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MICROPROCESSOR APPLICATION ENGINEERING PROGRAMME

DP/IND/84/030

INDIA

# Technical report: Strategy for the application of microprocessors for improving productivity of rail coach manufacture and miscellaneous lectures*

Prepared for the Government of India
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Eric J. Wightman, expert in microprocessor hardware and software development

Backstopping officer: V. Smirnov, Engineering Industries Branch

United Nations Industrial Development Organization
Vienna

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V.88-23767

# MICROPROCESSOR APPLICATIONS IN ENGINEERING

## INTEGRAL COACH FACTORY MADRAS

## ABSTRACT

In order to complement an ongoing programme of modernisation with the objective of increasing production of coaches, a number of areas, notably the machine shop, have been identified which will benefit from the application of microprocessors.

The introduction of computer numerical controlled (cnc) machine tools imediately creates the need to provide service facilities which respond instantly to breakdowns in Production. Thus the first priority is seen to be the setting up of an electronic laboratory staffed by electronic engineers trained in cnc machine tool technology. This facility will then possess capability to service any other microprocessor based support systems which may be developed.

A total of seven projects have been identified which would require MAEP assistance in varying degrees. Draft Specifications of Requirements have been compiled to define the scope of each project. An outline implementation programme covering all phases from feasibility to installation and commissioning of fully engineered systems is proposed, with staged project reviews.

These proposals include an assessment of the implications of the introduction of cnc machine tools, from which it is concluded that a total review of production stategy is urgently required to reap the maximum benefit from the ability of cnc machine tools, in terms of quick changeover of short run batches of components, leading to capability for a significant reduction in inventory and work in progress.

# LIST OF CONTENTS

## ABSTRACT

1 Introduction

2 Recommendations

3 Activities of the Expert

4 Conclusions (Please refer to Appendix 11 )

## LIST OF APPENDICES

I Itinery - E.J. Wightman 9th of February to 23rd of March.

II Microprocessor Applications in Engineering- Integrated Coach Manufacture, Madras.

111 Abstract "U.K. Developments in Microprocessor based Data Acquisition Systems for Disease Risk Assessment and Irrigation Control."

## 1. INTRODUCTION

The objectives of the mission as detailed in Job Description DP/IND/84/030/11-03/J13315 included the following tasks for the Expert, revised following discussions with Dr. Krishna Kant, Chief Project Co-ordinator, on arrival in Delhi on 10th February 1988:-

1.1 Advise on the use of modern automation and control methods, in particular the manufacture of railway coaches, based on experience in the U.K. and the continent.

1.1 Review existing manufacturing facilities,techniques and methodology at the Integral Coach Factory,(I.C.F.) Madras.

1.3 Formulate a strategy for improving productivity of coach manufacture, using advanced manufacturing technology and computer aids as appropriate.

1.4 Compile a report including a phased plan for implementing the proposed strategy.

The programme of work was to be carried out during the period from 14th of January to 23rd of March inclusive, of which seven working days were to be spent at home base, two days briefing in Vienna prior to departure, visiting India from 10th of February to the 21st of March, followed by two days debriefing in Vienna on 22nd and 23rd of March. The relevant activities are detailed in Appendix I "Itinery" and include a visit to Bangalore on behalf of I.C.F.and a visit to Jabalpur to present a lecture at an International Symposium on Electronic Measurement Techniques and Microprocessor Applications in Agriculture 8th-10th of March 1988.

## 2. RECOMMENDATIONS

2.1 The present practice of substituting computer numerical controlled (cnc) machine tools for manual machines requires to be preceded by a production strategy which takes account of the impact which computer control systems will have in terms of increased productivity, improved quality and quick changeover from one type of component to another. This will result in improved lead times, reduction in inventory and work in progress. These benefits will not materialise unless a planned implementation strategy embracing all production departments is undertaken. This point is detailed in Section 5 of Proposals included in Appendix 11.

2.2 The introduction of cnc machine tools with the ability to achieve higher productivity and improved quality highlights the need for prompt service in the event of breakdown. It is proposed that in view of the substantial numbers of machines involved a self sufficient service department is created within I.C.F. without dependance on outside contractors, as a first priority.

2.3 A total of seven projects have been identified within the constraints of this particular assignment, where microprocessors may contribute to increased productivity and improved quality. Feasibility studies are now required to enable design specifications to be compiled and costs quantified. Additional projects which are seen to be crucial to the success of the introduction of cnc machine tools are listed under "Factors to be Considered in Introducing cnc Machine Tools" in Section 5 of Appendix 11.

2.4 Joint project teams are required to be formed from management within I.C.F. and representatives of the Department of Electronics, Govt. of India, in order to manage the multi-disciplinary projects arising from this study.

## 3. ACTIVITIES OF THE EXPERT DURING THIS MISSION.

The predominant activities were centered on the Integral Coach Factory, (I.C.F.) Madras, interspersed with a lecture at the MAEP Agriculture Centre, Jabalpur.

### 3.1. Integral Coach Factory.

The Activities included:

- Briefing by Chief Executive Engineer, Indian Railway Board.
- Visit to Integral Coach Factory.
- Survey manufacturing facilities including forgings, spring manufacture, heat treatment, machine shop, fabrications, bogie sub-assembly, coach shell manufacture, furnishing.
- Review of facilities and recommendations for microprocessor applications to improve productivity and quality.
- Presentation of lecture on cnc technology.
- Compile draft report for presentation and discussion with senior management at I.C.F.
- Review of draft with Department of Electronics and finalise report.

### 3.2. MAEP Centre Jabalpur.

Attend International Symposium on Elecronic Measurement Techniques and Microprocessor Applications in Agriculture. Present paper "U.K. Developments in Microprocessor based Data Acquisition Systems for Crop Disease Risk Assessment and Irrigation Control."

3.3 Draft report "Microprocessor Applications in Engineering" for presentation at the I.C.F. Madras and subsequently revise following consultations with Chief Co-ordinater MAEP. This report is attached in Appendix 11.

3.4 Enclose Abstract of the lecture presented at the International Seminar on Electronics and Microprocessor Applications in Agriculture in Appendix 111.

NOTE:- Conclusions for the predominant activity at I.C.F. are appended to the separate report attached (Appendix 11, Section 6.)

## APPENDIX 1

Itinery-E.J.Wightman, 9th Feb-23rd Mar.1988

| DATE | TIME | ACTIVITY |
|---|---|---|
| Tue 9-2-88 | 8a.m. | Depart U.K. |
| Wed 10-2-88 | 1.40a.m. | Arrive N.Delhi. |
| | 10a.m. | Briefing UNDP with Messrs Islam(SIDFA),Ramachandran,Sethia |
| | 2p.m. | MAEP Dr. Krishna Kant Chief Proj. Co-ord.Review Itinery. |
| Thu 11-2-88 | 9a.m. | MAEP Project reviews. |
| Fri 12-2-88 | 9a.m. | MAEP. |
| | 10a.m. | Indo-Danish Toolroom Training Centre.D.Lal(Gen. Mangr.) Mr.VaradanAAP,Dr.CameronD.O.E. |
| | 2p.m. | Ind.Rlwy Board.Exec.ChiefExec. Mech. Engr.Mr R.C.Achayra, Dr. Krishna Kant MAEP. |
| Mon 15-2-88 | 4.30a.m. | Dep. for Madras. |
| | 2p.m. | Arr. Madras.Mr. Manivel I.C.F. N.L.Madhusudan,Dpy.Ch.Mech.Engr. |
| | 3.30p.m. | Mr.A.Balasubramanium,Ch.Mech.Engr |
| | 4.00p.m. | Mr.Satish Bahl,Gen. Manager. |
| | 4.30p.m. | Mr.V.Viswanathan,Financial Advr. Mr.B.C.Balasubramanium,Finl.Advr. Systems Dev. Group. |
| Tue 16-2-88 | 9.15a.m. | Group Discussions-Microproc.Applns. Ref.App.A of App. 11. |
| Wed 17-2-88 | 9.15a.m. | Tour of foundry,spring shop,mach. shop & body shell fabrication. Mr. Mallaya-Works Manager. Mr. Madhusudan. |
| Thu 18-2-88 | 9.15a.m. | Tour of Furnishing factory. |
| | 2.p.m. | Draft interim proposals with Messrs Madhusudan & Mallaya. |
| Fri 19-2-88 | 9.15a.m. | Summarise Proposals a)MAEP Projects b)Factors to be considered on introduction of cnc mach.tools. |
| | 2.30p.m. | Proj.reviews.Mr.Balasubramanium Mr.Viswanathan Ch.Proj.Manager. Mr.Madhusudan,Mr.Mallaya. Formulate Recommendations for D.O.E. |
| Mon 22-2-88 | 9.15a.m. | Complete Proposals for MAEP Projects. |
| | 2.30p.m. | Tour of proposed service laboratory. |
| Tue 23-2-88 | 9.15a.m. | Compile Draft Report. |
| | 2.00p.m. | Compile Spcns.of Requirements for proposed projects. |
| Wed 24-2-88 | 9.30a.m. | Demo.microprossor training kit. |
| | 2.30p.m. | Progress review-Mr.Balasubramanium. |
| Thu 25-2-88 | 9.15a.m. | Amend proposals. |
| Fri 26-2-88 | 11.00a.m. | Policy Meeting.Mr.Satish Bahl,Gen Mangr |

| | | |
|---|---|---|
| Mon 29-2-88 | 7.ooa.m. | Dep. for Bangalore |

Itinery-continued

| | | |
|---|---|---|
| Mon 29-2-88 | 2p.m. | Arrive Bangalore |
| Tue 1-3-88 | 10.30a.m. | Visit I.T.I.-Mr.Rajaram Mangr.CAD |
| Wed 2-3-88 | 9.30a.m. | CMTI-Mr. Murching Director. |
| | 12.30a.m. | H.M.T.Mr.V.K.Arora Depy.Ch.Engr. |
| Thu 3-3-88 | 9.30a.m. | Bharat Fritz Werner-Mr.B.B.Kasturi Depy.Gen.Manager,Mr.A.N.Chandrashekar Product Manager,cnc machine tools. |
| | 2.00p.m. | Depart for Madras. |
| | 8.00p.m. | Arrive Madras. |
| Fri 4-3-88 | 9.00a.m. | I.C.F.-Mr.Madhusudan |
| | 10.30a.m. | Progress Review-Mr.Balasubramanium |
| Sat 5-3-88 | 3.45a.m. | Depart hotel for Delhi. |
| Mon 7-3-88 | 4.30a.m. | Depart for Jabalpur. |
| | 10.30a.m. | Arrive Jabalpur. |
| Tue 8-3-88 to Thu 10-3-88 inclusive | | International Symposium |
| Fri 11-3-88 | 11.30a.m. | Dep. for Bhopal/Delhi. Plane delayed.Stopover Bhopal. |
| Sun 13-3-88 | 1.00p.m. | Depart for Delhi. |
| Mon 14-3-88 to Fri 18-3-88 inclusive. | 9.00a.m. | MAEP Centre Delhi.Compile final report. |
| Sun 20-3-88 | 11.00p.m. | Depart hotel for airport. |
| Mon 21-3-88 | 1.40a.m. | Depart for Vienna UNIDO. |
| Tue 22-3-88 | 9.00a.m. | De-briefing. |
| Wed 23-3-88 | 3.00p.m. | Depart for U.K. |

# APPENDIX 11

## PRESENTATION

## ON

## MICROPROCESSOR APPLICATIONS IN ENGINEERING

## TO

## INTEGRAL COACH FACTORY MADRAS - 38.

BY

MR. ERIC J. WIGHTMAN

UNIDO/UNDP EXPERT

## LIST OF CONTENTS

ABSTRACT

1. INTRODUCTION

2. REVIEW OF MANUFACTURING FACILITIES

3. PROPOSALS FOR MICROPROCESSOR APPLICATIONS

   3.1 MACHINE TOOL STATUS AND CONDITION MONITORING DEVELOPMENT SYSTEM

   3.2 AUTOMATION OF MANUAL MACHINES

   3.3 AUTOMATED TOOL MANAGEMENT AND STORAGE SYSTEM

   3.4 DIGITAL READOUT FOR MANUAL MACHINES

   3.5 SERVICE CENTRE FOR CNC SYSTEMS

   3.6 AUTOMATIC CHECK OUT EQUIPMENT FOR BOGIE TESTING

   3.7 COMPONENT GAUGING

4. IMPLEMENTATION PLAN

5. FACTORS TO BE CONSIDERED IN INTRODUCING CNC MACHINE TOOLS

6. CONCLUSIONS

## LIST OF APPENDICES

A. MANAGEMENT IN INTEGRAL COACH FACTORY.

## 1. INTRODUCTION

The Integral Coach Factory was set up in Madras during the First Five Year Plan as a Production Unit under the Ministry of Railways for the manufacture of all-welded all steel light weight monocoque or "integral" coaches with anti-telescopic end construction, in collaboration with Swiss Car & Elevator Manufacturing Corporation Ltd., Zurich, Switzerland. The design incorporates an all-welded trough floor integral with the body enabling the forces sustained by the coach to be borne by the entire body including the skin, similar to aircraft design. The bogies incorporate axles which are positioned in telescopic guides immersed in hydraulic dash pot dampeners inside helical coil springs. The axles rotate in self aligning spherical roller bearings.

Initially the Factory was designed to produce 350 Broad Gauge Coach shells per annum, furnishing to be carried out elsewhere. Presently the output is running at the rate of 850 completed coaches, the furnishing being carried out in-house. There are now four types of bogies and eight different body shells for Broad Gauge and Metre Gauge including 2-tier and 3-tier sleeper Cars.

Production is divided between four main activities, following classical batch production methods.

- Body Shell Assembly
- Bogie Assembly
- Painting and Finishing
- Furnishing

These facilities have been reviewed and are followed by proposals for Microprocessor Applications aimed at increasing productivity and improving quality of components and sub-assemblies.

## 2. REVIEW OF MANUFACTURING FACILITIES

### 2.1 Body Shell Assembly

The main Assembly Shop is equipped with 6 assembly lines on which the coach body shell is assembled in four stages:

1. Roof is welded on special rotatable jigs.
2. Underframe assembly
3. Underframe, sidewall panels and endwall panels and roof are welded together in the Body Assembly Jig to make the body shell.
4. Spot heating and straightening of panel sheets.

### 2.2 Bogie Assembly

The bogie is assembled from components machined largely from forgings and castings, to a frame which is a welded box type construction. The wheels and axles, roller bearings, helical springs, brake equipment, etc. are added and tested on a bogie testing machine.

### 2.3 Painting and Finishing

The body shell is grit lasted to take the first coat of paint, insulated with fibre glass against heat radiation mounted on its bogies and sent (by rail) to the Furnishing Division.

### 2.4 Finishing

Following the uniflow method of production, the coach body shell is furnished through various operations like flooring, roof packing, wiring, decoliting, fixing partitions, panels, moulding, plumbing, seats and berths, electrical fitting etc. Finally the coach is finish painted, inspected and certified before despatch. At the present time there are a total of twenty three different types of finished coaches which constitute the build programme of ICF.

### 2.5 Recommendations from Review of Facilities

Following an exhausting but by no means exhaustive series of visits to the various facilities, followed by in depth discussions with Senior and middle management (Appendix A) concerning limitations of present facilities, notably the machine shop, coupled with a new objective to increase production further, it was concluded that a number of specific projects could be identified which would benefit by the direct application of microprocessors. The proposals which have been compiled take into account an ongoing modernisation programme in the Machine Shop to introduce several CNC machine tools in the near future.

Factors to be considered in introducing CNC machines are summarised in a separate section at the end of this report.

Thus projects have been formulated which take account of the on-going short term need to sustain current production methodology and output targets. with longer term objectives of increased output and utilisation of CNC machine tools where it is advantageous to do so. The seven examples of potential projects range from more effective means of monitoring machine performance, addition of automation to manual machine to increase productivity and component gauging systems to improve quality. They comprise:

- Machine tool status and condition monitoring development system
- Automation of manual machines.
- Automated tool management and storage system
- Digital read out for manual machines
- Service centre for CNC electronic equipment
- Automatic check out equipment for bogie testing
- Component gauging

The above projects have not necessarily been listed in order of priority. For example after due consideration by ICF management, the proposed service centre for CNC electronic equipment was accorded the highest priority.

# 3. PROPOSALS FOR MICROPROCESSOR APPLICATIONS

## 3.1 MACHINE TOOL STATUS AND CONDITION MONITORING DEVELOPMENT SYSTEM

### 3.1.1 Rationale

The application of CNC machine tools is characterised by major operational benefits which put them in a category which is unique above manual machines:

- High productivity,typically three times that of an equivalent manual machine.

- High accuracy,up to ten times that obtainable from manual machines.

- Rapid changeover from one type of component set-up to another, typically minutes instead of hours.

These benefits may be totally eroded therefore, if the infrastructure supporting the application of CNC machine tools on the shop floor is not provided. Factors such as tool management, service etc. are described in later sections. The requirement for monitoring the actual performance, incidence of breakdowns and advance warning of tool wear are seen to be critical management functions which need to be independent from the vigilance of an operator - customarily the medium of communication for the status of a manual machine.

### 3.1.2 Proposed System

Each machine is to be equipped with a data collection microprocessor module for recording the number of components produced, down time, tool change and house keeping functions such as power supply, lubrication,coolant, swarf etc. if required, together with fault recognition. The machine monitors may be linked to a central P.C. based data collection system in the Production Supervisor's office for central monitoring to assist prediction of resources to be allocated to weekly call off batches.A later stage of development would link the P.C. monitor with the Central ICL computer for downloading work orders direct.

Development of the proposed system will pave the way for a computer based management system, using the PC as an intelligent micro based terminal for the machine shop.It is envisaged that all machines would be connected by a ring main wired to a central control room which may then be accessed remotely from the P.C. on demand. A printer will enable a summary daily log of events to be printed.

### 3.1.3 Draft Specification of Requirements

Features:

a. Working/Not Working
-Power available or not
-Main spindle running or not
-Feed Drive scews live or not

b. No. of comp. required/No. produced.

c. House keeping function
-Lubrication
-Coolant
-Chip conveyor
-Chuck Hydraulics
-Turret Hydraulics.

d. Tool Monitoring
-Tool Breakage
-Tool Life Prediction
-Time for changing tool

e. Gauging station

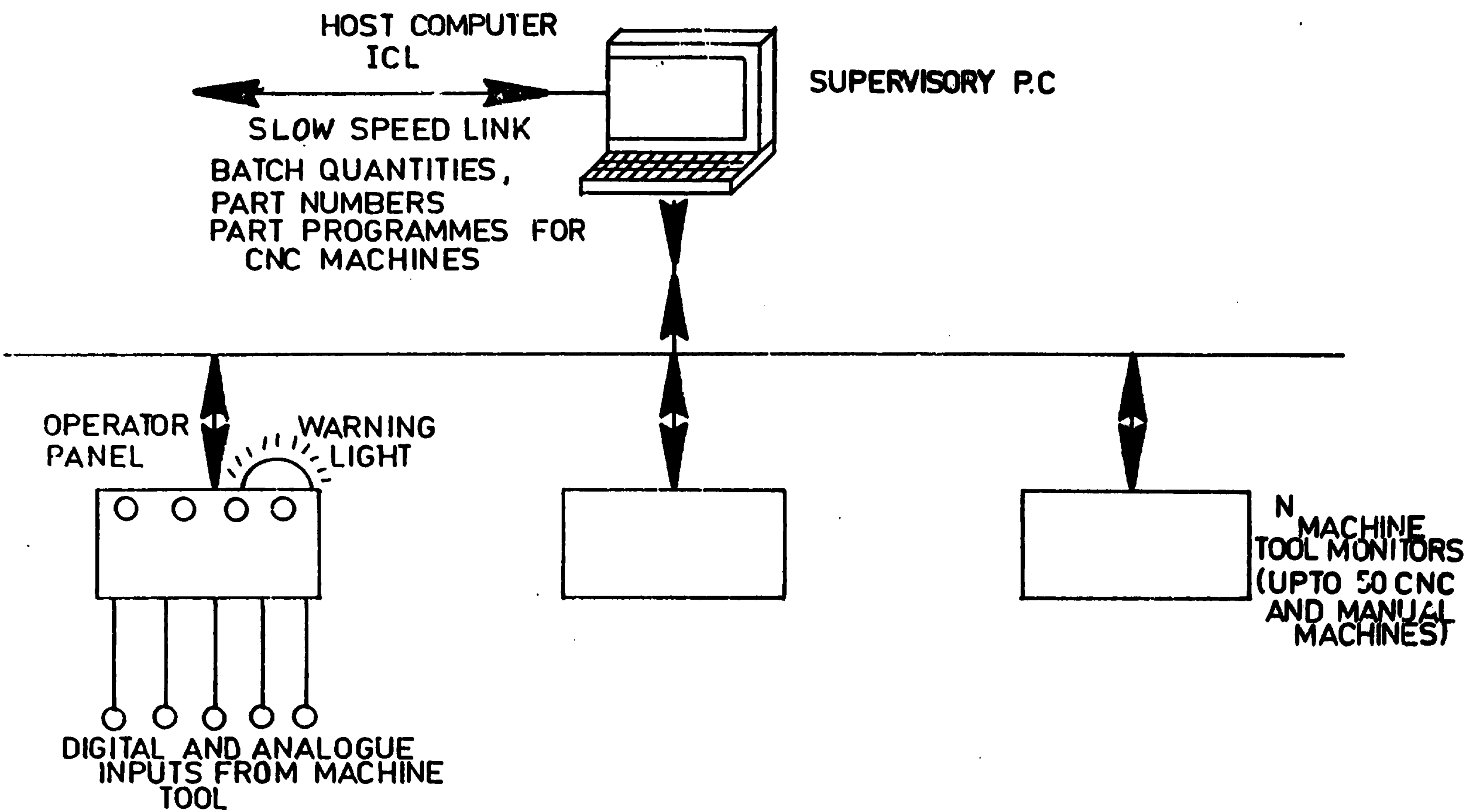
f. Machining Cycle Time -
-Power Monitoring/
Elapsed time for main spindle running

g. Daily Log Print out
- Part No.
- Qty. Produced
- Batch time
- Down time - Power Off
Tool Change

h. Automatic Loading and Unloading

i. Capability for downloading CNC part programme (DNC Link)

j. Low speed data communication link e.g. RS 232C interface for IBM PC, host computer




MACHINE TOOL MONITORING SYSTEM - SCHEMATIC

## 3.2 AUTOMATION OF MANUAL MACHINES

### 3.2.1 Rationale

Reference has been made to the introduction of CNC machine tools which are capable of higher productivity and closer tolerances of machining than the manual machines which they replace. While the bulk of components may eventually be produced on CNC machines, nevertheless there will continue to be requirements for "second operation" or finishing operations which do not justify the purchase of CNC machines. Examples of these operations include the machining of flat surfaces or keyways on turned parts (milling operations), threading on turned parts (turning) and drilling holes (drilling)

The increased output attainable from CNC requires to be complemented by increased output from manual machines allocated for second operation work. Whereas the purchase of additional machines provides one obvious solution, the cost is disproportionate and a more cost effective solution is to consider the partial automation of manual operations, particularly in the area of work holding and control of repitiive machining cycles.

### 3.2.2 Proposed System

The proposal requires sensors to be added to measure machine slide position and a microprocessor to store programmes for machine sequences. The microprocessor will interface with the existing machine electrics and interact with the operator by means of a simple control panel.

In operation, the operator would load the parts and start the machining cycle by pressing a button. On completion of a batch, the control unit would signal the need to change the tool.

As a secondary phase, the automation of component loading by means of simple work handling machanisms can be introduced. The sequencing of the work handling mechanism would be interlocked with the machine control cycle.

The first priority is seen to be the partial automation of manual drilling machines which are used for a variety of jobs. These machines currently rely upon the use of mechanical stops for positioning the depth of drilling and controlling the commencment of drilling cycle. The time required to change the positions of these mechanical stops is an impediment to quick changeover from one type of component to another and operators are loathe to change a set up once the machine is in regular use. The proposed approach should not be confused with full CNC retrofit which is further option; experience to-date suggests that the costs of such CNC conversions are high and in many cases hardly competitive with the cost of a new machine.

3.2.3 Draft Specification of Requirements:-

Drilling machines, Milling machines and Lathes

a. Assumptions

1. Main spindle drive motor will be unchanged
2. Control will be established through existing electrical contactor with manual handling attachment.
3. Operator will be responsible for material loading of component and tool change.
4. Existing tools will continue to be used.

b. Axis Drive

1. Control through existing feed drive motor where available
2. Investigate benefits of adding external drive motors vs the existing motor drives and clutch.

c. Measuring System

1. Proprietary DRO to be considered for interfacing with new controller. Alternatively conventional LVDT can be used where accuracy permits e.g. in the case of milling machines.
2. Microprocessor plus encoder with a read out on operator control panel.

d. Controller

MIcroprocessor based unit which will receive slide position data from the measuring system. Comparator function will be used for comparing slide demand position and output command to the axes drive system and main spindle control.

e. Control Panel

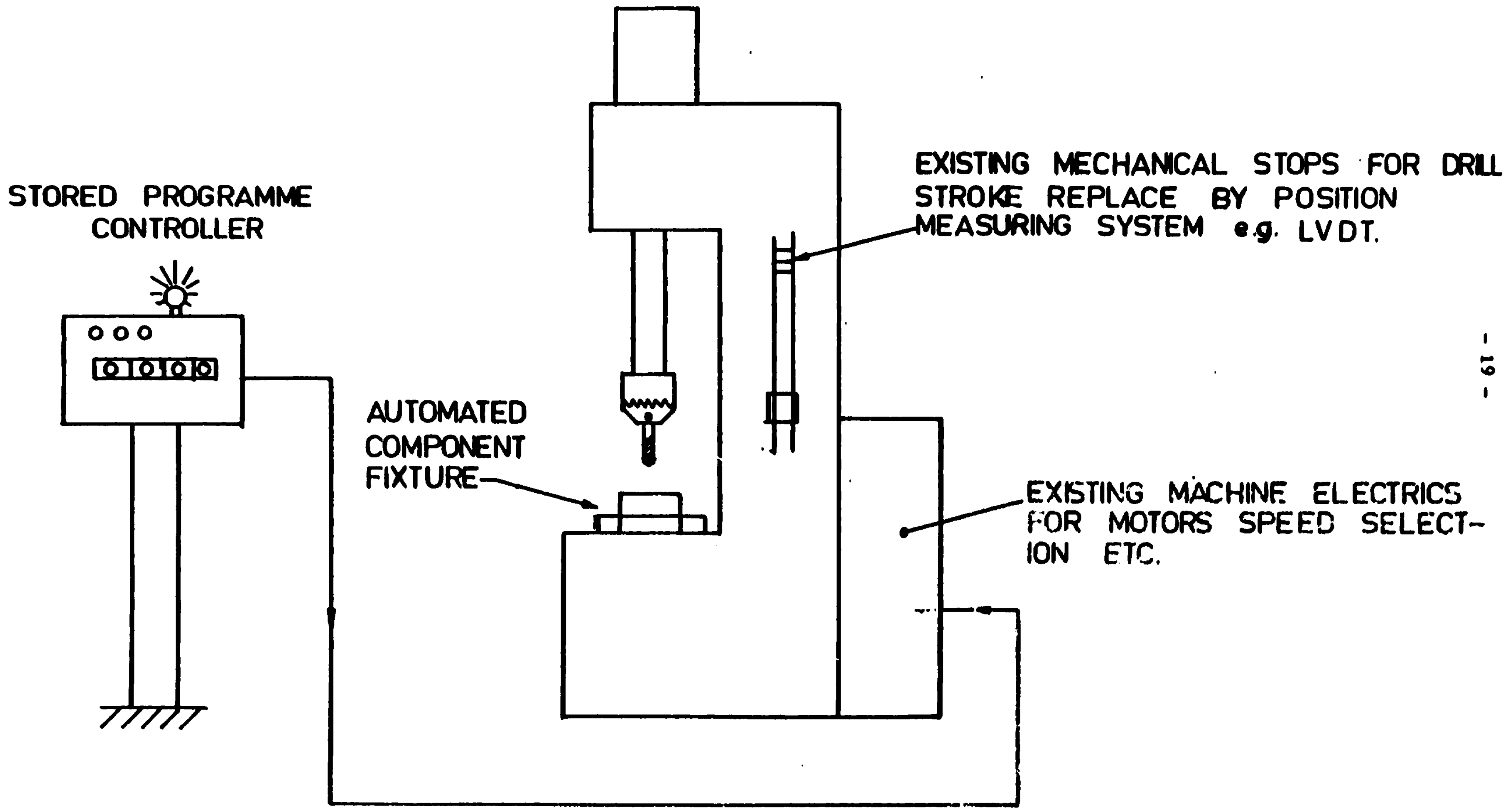
Splash proof key board - dust proof sealed to certain inputs for control programme, safety start/stop and axes job controls. Self-test facility. Emergency stop.

f. Power Supply

Desirability of floated battery power supply back up to mains input.

g. Safety

Shut down in the event of malfunction in a controller manner i.e. "failsafe".






MANUAL MACHINE PARTIAL AUTOMATION SCHEMATIC

## 3.3 MICROPROCESSOR BASED TOOL MANAGEMENT AND STORAGE SYSTEM

### 3.3.1 Rationale

The introduction of CNC machine tools requires a fresh approach to the problem of tool management. The productivity and accuracy of a CNC machine are higher than a conventional machine and the capability of quicker changeover between batches of smaller size requires tools to be available at the appropriate type at the changeover stage. Tool wear is also an important factor and tool wear monitoring systems which are now available on the machine, together with pre-set/qualified tooling with "throw away" tips results in new disciplines for tool management.

### 3.3.2 Proposed System

It is proposed to introduce a tool management and storage system which by virtue of being micro-processor based includes the following features:

- Tool identification for classification and storage location.

- Tool marshalling system

- Automated warehousing

- Minimum stock level control

Although introduced primarily to ensure maximum productivity from the use of CNC tools, the system may be extended to embrace all tooling requirements.

It is proposed that in the first instance, following a detailed feasibility study and system specification, a pilot project is introduced to evaluate concepts and develop suitable reliable equipment for ICF environment. The system may be ultimately linked with the proposed machine monitoring system to form part of an integrated computer based machine shop manufacturing control system.

3.3.3 Draft Specification of Requirements.

Basic features include:

- Tool coding - e.g. bar code
- Tool storage
- Automated retrieval
- Record of receipts and issues - microprocessor based accounting system.
- Refurbishing/Replacement facility
- Kit marshalling area - sets of tools for specific components on specific machines.
- Tool containment system

Each of above headings will constitute a subsystem which will require to be constructed and evaluated under simulated plant conditions before a total integrated system can be assembled. A detailed feasibility study is required for each of the above features, firstly to assess current "state of the art" technology, secondly to generate design proposals for inviting tenders for the supply of a development system.

## 3.4 DIGITAL READOUT FOR MANUAL MACHINES

### 3.4.1 Rationale

The proposed introduction of CNC machine tools is planned to take effect during a two year period, during which production will be stretched to cope with an on going expansion programme.

The first requirement in the present machine shop is to increase the output from the existing manual machines without loss of quality. One solution which is becoming increasingly popular in western manufacturing units is to equip manual lathes and milling machines with digital readout systems to relieve the operator from the strain of controlling dimensions of machining operations by counting the rotation of conventional handwheels.

### 3.4.2 Proposed System

With a digital readout system, the machine slide position is measured by means of a digital encoder and the resultant increments of movement indicated on a large, clear, unambiguous display mounted at the eye level of the operator. Pre-set values may be entered by the operator if required and the handwheels controlling tool position rotated in the conventional way until the digital readout approaches zero.

Experience has shown that the addition of such read out to manual lathes and milling machines increases productivity by 30-50%. One of the problems in this particular application at ICF in the high ambient temperature, typically 45 degree C. in the shade during summer months. Local temperature in the machine shop may be somewhat higher and approach the upper-limit for operation of of microelectronic equipment typically 50 degree C.

The first step is seen to be carry out a feasibility study of currently available digital measuring systems and to carry out an evaluation of reliability under simulated workshop conditions of high temperature,followed by re-engineering, re-packaging etc. as required.

3.4.3 Draft Specification of Requirements:

Lathes and Milling machines.

- Choice of alternative suppliers suitable for two and three axes applications.
- Final installations as sample on each type of machine
- Target accuracy +/- 2 micron
- Investigate stored programme for multiple dimensions entry
- To be installed by vendor to qualify for guarantee

## 3.5 SERVICE CENTRE FOR CNC ELECTRONIC EQUIPMENT

### 3.5.1 Rationale

The complexity of CNC machine tools,by their very nature embracing multi-disciplinary equipment, poses special problems in servicing in the event of break down. The problem is further exacerboted because of the high production capability of such machines, typically three times that of an equivalent capacity manual machine. Thus a break down will quickly disrupt the productions cyle for a particular type of component and urgent response is required to remedy the fault.

During the first twelve months of operation the supplier contracts to service the machine free of charge and the witholding of final payment until acceptances of the machine, following a successful commissioning period, ensures a speedy response for service calls.

Experience in the western world however shows that after expiry of the twelve month guarantee period few suppliers or their nominated service agencies honour their committment for service within 24 hours of breakdown and the attendant costs of service calls tend to be exorbitantly high.

### 3.5.2 Proposed system

It is proposed that ICF consciously plan to set up a totally indegenous service department for maintaining and servicing all CNC machine tools,initially by substitution of sub-assemblies, then full repair capability down to component level. This is because while spare electronic modules may provide substitute relief,the working card formerly held as a spare decomes faulty card. Previous experience ( by HMT for example) required cards to be returned to the manufacture of origin, frequently to Europe or Japan, with consequential delays and risk in the event of further breakdowns of the same type.

For the volume of CNC machines planned (19 initially to be followed by a further 10) it is highly probable that at least one machine will be always out of service and an inhouse service capability is fully justified.

Proposals are required for manning levels, qualification and experience of engineers required, together with specialised test,spares back up etc.

The proposed service centre will also be responsible for all future applications of microprocessors e.g. intelligent terminals, automation systems etc. together with possible development of specialised microprocessor based test and inspection equipment for testing circuit cards.

### 3.5.3 Draft Specification of Requirements:

Preferably not more than 2 types of control systems e.g. FANUC/SIEMENS will require to be serviced.

The following rationale will apply to any type of CNC:-

a) Service by substitution

For each type of equipment a slave system will be required for demonstrating card functions for the suspected faulty machine controller.

b) Service of Modules

Recommended modules should be stocked as spares.

c) Diagonistic test equipment for servicing faulty modules at component level.

Required equipment to be specified by consulting the Control system supplier, MAEP HMT and ITI Bangalore.

d) Spare components

Recommendations for component spares to be obtained by consultation with CNC system supplier.

e) Resources

-Workshop - airconditioned, electronic benches, distributed power supplies, component storage

-Engineers-Graduate level electronic engineers, Digital circuit specialisation, servo applications, Machine Tool experience.

## 3.6 AUTOMATIC CHECK OUT EQUIPMENT FOR BOGIE TESTING

### 3.6.1 Rationale

At present the bogies undergo a static test only by applying a load on the centre. There is no provision for checking individual wheel forces to check symmetry of loading or the actual performace of the shock absorbers.

### 3.6.2 Proposed System

It is proposed to investigate two courses of action to improve bogie testing:

(i) Add load calls under each wheel to check symmetry of loading to confirm that spring rates are balanced.

(ii) Add simple hydraulic actuation (such as bellows) under each load cell so that pulsed loads may be applied to each wheel to check the rebound ratio of each suspension system and hence the effectiveness of each dashpot.

These may be caried out under control of a microprocessor and deviations for an acceptable norm displayed and/or logged for corrective action.

Because of the physical nature of this application, where the product is incapable of being handled manually, the mechanical design of the test rig assumes major proportions which dominate the direction of engineering resources required to expedite the project. The microprocessor and relevant sensors and interfaces required are relatively simple to apply once the physical environment for supporting the bogie has been established, thus project management for this proposed equipment is required to be multi-disciplinary and external consultancy expertise may be sought.

### 3.6.3 Draft Specification of Requirements

a) Feasibility study by Local Technical Institute or Research Centre.

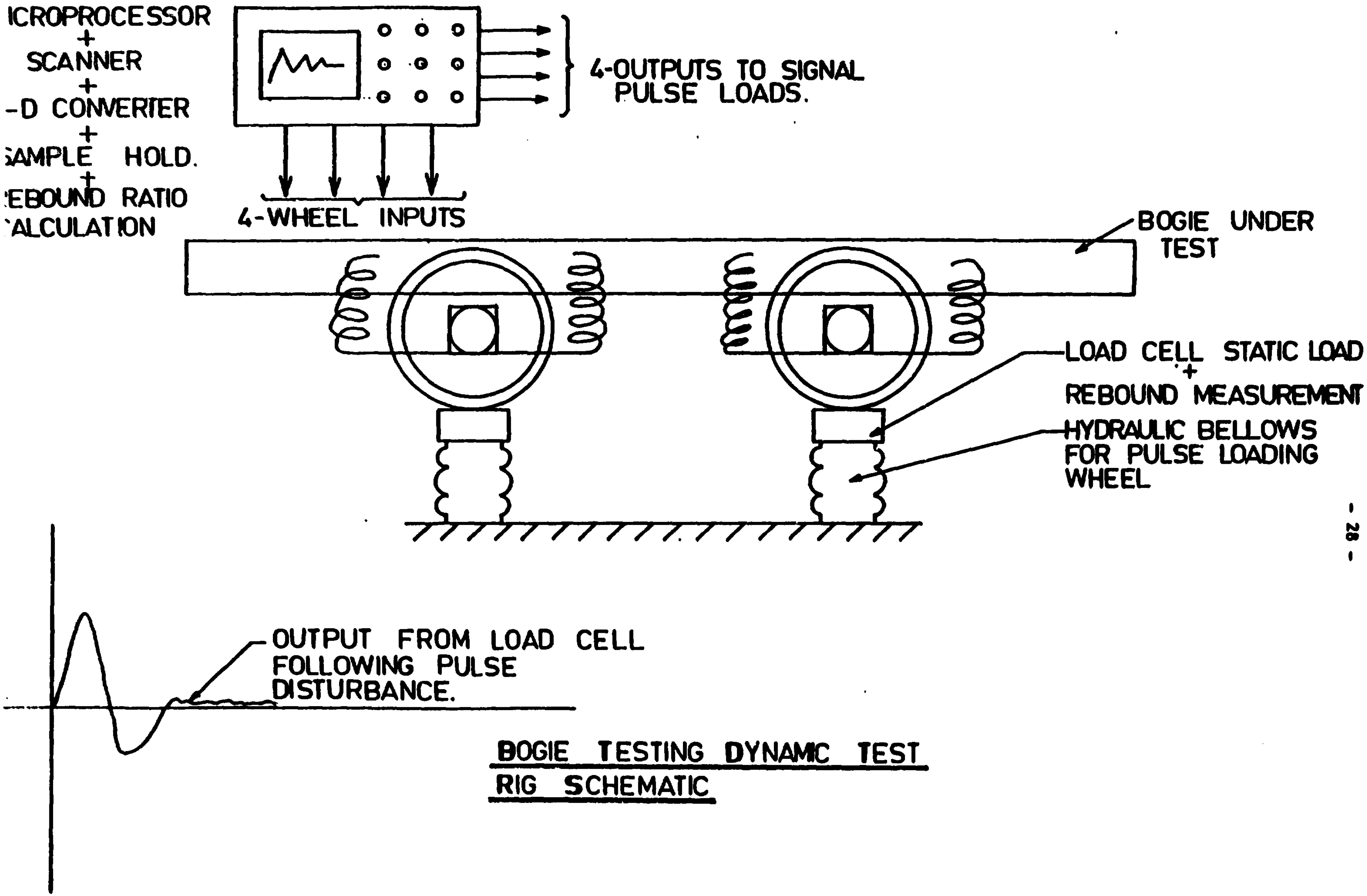
b) Laboratory testing to demonstrate concepts

c) Design of suitable test rigs, manufacture and commissiong of fully engineered check out equipment for evaluation.

d) Design criteria

Displacement/Load criteria

Damping coefficients (To be supplied by Design Office)




BOGIE TESTING DYNAMIC TEST RIG SCHEMATIC

## 3.7 COMPONENT GAUGING

### 3.7.1 Rationale

Notwithstanding plans to increase production, there is growing evidence to support the view that quality can be greatly improved. Examples range from machined items to fabrication and sub-assemblied e.g. window frames. In the case of the latter, considerable re-work is required on final assembly to make things fit properly and the need for intermediate stage inspection is indicated.

The improved accuracy obtainable from CNC machine tools- typically ten times that obtainable from current manual machines raises fundamental questions of measurement at the new increased rate of manufacture. Clearly the relatively slow manual methods of measurement are inadequate-the CNC machine tool will be capable of producing a further batch of components which may be out of tolerance , in the time it takes an operator to detect an error.

### 3.7.2 Proposed System

There are several applications which warrant the use of electronic gauging allied to a microprocessor based system for checking components and sub-assemblies. Typical examples include the checking of components by means of automated fixtures for CNC makchined components where a high order of accuracy is obtainable and an automatic inspection fixture for checking window frame sub-assemblies.

This project is heavily dependant on the type of fixtures required for holding a component or sub-assembly during the gauging process; whereas the types of sensors required for measuring values and microprocessor for processing resultant data may be standardised to a large extent, each component will require a special fixture to be designed. This indicates the need for setting up a project team comprising a mechanical design/development engineer and an instrumentation/electronic engineer for integrating the measuring system.

A feasibility study is required in the first instance to catalogue requirements for critical parts and to propose designs of gauging stations for their measurement.

3.7.3 Draft Specification of Requirements:

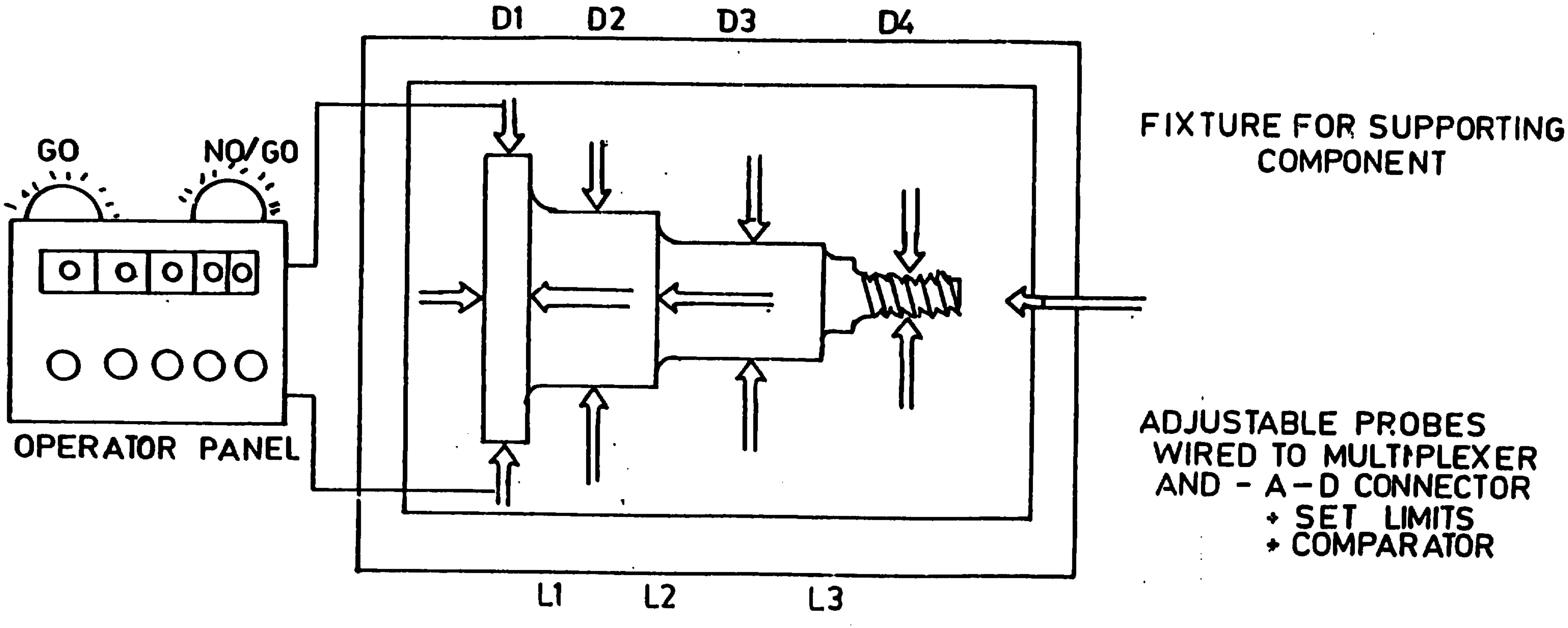
a) Choice of sensors - Investigation into range of sensors of varying sesitivites with the objective of standardising as far as possible.

b) Read out facilities- investigation into preferred type of read out system e.g. indication of go/no go system or absolute indication on both

c) Application of microprocessor to scan multiple readings where appropriate

d) A "set limit" facility for multiple sensors.

e) Output commands for automating sensor selection as a secondary requirement.




IN PROCESS GAUGING SCHEMATIC

## 4.0 IMPLEMENTATION PROGRAMME

The following stages are identified as milestone events for purposes of implementing the above projects and a standardised approach is recommended for implementation.

4.1 Specification of Requirements
Objective of Project
Cost Estimates

4.2 Design Specification

Packing
Mechanical
Electrical
Interfacing
Operator Controls
Power Supplies
Environment

4.3 Prototype manufacture evaluation

Evaluation report
Confirmation of cost estimates

4.4 Fully engineered pre-production models for field trials

Field trial Report

4.5 Production equipment

- Installation

- Commissioning.

## 5.0 FACTORS TO BE CONSIDERED IN INTRODUCING CNC MACHINE TOOLS

### 5.1 Rationale

These notes have been compiled to illustate the various ways in which computers may be harnessed to assist the management and execution of a manufacturing business. In order to be competitive in world markets, lead times now have to be measured in minutes rather than days or weeks and batch sizes are much smaller, tending towards the number required for a single finished assembly. To control production of parts and assemblies effectively, the information systems need to respond almost immediately to any changes.

Conventional computer-aided production management (CAPPM) systems tend to be based on manufacturing resources planning and can only achieve this responsiveness if supported by an increasing number of computers on the shop floor which may eventually prove to be counter productive.

Additional computer aids which have attracted much publicity in recent years include Computer Aided Design (CAD) and Computer Aided Manufacture (CAM), to mention a few. The purpose of these notes is to assist in assessing how computer aids may interact with each other in assisting the principal functions of a manufacturing business and be introduced in a systematic manner.

The main functions are seen to comprise:

- Control of the business
- Engineering the product
- Computer-aided production management
- Production quality control and test
- Data storage and communications
- Accountability

### 5.2 The impact of CNC Machine Tools in Production

The implications of the introduction of CNC machine tools in ICF have been briefly examined. While they are secondary to the main objectives of this particular MAEP missions they indicate requirements for computer aids relating to management of data transfer between departments and in some cases impinge on the corporate strategy for production.

Examples include, but are not restricted to the following:-

| | | |
|---|---|---|
| 5.1. | Production Engineering | - Computerised aids for producing office based part programmes for machining components. This is usually referred to as Computer Aided Engineering(CAE) |
| 5.2 | Production Engineering | - Process planning to be re-estimated in the light of improved cycle times made possible by CNC. This is referred to as Computer Aided Process Planning (CAPP) |
| 5.3 | Production Control | - Work flow to be reviewed in particular scope for automated component handling equipment between machines. |
| 5.4 | Design/ Production Engineering | - Future plans for the introduction of Computer Aided Design(CAD) to be evaluated against requirements for interfacing CAD data with part programming facilities. |
| 5.5 | Production Control | - Reduction in batch quantities enabling smaller batches to be produced economically thus speeding up response to production demands, reducing work in progress and inventory. |
| 5.6 | Production Control/ Purchasing | - Effect of small batch manufacture on material requirements and purchasing strategy. |
| 5.7 | Accountability | - Effect of high productivity of CNC machines and the need to restructure the present incentive system. |

The most important conclusion which may be drawn from this list of implications is that all activities benefit from a computer base for implementing any change to current manufacturing practice.

The first step to be taken is to carry out a feasibility study which would embrace each of the above items as an element, co-ordinated to become a total integrated manufacturing strategy for production as a whole.

Each of the the above activities would require an input of approximately one man month of manufacturing/computing/consultancy expertise to produce a programme for implementing the proposed improvements.

## 6.0 CONCLUSIONS

6.1 A number of areas have been identified which enable microprocessor application to improve control of production resources and improve quality

6.2 An initial quantity of seven projects have been defined for design and implementation jointly between MAEP centre, New Delhi and ICF, Madras.

6.3 From a preliminary assessment of the proposed projects, expertise and equipment capable of implementation is available idigenously. Possible short term assistance in terms of know-how and equipment may be required from UNIDO/UNDP based on related examples of similar projects in developing countries.

6.4 A total review of the manufacturing strategy is required.

6.5 A formal Project Management Structure headed by ICF is necessary to ensure accountability for each Project. For example the day to day direction of specialists from ICF, MAEP, Technical Institutes, UNIDO Experts and contractors will require to be co-ordinated from the inception of each Project.

# APPENDIX A

## MANAGEMENT IN INTEGRAL COACH FACTORY.

General Manager ... .. Shri Satish Bahl

Function: Head of Department and others SAG (Senior Administrative Grade) Officers.

1. MECHANICAL

| | | |
|---|---|---|
| Chief Mechanical Engineer | ... .. | Shri A. Balasubramanian |
| Chief Workshop Engineer/Shell | . .. | Shri B. Rengarajan |
| Chief Workshop Engineer/Fur | ... .. | Shri P. G. Reddy |
| Chief Design Engineer/Mech | ... .. | Shri M. G. Sripathi |
| Chief Project Manager | ... .. | Shri V. Viswanathan |

2. ELECTRICAL

| | | |
|---|---|---|
| Chief Electrical Engineer | ... .. | Shri T. Parthasarathi |
| Chief Design Engineer/Ele | ... .. | Shri C. P. Gowrishankar |
| Chief Design Engineer/Metro | ... .. | Shri L. Thyagarajan |

3. ENGINEERING

| | | |
|---|---|---|
| Chief Engineer | ... .. | Shri T. S. Natarajan |

4. ACCOUNTS

| | | |
|---|---|---|
| Financial Adviser & Chief Accounts Officer | ... .. | Shri V. Viswanathan |
| Financial Adviser & Chief Accounts Officer (Systems Development Group) | ... .. | Shri B. C. Balasubramanian |

5. STORES

| | | |
|---|---|---|
| Chief Controller of Stores | ... .. | Shri P. K. Govindrajan |
| Chief Materials Manager/Shell | . .. | Shri D. Felix Arokiaraj |
| Chief Materials Manager/Fur | ... .. | Shri A. Prahladha Rao |

6. PERSONNEL

| | | |
|---|---|---|
| Chief Personnel Officer | ... .. | Shri V. R. Subramanian. |

Shri S.Sankaralingam,
Deputy Chief Electrical Engineer
(Electrical Maintenance)

Shri R.Chandrasekharan
Deputy Chief Elec. Engineer
(Electrical Maintenance & Project)

Shri V.Narayanaswamy
Senior Electrical Engineer/Maintenance
(Electrical Maintenance)

Shri T.G. Arumugham
Deputy Chief Mechanical Engineer
(Mechanical Designs)

Shri V.Carmelus
Deputy Chief Mechanical Engineer/Modernisation
(Procurement of CNC machines)

Shri P.Govindan
Deputy Chief Mechanical Engineer/Project
(layout of machines)

Shri Thomas Mathew
Deputy Chief Mechanical Engineer/Systems
Development Grouyp (Computer)

Shri B.P.Sreepad
Senior Mechanical Engineer
(Mechanical Plant Maintenance)

Shri Mohan Sunder
(Works Manager/Assembly/Shell
(Production Assembly)

Shri Mallayya
Works Manager/Manufacturing/Shell
(Production and Manufacture)

Shri Ramaswamy
Asst. Works Manager/Manufacturing
(Production and Manufacture)

| | OFFICE TELEPHONE NOS. Railway | P&T. |
|---|---|---|
| Shri N.L. MADHUSUDAN<br>Deputy Chief Mechanical<br>Engineer/Plant Maintenance | 4378<br>8065 | 610294 |
| Shri JYOTI KUMAR<br>Secretary to General Manager | 4343<br>8001 | 610152 |
| Shri MANIVEL<br>Public Relations Officer | 4259<br>8004 | 618111 |
| Shri Badri (Transport) | 8008 | |
| Shri R.Venkataramanan<br>Confindential Assistant | 8234 | |

## APPENDIX 111

**U.K. DEVELOPMENTS IN MICROPROCESSOR BASED DATA ACQUISITION SYSTEMS FOR CROP DISEASE RISK ASSESSMENT AND IRRIGATION CONTROL.**

Presented by E.J.Wightman UNIDO/UNDP Expert during the International Symposium on Electronic Measurement Techniques and Microprocessor Applications held in Jabalpur 8th-10th March 1988.

This paper reviews how the application of low cost microprocessors has enhanced the performance of automatic weather stations for agricultural applications.The two main areas which have benifitted from this technology are those of disease risk prediction and irrigation control.The power of the microprocessor is seen to be the salient factor in enabling complex repetitive mathematical computations to be carried out based on modelling techniques tailored to suit the macroclimate of a particular farm locality.

Currently available sensors and their potential accuracies are reviewed, together with a resume of typical features which are currently incorporated in automatic weather stations developed in the United Kingdom.

Examples of how data may be processed and displayed to the user are given, together with factors which influence the specific application of an automatic weather station.Requirements for power supplies for an unmanned station have resulted in a choice of equipment being offered which can either run from mains supply, dry cells or batteries chargeable from solar panel- the latter of particular relevance to India where power may pose a problem in isolated areas.

The value of disease prediction is discussed, together with criteria which contribute to the assessment of eighteen different types of disease. Additionally, factors which contribute to evaporation loss and irrigation control are examined.

The paper concludes with estimates of costs for modern automatic weather stations which in simplest form may be used by a farmer or which are potentially capable of transmitting data to a remote location and interfacing with a personal computer for analysis and print out of data for research purposes. It is concluded that there may be strong economic grounds for the investment in automatic weather stations which can be used both for safeguarding crops from the onset of disease and for increasing yield by more accurately forecasting requirements for irrigation, with the future possibilities of direct control when circumstancies permit.