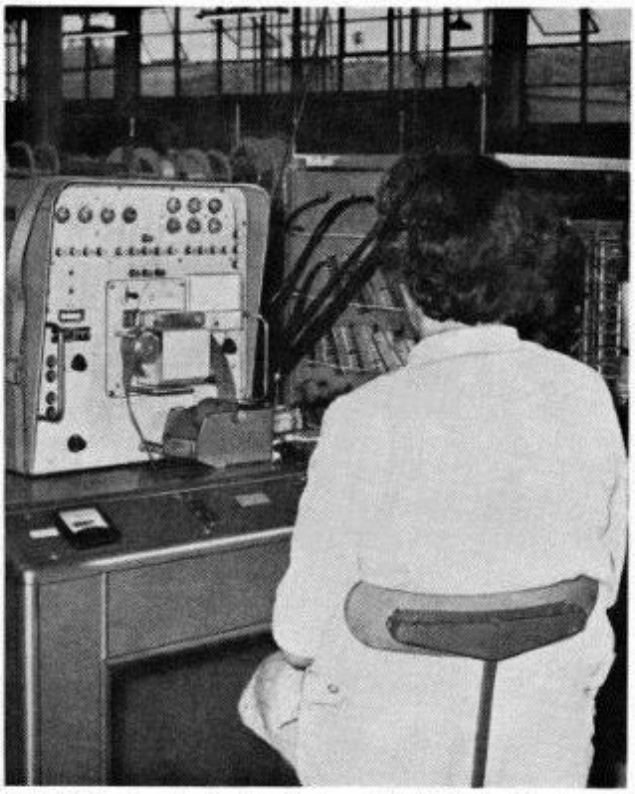

Fig. 5. CCU undergoing test on tape controlled 'Robotester'.

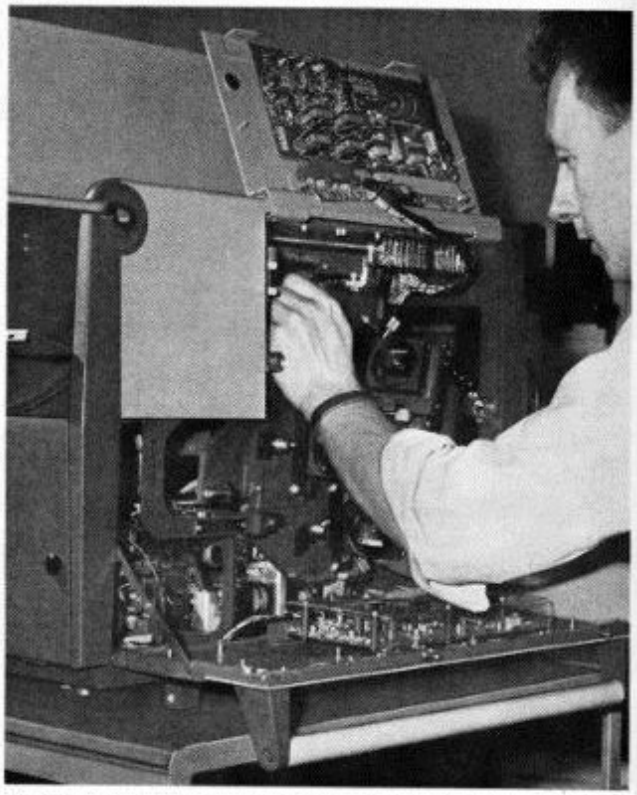

Fig. 6. Fitting precision-engineered optic bed into Mark VII camera body.

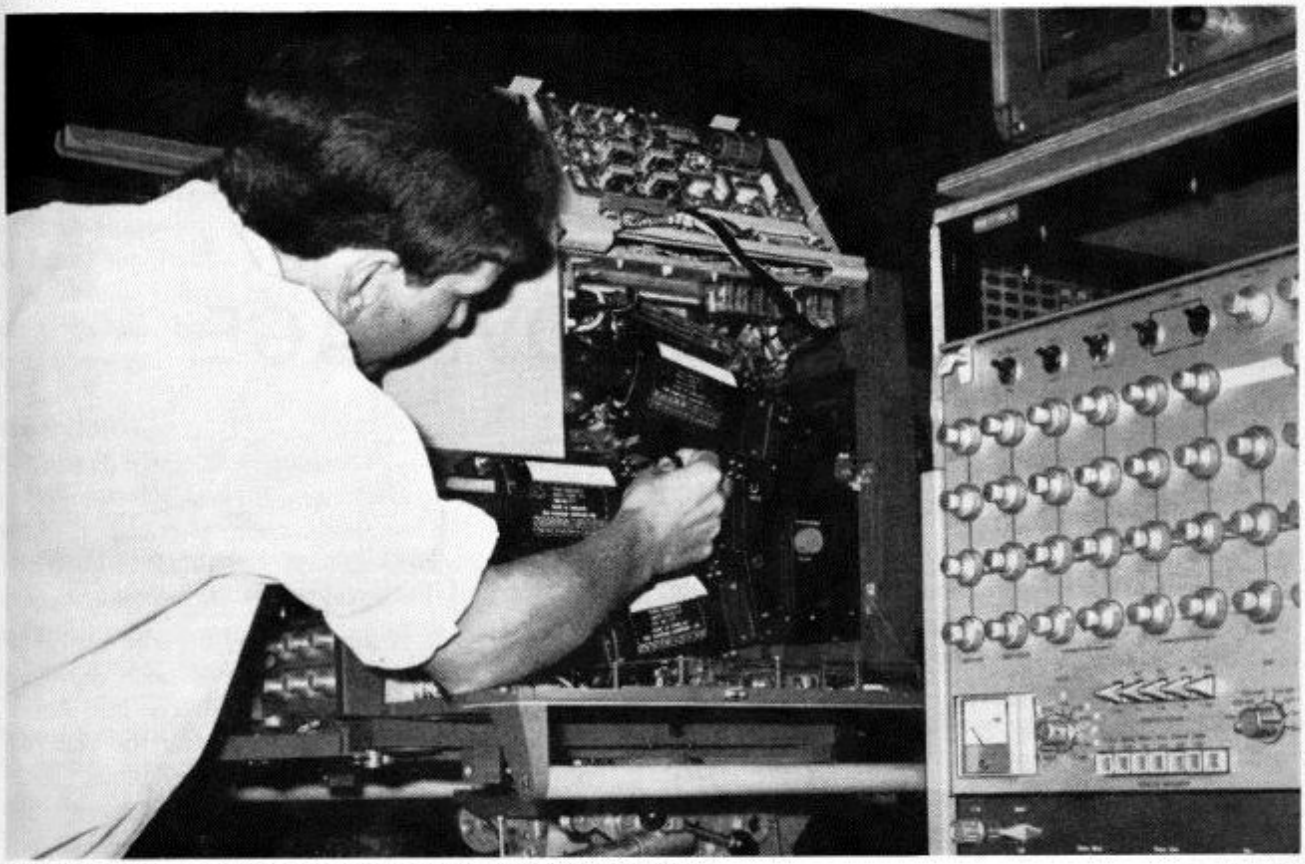

Fig. 7. Overall setting-up of camera chain, involving Mark VII camera and CCU.

and test equipment, and stipulate standard times for all operations. Production and test departments organize the necessary skills and facilities.

The works quality assurance organization controls across the whole manufacturing and material supply operation, including any sub-contracted work. As head of this organization the chief inspector is essentially responsible for satisfactory quality control of manufacturing processes, and verification of end-products fully to their drawings, specification and order requirements. An idea of the numerous other responsibilities which follow consequentially can be obtained from the chart.

All processes of manufacture are subject to direct inspection although the actual technique used will depend upon the nature of the process, and the criticality of its contribution to the product being manufactured. Work cannot pass from one operation to the next unless cleared by inspection, and the quality control documentation system demands final inspection clearance before units and equipments are passed to the test rooms. No deviation from drawings or specifications is allowed unless authorized by the chief inspector or the product division quality manager depending upon circumstances. Post-test inspection is carried out on complex equipments immediately prior to despatch, which amongst other things establishes that the modification state is up to date.

The Cycle Completed

Some customers carry out acceptance tests in the works before despatch while others need the equipment installed on site. In such circumstances site inspectors or commissioning engineers take over the final quality assurance phase before acceptance by the customer.

There is, however, a further phase involving product division field engineers, after-sales services and the customers. This is the collation, investigation and analysis of field information, for example the nature and frequency of failures, service hours logged, out-of-service time—all such information helping to formulate design or manufacturing improvement programmes. It is also valuable history when composing the product defining specification for a new project.