Part 2—The Design, Production and Quality Assurance Techniques for the Manufacture of Consoles, Assemblies and Units

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SYNOPSIS

This Paper will discuss two prime considerations - Production of Versatile Console Systems and Quality Control and Assurance during production.

The two subjects, although very much inter-related, will be discussed separately and will consider design, construction, production processes and techniques employed during manufacture of the necessary methods of defining and maintaining quality standards from initial design throughout the production period to final customer acceptance.

The versatile console system for a particular ship or application is designed in layout and console specification resulting from consultation with shipbuilders, constructors, navigational experts, ships systems and co-ordinating engineers. Consideration is given to all ergonomic anthropometric, physiological recommendations discussed in published data.

Also considered are the environmental specifications for the particular piece of equipment, such as method of mounting the console or assembly, the shock and vibration levels which the console must withstand and many other engineering and environmental features as incorporated into the specification by accepting authority. Also space and limiting dimensions features, such as internal access, method and size of ship's cable entries, heat dissipation within an enclosure must also be considered during the design.

DEFINITIONS

For production purposes, the VCS is considered as two distinct and separate elements -

1. Consoles and Assemblies
2. Units

Consoles and Assemblies employ different processes and manufacturing techniques from those necessary in Unit production. For ease of terminology definition, Consoles and Assemblies, the frameworks from which they are constructed, and Units which are housed in them, are defined as follows:

a) A framework is the housing into which boxes are fitted and wired. It is

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built of aluminium extruded members and cast or fabricated fittings from a range of Widney Dorlec components, manufactured by Hallam Sleigh and Cheston Limited (Fig.1).

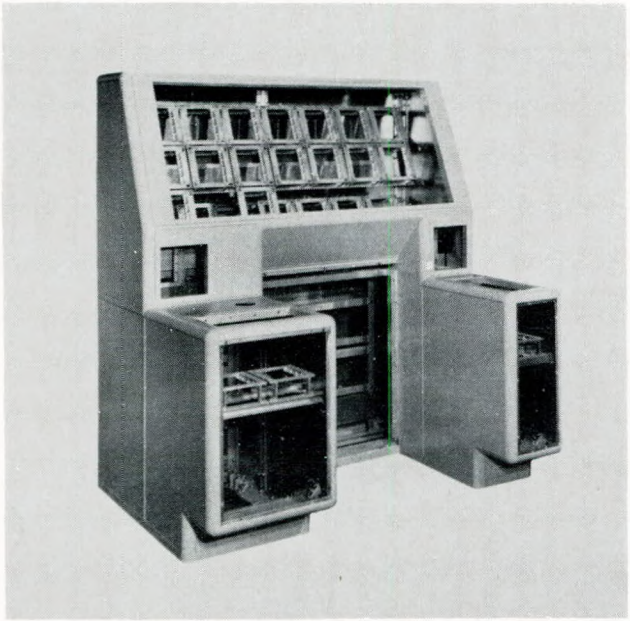

FIG. I FRAMEWORK

b) A console is a framework built to a specific design and shape and intended for mounting directly, or via anti-vibration shock mounts on a deck. The console is wired internally from plugs fitted at the rear of the boxes to terminal blocks normally mounted in the bottom section of the framework to accept ships' cabling, normally entering through the base of the console. Access to the terminal chambers is provided by a removable panel, or panels (Fig.2).

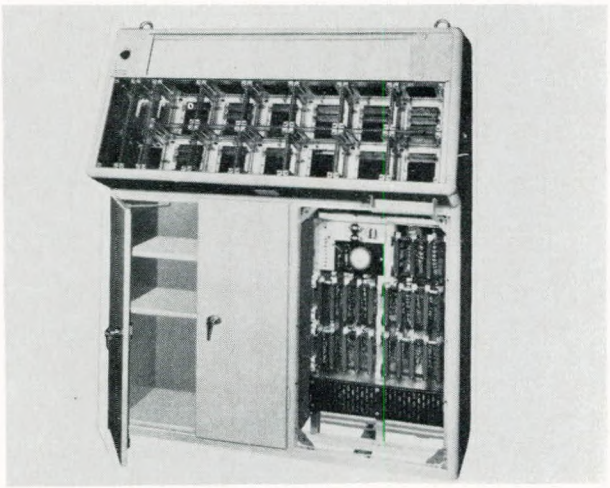

FIG.2 TYPICAL CONSOLE

c) An assembly is a framework intended for mounting, either directly, or via shock mounts, on a bulkhead, deckhead, or desk-top; it may not necessarily contain a terminal chamber. Ships cables may enter through any surface, except the front, and may be terminated directly on to the plugs at the rear of the boxes containing units, or on to terminal blocks, housed in a suitable position within the assembly (Fig.3).

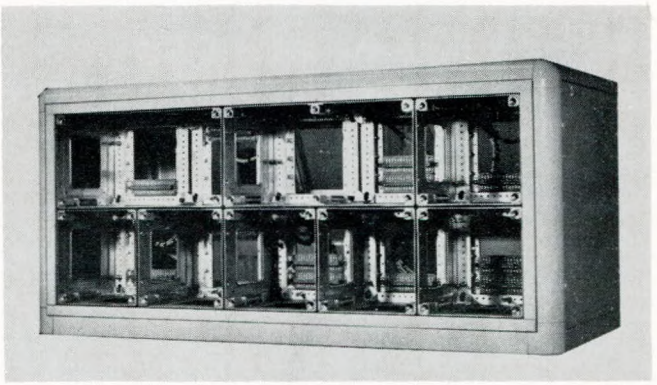

FIG.3 ASSEMBLY

d) The VCS Unit is a removable plug-in module, designed to fit into a range of standard boxes, housed within a console or assembly. Every unit is unique in design and is allocated a type number. There is no limitation of unit types, but each type has its own location spigot holes, to avoid interchangeability with units of different types. As well as M.O.D.(N) registered units, there are many which have been designed specifically for use within ships of commonwealth and foreign navies, using the VCS principles (Fig.4).

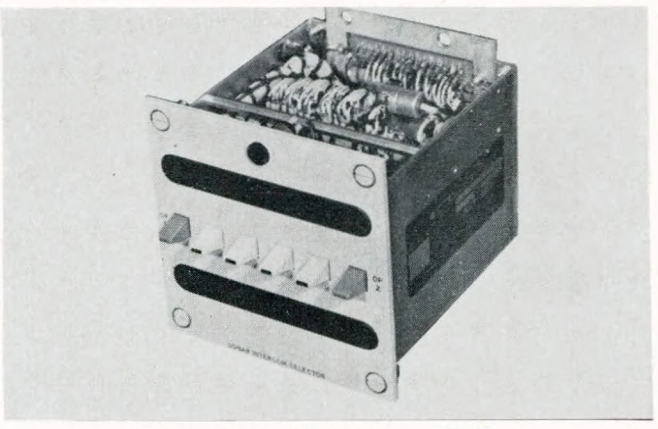

FIG.4 TYPICAL UNIT

e) A box forms the housing for VCS Units when they are fitted into a console or assembly (Fig.5).

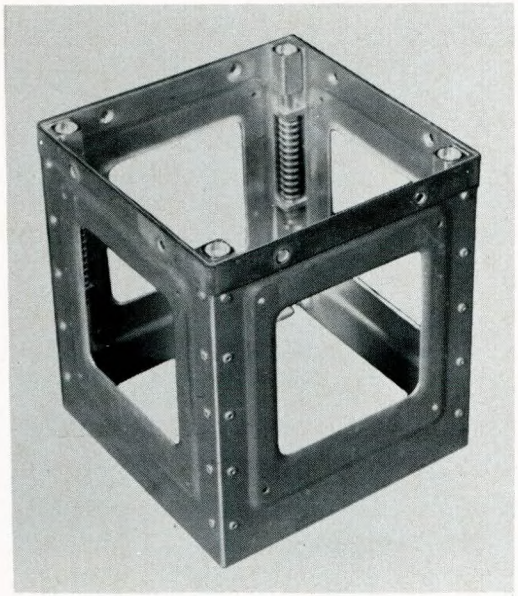

FIG.5 BOX ASSEMBLY

f) A number of boxes rivetted together to form a single nest is referred to as a multi-box (Fig.6).

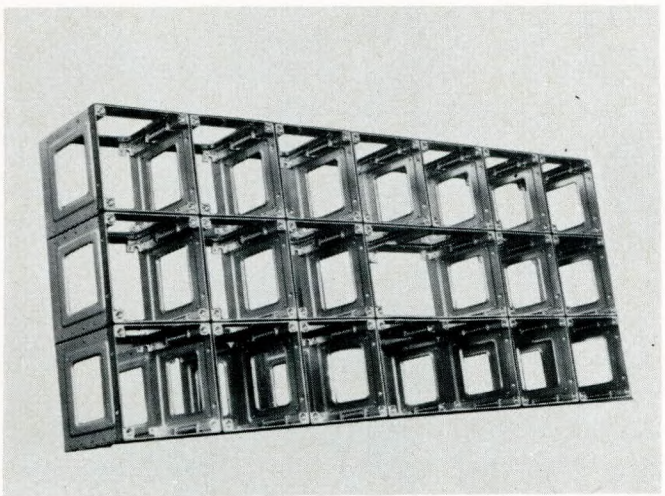

FIG.6 MULTIBOX NEST

These then are the major components of the VCS equipment. We now consider the design and production of each in turn, and as consoles and frameworks perform similar functions, these will be discussed collectively.

CONSOLE - Design

The general shape and design of the console or assembly having been determined, the draughtsman calculates the overall size and selects the necessary die castings and other standard parts from the Widney Dorlec range to construct the framework. Types of extrusions are selected and lengths calculated. To the framework drawing is added the necessary internal supports for the boxes, chassis to support ancillary components housed within the consoles, or assembly, and terminal chamber supports. Finally, boxes, as required, are added. At this stage, item lists are drawn up, itemising all mechanical components, electrical items are added at the end. Wiring schedules are compiled from circuit diagrams which show route, size, colour and number of each wire, screening and separation of sensitive circuits within the console, and will enable the complete console to be wired. In some instances, where a number of identical consoles are required, wiring is pre-loomed, but as the usual requirement is for small quantities, it is not normally economic to create loom drawings and boards. Drawings for boxes are selected from standard lists and specified within the master items list. Completed and checked drawings are passed to a Production Planning Department, to enable Shop routeing, processing, and finishing stages to be documented and monitored. The Chief Inspector is consulted as necessary to determine Inspection Standards, monitoring points and necessary documentation.

Production

Due to the large quantities used, standard parts and extrusions selected from the Widney Dorlec range are normally held in stock. Extrusion is accurately cut to length, tolerances being to plus or minus 0.1¼mm in a cutting process workshop. Internal members, strengthening gussets, supports, component mounting plates are manufactured by general sheet metal - working fabrication processes, using presses, guillotines and fitting skills. There are some machined parts, but these normally take the form of spacers, and studding, and are the exception rather than the norm, and where used, employ Machine Shop technique

The boxes used to house units are produced in large quantities and have therefore been fully productionised, For the basic 153 x 153 x 168 (standard box) the assembly consists of four die cast corner fixing brackets, to which are rivetted the side panels, forming a box. To the die castings are then fitted the plunger assemblies which form the ejection mechanism of the units. The need for ejection mechanism will be explained later. The boxes can be assembled into nests of 'multi-boxes' as required for a particular console or assembly. Where deeper or larger boxes are required, the method of manufacture is similar to that for standard sized boxes, except that for boxes deeper than 168, extension castings are used in the corners, and for larger boxes, using more than 4 corner fixings, additional unit fixings may be incorporated (Fig.7).

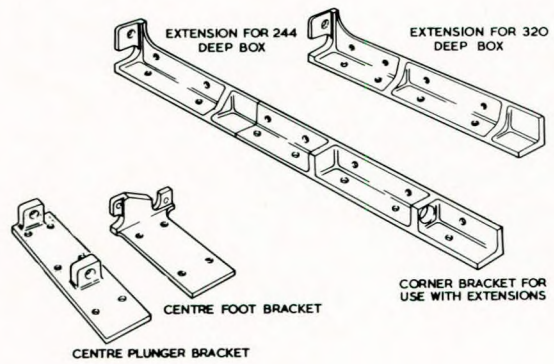

FIG. 7. ADDITIONAL CASTINGS FOR LARGER BOXES

The rear of the box assembly is open and designed to fit over the outer edge of the Plug Platform, which is a die casting to which is fitted the McMurdo Plug or Plugs, which provide the electrical connections into the back of the unit when screwed into the box and is the electrical interface between console or assembly and unit. The four faces of the platform are drilled to accept locating spigots in any one of ten holes in each side. The positioning of the spigots corresponds with spigot hole configuration allocated to each unit. Spigots also serve to guide a Unit into alignment for engagement of the socket on the unit with plug on plug platform, although the side spigots are considered to support the back of the unit, it is acknowledged that all spigots serve this purpose.

We have made earlier reference to an ejection mechanism fitted into the corners of the box and heard in Paper I that the philosophy of the VCS is based upon plug-in modules, having no trailing cabling or appurtenances, and being completely de-energised on removal from the console or assembly. Insertion of a unit is made by screwing the fixing screws into the plunger or ejection mechanism in the box, a few turns at a time to ensure regularity of movement of unit into the box and ensuring that the unit remains at 90° to the plug during insertion, thereby avoiding damage to plug and socket contacts by distortion or accidental impact. There is some mechanically controlled 'float' in the socket locating holes to allow for tolerance overlaps and initial location locking, which also ensures accurate alignment. The corner fixings are part of a spring-loaded plunger mechanism which is 'free' when unloaded and fully depressed and loaded when a unit is fully located in its box. (Fig, 8 shows the assembly parts).

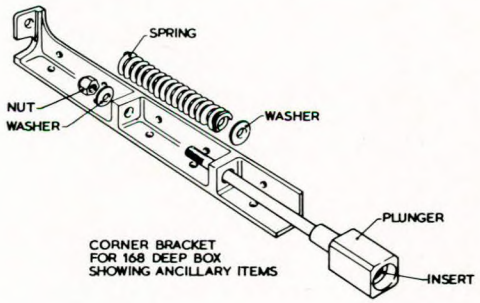

FIG. 8 EXTRACTION MECHANISM

The mechanisms are depressed as the captive screws are tightened separately into the fixings. The mechanism is required to overcome the force of 7.25Kg , which is required to fully mate a 32 contact McMurdo red range plug and socket. To determine a standard for the spring load, consideration has been given to a standard unit having a maximum 4 sockets, total

force required to mate, or disengage would be 29Kg . On engagement the plug exerts the force, on disengagement, as the fixing screws are slackened, the compressed springs are released when the plug force is overcome, thus releasing the unit, which can then be pulled easily from the box. Each spring thus exerts a force of 7.25Kg .

The final assembly of a box is completed by the fitting of a 12mm wide rubber strip bonded to the sides of each box (over-lapping front edge). The strip acts as a seal between the rear of the front panel on a unit and the box asisting in preventing ingress of dirt or dust and some protection against water in emergencies. An assembly flow chart is shown in Fig.9, indicating sequence in which parts are assembled. Boxes are assembled singly or into multi-box nests prior to commencement of assembly and checked with gauges.

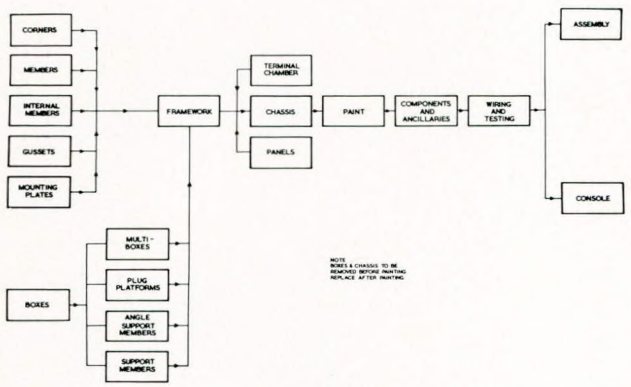

FIG.9 CONSOLE AND ASSEMBLY CONSTRUCTION CHART

Console build technique is by joining die casting corners to extrusion lengths by screws, bolts and nuts, and following an assembly sequence shown in Fig.10. Corners and extrusions are blended where necessary to achieve smooth corner areas. It should be noted that a finishing process is shown at an advanced stage in the assembly sequence. VCS equipment is used primarily in an air-conditioned or protected environment and painting by a stiving process, is specified only for external faces and edges of consoles and assemblies.

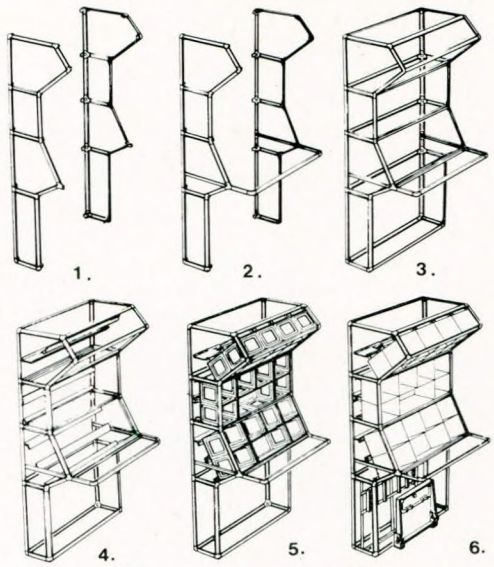

FIG.IO FRAMEWORK ASSEMBLY SEQUENCE

The painting stage is followed by completion of mechanical assembly, including fittings of ancillary items, such as ashtrays, stowages for various items, panels, doors, footrests and cupboards, where specified. Electrical components, which include alarm bells, transformers, relay banks, etc., are finally incorporated into their specified positions. The cabling and wiring is then commenced, cables are sized, identified, routed and segregated in accordance with the wiring schedule of the equipment being worked.

Discretion must be exercised when routeing, to ensure that speech circuits, higher than normal frequency, i.e. 400 Hz lines, are run in twisted pairs, or triples, and separately loomed. There are other considerations, such as screened cabling on discrete circuits, and these are determined by the engineers when preparing circuit diagrams and wiring schedules. Linking between unit plugs is normally considered 'non-preferred' practice, but should be carried out at input terminals which have linking facilities. In instances where special screened boxes are incorporated for interference sensitive circuits into the console assembly, wiring to these may be direct by shipbuilders cables through filters, or specially segregated in terminal chamber for these services. The terminals normally provided

in consoles are the 20 pole, 60-way taper pin type and are for up to 440V A.C. with a current rating not exceeding 5A. Cables larger than 32/o.2 (40/0076) would have to be accommodated within suitable terminal blocks and the services specifically nominated. A console must incorporate within its circuitry the means of dimming all illuminations on the units in that console, dimming is achieved by routeing a ship's 115V supply through a transformer housed within the enclosure to produce up to 50 volts to the dimmer control. Illumination for all units within the console is controlled through the dimmer control unit, and units are designed to incorporate dimming facilities. On completion of all wiring and loom anchoring, the console is thoroughly cleaned internally, to remove snips of loom ties and other items of debris which are dropped and accumulate in the base during the assembly process. The assembled item is now complete, less panelling, ready for submission to preliminary inspection.

Inspection and Test

The assembled item is submitted to an inspection, which consists of visual and mechanical viewing of component mounting, cable runs and looming technique, and general cleanliness. Electrical check out commences with exhaustive point to point continuity checks, formulated to detect dry joints, loose component connections and ensuring compliance with earthing requirements of VCS specification. Functional testing follows where specified and is confined to consoles or assemblies incorporating alarm circuits, relay networks, or similar circuitry, and is designed to prove circuit integrity and component operation. Units are not normally fitted for console testing, as ships operational simulation is not a requirement for testing of a console. On completion of electrical inspection, panels. doors, identification labels and a print of the circuit diagram are fitted. The console exterior is cleaned and polished, and final inspection carried out, after which serialised records and documentation are completed, which enables the equipment to be despatched. Final inspection concludes the design, production and completion of VCS Consoles and Assemblies.

VCS UNITS

The VCS Unit, or module, is one of a large family of over 500. The function performed by units is diverse, from a single indicator lamp to sophisticated automatic steering, fire control and weapon firing systems. Design commences with a circuit, designed to perform a function or conform to a Statement of Requirements by a system designer which specifies the unit operation. Units vary in size from 152 x 152 x 154, excluding plug, to a recommended maximum of 456 x 456 x 306, designed in 75mm steps, providing that the packaging of the components conforms to the design parameters and constraints of the VCS system. The basic requirements of a unit are that it shall have a front, side panels and a rear panel, which is identified as the socket mounting plate. The front panel design must incorporate the captivated fixing screws in each corner and in the case of units in excess of 152 x 152, there should be further intermediate fixings. There is an alternative fixing, a cam-operated handle, but this is restricted to specialised radio and communication units, The front panel presents all the information and controls for the operator's use, there is no access to sides when in an operational mode.

Service requirements demand operation of units in all intensities of light. For this purpose illumination of dials, identification labels and such other functions is specified. A further demand is that units which incorporate instrument illumination or illuminated legends must be capable of being dimmed. The means of illumination is by incorporation of edge or dial lamp fittings which direct light into the movement face, or sandwich type opaque plastic panels which, when engraved, allow light only to pass through engraved

legend. Dimming is achieved by inter-linking all units through a control dimmer unit supplied through a transformer, ensuring that the voltage for the lamps is controlled to correct levels. Units designed to impart information by pointer movement on a dial, i.e. shaft speed, wind speed, ships head, drive for the pointer is normally through syncros, energised from respective systems. The necessity for accuracy in positioning the syncros mounting and gear mechanism necessitates the panels being jig-bored to an accuracy of $\pm$ .002mm, and normal side panels would be unsuitable, for such units a slight variation to design of assembly is necessary. Accurately manufactured support spacers are fitted to the rear of the front panel, which support a syncro mounting plate, and this supports shorter side panels and so builds up a unit which maintains the accuracy required for syncro mounting, and also enables components and other ancillary items to be mounted on a sub-chassis attached to a side panel variant. For a majority of units, the front or side panels provide the mounting for components within the unit or sub-chassis to support other sub-circuitry.

Recent advances in the use of L.E.D.'s, logic boards and mother-daughter printed circuit board techniques has led to many variations of layout of a conventional unit. As technology produces miniature components currently found in integrated circuit chips, units are tending to become miniature systems and can achieve a high degree of sophistication. Wiring techniques used within units are of a general nature, cables have maximum rating of 5 amps, and as the loading on circuitry within a unit is always within this maximum, cable size does not normally present space problems. Cables are identified and sleeved at both ends and tied at suitable positions along their runs. To overcome movement experienced during certain vibration frequencies. looms are attached to chassis or panels, where suitable.

Unit designers are free to select positions of sockets on the socket mounting plate which best suit their needs or component layout. Constraints are imposed ensuring that socket orientation is consistent and certain contacts on Socket A (which is the top position of four possibles) are reserved for common services, such as earth bonding, instrument illumination and indicator supply. Choice of components is restricted to Preferred lists as first option, but availability and obsolescence may restrict choice. Care must be exercised to ensure that individual characteristics are compatible within the circuit. On completion of design, drawings are prepared for approval by the specifying authority and from approved circuits, wiring diagrams and schedules are drawn up, which include routeing, sizing, and identification of all cabling in the unit. Detail drawings are produced and on completion, a test specification is compiled by the engineer responsible for design, in conjunction with the Chief Inspector. This becomes the definitive test document and standard against which all units of that type are accepted.

Production

Production follows the general pattern of small electrical assembly technique, quantities required determine the means of manufacture of piece parts and procurement of components. It is considered that as all 152 x 152 units require a basic front panel with four fixing holes, these parts are produced in large quantities and machined to suit the particular requirements of an individual unit type. Similarly, socket mounting plates are pressed out in basic form with one socket cut out, and the most frequently used panel incorporates one socket facility so that stocking of this part is both economic and convenient. Further socket cut outs can be punched out as required and the unique spigot holes drilled or punched to suit. Side panels are produced in economic quantities and modified to suit individual applications.

Over a period of production, a pattern emerges of the commonality of certain electrical components, such as resistors, lamps, diodes and relays. These are procured in viable quantities and used as required, the question of specialist items for specific units is treated as peculiar to that unit or family of units and procured accordingly. The techniques employed in assembly shops is indicated by the type of assembly. For electrical units, it has been found that assembly of units is best effected by persons exercising a high degree of dexterity, and with the ability to work in confined or restricted spaces, and correctly identify small and delicate components. For units which incorporate syncros or similar drives to gear trains, the assembly sequence and skills employed will be necessarily different. Instrument fitters are necessary to assemble and position gear trains before passing the unit to electrical assemblers to complete the wiring.

Quantities of a particular unit determine the assembly process employed, all parts are finished prior to commencement of assembly, including legend engraving and component identification. Assembly commences with front panels and is followed by sub-chassis assembly, these are wired, 'idented' and cabling tied, allowing a loom to be formed which will be attached to the McMurdo socket. Intermediate on-line inspection is carried out where necessary. On completion of all wiring and attachment of an identification label, the units are submitted to the Test Room, where inspection is carried out on components and wiring, and also for overall size in a go-no-go gauge; spigot positions are compared against a central VCS register. The unit is finally submitted to a functional test against a test specification, serial number and modification state confirmed, and test documentation completed.

As there are over 500 types of units and many manufacturing processes and techniques employed, the foregoing is an outline of general units, the design and production of which has been generalised within the context of this Paper. Many designs exist and are in production for Ministry Departments and Shipbuilders which comply with the philosophy, but are somewhat different from conventional construction. Even so, the design philosophy remains for all VCS Units, no matter how complex or simple may be their function or performance.

QUALITY ASSURANCE

When the committee of Defence Equipment Inspection Policy published their report in 1969, there were many important recommendations which affected defence equipment contractors. Considered to be the most important was that the Defence Procurement Organisation should evaluate the technical competence of potential contractors before placing defence contract with them and, further, that only firms with adequate quality assurance arrangements should be invited to tender. 1972, saw the adoption of rationalised specifications originating in NATO and approved by industry.

One can consider the number of differing types of companies at that time manufacturing defence equipment, from the multinational, to the small sub-contract machine shops. Inspection standards which exist depend on complexity of the item produced and also size of quality assurance department which a company is prepared to set up within its own organisation. The question was posed, "How should the Procurement Executive evaluate contractors, and by what standard?". Assessment of potential contractors to a new quality assurance criteria and restriction of contract opportunities to approved contractors with satisfactory quality assurance arrangements became policy.

Quality standards within the Defence Standards framework were introduced and firms assessed, according to their particular product potential.

The Standards and their NATO counterparts are now established and stipulate requirements at three levels of quality control and inspection organisation.

(i) DEF STAN 05-21 Quality Control System Requirements for Industry.

(ii) DEF STAN 05-24 Inspection System Requirements for Industry.

(iii) DEF STAN 05-29 Basic Inspection Requirements for Industry.

The standards formalised in (i) are the highest that can be set for a company and allows them to design, produce and inspect equipment to M.O.D. standards, which may or may not require a complex inspection organisation, but essentially an adequate quality control system. The requirements for (ii) are such that a company can inspect and manufacture equipment to established production specifications and drawings For (iii) the standard permits manufacture of equipment which requires only basic inspection facilities of the finished item.

To enable a company to meet its obligations and requirements for the 05-21 Quality Assurance Standards, organisation of the company structure and responsible senior personnel had to be defined; likewise the administration of design planning, material control, production and inspection departments in a composite manual, accessible to all persons 'needing to know'. The handbook is known generally as the 'Quality Manual' and therein are catalogued all facets of quality control, administration documentation and personnel responsibility. Companies have been, or are being, assessed, to prove suitability to work to the standards, and all Defence equipment tenders and contracts now invoke one of the above quality standards.

To indicate how quality standards apply in the VCS sense, a contract which requires the design and manufacture of consoles, assemblies and units for a ship's system would normally be entrusted to a firm which is approved to DEF STAN 05-21, whereas units which have established designs and for which manufacturing drawings exist could be manufactured by an organisation approved to DEF STAN 05-24.

Quality is controlled through a Quality Director, answerable to the Board of Directors, and normally delegated through the Chief Inspector to Heads of Departments and the Inspection Department.

Quality Standard Implementation

Because of the nature of design and manufacturing techniques employed in the VCS equipment, quality standards must be monitored at each and every stage. The quality control procedure for consoles and assemblies is somewhat different from that employed for units, but the procedure can be equally applied to any electrical mechanical assembly. Initial mechanical drawings are prepared for console and units and these are approved by the customer, or accepting authority. Circuit diagrams, wiring schedules and test specifications are likewise approved and accepted, details prepared, checked, and issue state defined. It should be emphasised that customer approval does not relieve the contractor of quality maintenance. At this point, definitive information is established against which material procurement is initiated. Specifications for raw materials define requirements and it is against these specifications that all raw material, both mechanical and electrical, are accepted. Any deviations due to obsolescence or unavailability are approved by customers or representatives under standard procedure, which also indicates penalties in time, cost, interchangeability and logistic support potential.

Quality is monitored on all piece parts through normal shop inspection. All electrical components are procured and accepted against specification and released through suppliers by conformance certification to DEF. STANDARDS. Parts and components purchased through this procedure, also parts sub-contracted to plating and finishing contractors, are quarantined in a bonded store until issued to shop floor for assembly purposes. A reject and replacement monitoring system is operated as a requisite of a quality control organisation. Operation of this procedure is essential to any firm employed in manufacture of equipment, such as VCS Units. Completed drawings are issued to Planning Department and planning proceeds according to job requirements and process involvement. Batch cards are generated for production of piece parts and assemblies, listing all processes and inspection points. Each process must be signed off prior to proceeding to the next in sequence. Operators are instructed to follow this procedure without deviations. Assembly of all mechanical parts proceeds with some intermediate floor inspection, until complete. At this stage a full mechanical viewing is carried out, using jigs and gauges to check apertures, boxes, fixing centres and other critical dimensions. After painting and re-assembly, electrical wiring is carried out under supervision with quality monitoring at the discretion of the Chief Inspector. Cable crimping tools, soldering irons and other hand tools are regularly checked and calibrated, to ensure compliance with specified standards.

Completion of all work to a console or unit on the shop floor initiates stringent inspection procedure and documentation, on completion of which the equipment is prepared for customer acceptance. This can range from representative visits during functional tests to full functional testing of specialised systems incorporated within a number of consoles or assemblies. Responsibility for correctness of product and maintenance of quality is always the company's, but delegation of acceptance to the company's own Inspection Department exercising quality control to a DEF STAN may be specified. This form of acceptance allows the Chief Inspector to release the equipment with a Certificate of Conformance and Test Certificate, to verify compliance with customers specification. Following release by the Inspection Department for despatch, the equipment is quarantined pending issue of packing or despatch instructions, together with release formalities, and the procedure is strictly controlled by the Chief Inspector.

CONCLUSIONS

In the foregoing chapters, design, production and quality control of VCS Consoles and Units, the method of construction are those preferred by definitive engineering specifications, although, as previously stated, the specification is not mandatory, but a guide for designers to ensure consistency and interchangeability of items, using different manufacturing techniques. There are many design engineers who prefer different layouts within the VCS Unit structure, likewise, chassis mounting in consoles will differ. Manufacturing techniques depend on production tooling employed in a particular firm and providing that the designs conform to the VCS philosophy, each design should be acceptable. In broad terms, a console may be considered as technical furniture for the mounting of operator used modules and allows a console to be constructed from basic parts with minimum mechanical design involvement. Ever mindful of economic production techniques, value engineering exercises are carried out periodically, ensuring that techniques are updated in line with current manufacturing advances. The gradual replacement of modular systems with console or rack mounted cassettes,

where all-electronic equipment is fitted, is a possibility.

A study currently being carried out will investigate the VCS system and product ion techniques, efficacy of design and areas where updated technology can improve electronic packaging techniques, ensuring that operator and maintainer's tasks are made simple, and manufacturing economic. The use of fibre glass materials may be considered for consoles and small cubicles.

Regarding quality, this will differ in the way in which firms implement Quality Standards, accordingly, customers must be able to recognise and identify system deficiencies which put at risk product quality. In implementing any quality standard, difficulties of interpreting requirements and agreeing the extent of their application, depends upon co-ordination of thought and action between customer and contractor, to resolve the problems arising, in the best and most economic manner in which equipment can be designed and manufactured 'fit for its purpose'. Perfection is not the aim of Quality Assurance.

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