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DEVELOPMENT OF MICROPROCESSOR BASED AGRO DAIRY INSTRUMENTS

DP/IND/81/025

INDIA

Terminal report *

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 Electronic Systems Punjab Ltd.
through the Department of Industries

Backstopping officer: J. Fürkus, Engineering Industries Branch

United Nations Industrial Development Organization
Vienna

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SUMMARY OF THE REPORT

TITLE OF THE PROJECT	:	DEVELOPMENT OF MICROPROCESSOR BASED AGRO DAIRY INSTRUMENTS
Project Number	:	IND/81/025/A/01/37
Government Implementing Agency	:	Electronic Systems Punjab Ltd. Chandigarh through the Deptt. of Industries, Government of Punjab, India
Executing Agency	:	United Nations Industrial Development Organisation (UNIDO)

The Project was approved on 5th January, 1982 for a period of two and a half years. As per the Project Document, the contribution of Govt. and the UNDP to the Project was Rs. 2,000,000 and US $ 2,92,000 respectively. The Project's duration had to be extended upto December 1986 due to circumstances beyond the control of Project Authorities. The previous UNDP inputs of US $ 2,92,000 were also revised to US $ 3,59,350.

The Project envisaged two immediate objectives as enumerated in the Project Document:

(a) To design and fabricate prototypes of Microprocessor based Grain Quality Analyser, and Microprocessor based Milk Analyser, and;

(b) To develop indigenous expertise in Instrumentation for Agro-Dairy Applications through the training of National Personnel.

Under the Project, a Microprocessor Near Infra-red based Cereal Grain Analyser capable of measuring percent protein and moisture contents in Cereal Grains has been successfully designed and developed. The instrument, developed for the first time in India has been calibrated on wheat and has been field tested at Indian Agricultural Research Institute (IARI), New Delhi. The design of the Milk Analyser is similar to that of the Grain Analyser subject to some modifications.

For developing indigenous expertise in instrumentation for Agro-Dairy Applications, experts in infra - red Agro - Dairy Instrumentation were identified and their visits to the Project site were arranged. Based on their recommendations, project engineers were sent abroad under fellowship training programme. Thus the necessary infrastructure for the development of Microprocessor based Agro- Dairy instruments has been created which can take up development of similar sophisticated Microprocessor based Agro-Dairy instruments in future.

I. OBJECTIVES AND LOGIC OF THE PROJECT

I.1 OBJECTIVES

The immediate objectives of the Project were :

i) To design and fabricate prototypes of the following two instruments :

(a) Microprocossor based Cereal Grain Quality Analyser, and
(b) Microprocessor based Milk Analyser

ii) To develop indigenous expertise in Instrumentation for Agro-Dairy Applications through the training of National Personnel

I.2 PROJECT LOGIC

Increasing agricultural and dairy production continues to be a priority in India. Although advances have been made in the field of production of grains and cereals in India, these are not yet enough to offset the effect of rising population pressure in the country. To increase the level of agricultural production to a suitable level, it is vital that all agricultural processes be optimised to utilise all material inputs with as high an efficiency as possible. Therefore, it becomes necessary to provide adequate instrumentation that can measure the appropriate agricultural parameters and help in a more effective control of agricultural processes.

Due to lack of quantitative measurement at critical points in the production and distribution of agricultural materials, a significant quantity of possible produce is being lost. Examples are :loss of grain in storage due to inadequate monitoring of storage conditions and grain quality; loss of dairy production due to poor control of nutritive contents of fodder fed to the cattle and poor storage methods etc. Although these factors are not unknown to the agricultural community, there is a dearth of reasonably priced measuring instruments. A few instruments that are available are being imported at a high cost and the measurements are also equally expensive. There has been therefore, an urgent need to develop and manufacture agricultural instruments that are capable of making agricultural measurements needed by Indian farmers and are , in addition, capable of operating under Indian field conditions.

To prevent grain loss in storage due to decay, it is necessary to continuously measure the nutrition contents of stored cereal grains. An instrument capable of quantitative evaluation of grain quality by measuring the moisture, protein and oil contents in grain samples would go a long way towards solving this problem. In addition, such an instrument can be used for grading of grains being brought into the market. Similarly, to operate the modern dairy industries efficiently, it is necessary to monitor the quality of raw milk being supplied to users and also to maintain the nutrition and fat contents of processed milk. For this purpose,instruments like milk analyser are needed in large numbers to rapidly determine the composition of given samples of milk.

Both the instruments mentioned above can be built using the technique of near infrared spectroscopy, coupled with latest microprocessor based techniques. Because of the universal applicability, this measurement technique was chosen for development in the Project. Therefore, the objectives of the Project, as stated earlier,include the design and fabrication of prototypes of Cereal Grain Analyser and Milk Analyser based on near infra-red, microprocessor based technique.

Due to lack of competence for manufacturing these instruments indigenously, it was considered necessary to create expertise in the related areas among the national personnel. Therefore, the second objective of the Project was to develop this expertise among national personnel through training at places abroad where this technique has already been well established.

II. METHODOLOGY ADOPTED

II.1 STATUS OF TECHNOLOGY :

Primarily, there are two types of near infra-red spectroscopy based food quality analysis instruments, namely Fixed Filter Type Instruments and Tilting Filter Type Instruments. Some of the companies commercially producing such instruments in the world are:

(a) M/s Pacific Scientific of U.S.A. using optical filters in a tilting mode and making grain analysis instruments;

(b) M/s Technicon using fixed filter technology and making agro dairy analysis instruments;

(c) M/s Foss Electric, Denmark using fixed filter technology to make dairy analysis instruments;

(d) M/s PERCON using fixed filter technology to make grain analysis instruments;

(e) M/s MULTISPEC making milk analysis instruments using fixed filter technology etc.

In the the beginning, therefore, a detailed survey of these technologies and the different products built on these technologies was made to determine their relative merits and demerits. As a result of the survey,it was found that the use of optical filters in a tilting mode configuration was more suitable. The advantages of tilting filter technique over the fixed filter technique are as under :

i) Products based on tilting filter technique are less costly as compared to those based on fixed filter technology as they use lesser number of optical filters;

ii) Tilting filter technique allows the use of a variety of mathematical treatments on the optical data; whereas in fixed filter instruments, generally, delta log 1/R technique only is used.

iii) As the effective wavelength passed by an optical interference filter in tilting mode can be shifted by 10 % without serious distortion, large number of discrete wave lengths can be generated for scanning the sample using one filter only. This means lesser number of optical filters have to be used in tilting mode. In contrast, for the fixed filter technique, one filter is needed for each measurement wavelength. Use of tilting filter technique, thus, reduces the cost of instrument, particularly as these filters are not manufactured in India and have to be imported.

In light of the above, it was decided to proceed with a near infra-red spectroscopy microprocessor based instrument using tilting filter optical technology.

II.2 IMPLEMENTATION

The development of the Grain and Milk Analysers involves both electronic and near infrared optical designs.

(a) As Electronic Systems Punjab Limited (ESPL) had adequate in-house facilities in the field of electronic design and development, it was decided that ESPL itself should take up the design, development and fabrication of electronic sub-system. The electronic sub-system as used in the instrument consists of three major circuits:

i) Microprocessor and its associated Logic Circuits
ii) Analog-to-Digital Convertor
iii) Analog Amplifier

All these circuits are described in detail in Annexure I "Electronic Subsystem Description" of this Report. The complete circuit diagrams of the instrument are given in Diagrams D3 - D15 in this Report.

(b) As the necessary expertise for the development of optics sub-system did not exist with the Project Authorities at the time the Project was conceived, it was decided that experts from abroad in the field of near infra-red instrumentation should be identified and invited to the Project site for help in developing the opto - mechanical portion. In addition, collaborative programmes should be established with the national institutions for fabrication of the electro-optical subsystem.

The Diagram I gives details of the optical sub system. This is briefly explained in Annexure II.

The light energy is generated by a tungston halogen lamp(6V) being cperated at 5V. The light is then collimated by a quartz lens.The parallel beam of light after passing through the interference filters mounted on the encoder wheel, falls on a blocking filter. The blocking filter blocks out any external light and allows only the measurement wavelengths to pass through. The wavelength after passing through the sample cup window falls perpendicularly on the sample. A pair of lead sulphide detectors are mounted at an angle of 45 degrees to collect the diffusely reflected radiaton. Please refer to Annexure II. Technical Specifications of the optical subsystem are given in Annexure III.

(c) The second objective of the Project was to develop indigenous expertise in related fields. This was sought to be accomplished through the training of national personnel in suitable places abroad as suggested by the invited consultants and experts to the Project. In addition, these experts were to train the Project personnel on various aspects of near infra-red technology during their visits to the Project site.

(d) To create the necessary infrastructure for achieving the Project's immediate objectives, various test equipment were identified and requisition for the same were placed with UNDP. During the period, the Project was under implementation, these items were duly procured by UNDP and supplied to ESPL. The complete list of all such equipment is given in Annexure IV.

III. ACTIVITIES CARRIED OUT AND OUTPUTS PRODUCED

III.1 Design and Development Activities

i) It was decided to proceed with the design and development of a Cereal Grain Analyser initially. The development of the Milk Analyser is similar to that of Grain Analyser which can be used as Milk Analyser but with some modifications.

ii) The specifications of the proposed instrument were finalised after indepth discussions with the potential customers like NDDB. The technical specifications of Cereal Grain Analyser are given in Annexure V.

iii) The Cereal Grain Analyser design can be divided into two main stages :

a) Electronics Sub system design; and
b) Opto-mechanical Sub system design

III.2 Electronic Sub-System Design

The electronic sub-system design further consists of different design activities :

a) On the hardware side, the sub-system design includes printed circuit board design, circuit design, identification of electronic components, wiring diagrams etc;

b) The software design involves development of software in assembly language for the system and testing it simultaneously with the hardware, sorting out any bugs present and improving the software to make it as user friendly as possible.

All these activities were successfully carried out.

c) Instrument software was developed for performing complex regression analysis on the optical data picked up by the optical subsystem.

d) All the electronic components were identified along with their sources of purchase, with effort being made to keep the import content in the components as little as possible.

e) Hardware design was also finalised and three major printed circuit boards were developed for the assembly of electronic components. These boards were : Microprocessor Board, the Analog-to-Digital Convertor Board and the Amplifier Printed Circuit Board. Detailed description of the electronic subsystem can be seen in Annexure I.

III.3 Optical Subsystem Design

As mentioned earlier, after making a detailed study of optical designs of commercially available instruments in the world market, a near infra-red (NIR) tilting filter design was chosen. As the visit of foreign experts to the Project site and the training programme of project engineers was delayed, it was decided by the Project Authorities to continue on their own, the development of the optical system design which could be further upgraded or modified after the experts' arrival, based on their advice. Accordingly all the optical components were identified and the complete design of opto-mechanical subsystem was done. Annxure II describes the optical subsystem.

III.4 Engineering Activities

Electronics

i) All the identified electronic components were procured. Some of these components had to be imported from different countries since they were not available indigenously.

ii) Orders were placed with UNDP for the purchase of Test and Production equipment required for the fabrication, testing and calibration of the Cereal Grain Analyser.

iii) Complete Printed Circuit layout and design was done for the three Printed Circuit Boards(PCBs) as described in Annexure I. The PCBs were then fabricated as per the design.

iv) The printed circuit boards were then seperately mounted with electronic components and were fully assembled alongwith their power supply.

v) All the electronic printed circuit boards fabricated earlier were tested separately and as a whole for testing of the complete electronic subsystem.

Opto-mechanical

i) As ESPL did not have facilities for fabrication of complex opto-mechanical parts, it was decided to carry out the fabrication of the electro- optical subsystem with the technical assistance of Central Scientific Instruments Organisation (CSIO), a national laboratory under Council of Scientific & Industrial Research (CSIR). A sub contract was given to them for this purpose with the understanding that all optical components would be supplied by ESPL. Many of the optical components were not readily available in the world market and were purchased after considerable joint efforts of ESPL and UNDP.

ii) The visit of UNDP experts in near infra-red technology to the Project site was delayed and they could visit the Project only in 1985. However, their visit could not contribute much towards achieving the Project's objectives. In the absence of any concrete proposal for an alternate optical design, it was decided to proceed ahead with the original optical design and complete fabrication of opto-mechanical subsystem was done with the technical assistance of CSIO.

III.5 Integration

The electronic and opto mechanical subsystems were integrated together and the system was tested successfully as a whole to produce the first prototype of Cereal Grain Analyser.

III.6 Calibration Activities

i) Before the instrument could be put to field use, it had to be properly calibrated. Realizing the importance of calibration of the instrument, the Project Authorities requested UNDP for provision of an international expert in calibration for the Project. The name of Mr. S.A. Nexo was approved in this context and he visited the Project site during May 1986. After his visit, the Project Authorities requisitioned UNDP for purchase of equipment for calibration based on his advice.

ii) In addition to advising about calibration methods for the prototype, Mr. Nexo had also suggested some improvements in the first prototype design. As the Project Authorities found his suggestions useful, a second prototype similar to the first one but incorporating the modifications suggested by Mr. Nexo was fabricated afresh and tested.

iii) Calibration of Cereal Grain Analyser involved collection of a large number of grain samples. These samples not only had a representative range of constituents to be measured but also had many different varieties and were from as many different places of the country as possible. Realising the importance of good calibration, the Project Authorites established contacts with many agricultural institutions all over the country and thus collected various samples of wheat of different varieties with varying percentages of protein constituent.

iv) In view of the importance of calibration in such instruments, Project Authorities requested UNDP for a second visit of Mr. Nexo to the Project. Mr. Nexo visited the Project for a short duration again in December 1986. The second prototype of the Cereal Grain Analyser was successfully calibrated on the grain samples collected for protein and moisture.

v) Field testing of the two prototypes was done over a period of five days at the Wheat Project Directorate, IARI, New Delhi. The letter certifying the performance of the instrument is attached as Annexure VI in this Report.

III.7 Training Activities

i) UNDP experts in infra-red technology were to visit the Project in 1984. However, their visit could be arranged during 1985 only. The Project was visited by Mr. John Shield in February 1985 and by Dr. H A Gebbie in April 1985. However, their visits were not useful towards meeting the Project objectives.

ii) The training of the project personnel was originally suggested in 1984. Because of difficulties faced in the placement of this personnel, the training of selected persons was delayed and the first two engineers were able to under go their training during the period November 1985 - April 1986, and the third engineer could only receive training in May - July 1986. The fourth engineer was sent abroad for training in February 1987 for a three month period.

IV. ACHIEVEMENT OF IMMEDIATE OBJECTIVES

i) The Project's immediate objective of design and development of a suitable Cereal Grain Analyser has been achieved. The Cereal Grain Analyser has been calibrated on wheat samples and the field testing of the prototypes has been done at IARI, New Delhi.

ii) The design of the Milk Analyser is similar to that of the Grain Analyser. With modifications, the Grain Analyser can be used as a Milk analyser. (Annexure VII).

iii) The Project's second objective of training national personnel for developing indigenous expertise has also been achieved. Four Project engineers have been trained abroad in the field of near infra-red instrumentation and a well equipped laboratory has been established at the Project site for undertaking development of such sophisticated instruments.

V. UTILISATION OF PROJECT RESULTS

Keeping in view, the importance of the product in enhancing the quality of agro-dairy products, ESPL has taken several steps for effective utilisation of the Project results.

i) Commercialisation and Future Development

As a result of keen interest evinced by various user agencies, ESPL is going ahead with plans to manufacture a Near Infra-red microprocessor based Grain Composition Analyser. Initially, the target is to manufacture about 1000 number of such anaylsers every year.

In order to update the existing instruments, ESPL has further taken up the development of an oil analyser for oil measurements in oil seeds. This instrument will also be based on near infra red technology and will incorporate the latest technology.

ii) Creation of Necessary Research Environment

Because of the fast changing technology in the field of microprocessor based electronics and optical techniques, there is an imperative need to keep pace with the state-of-art technology in these areas. Therefore, ESPL is keeping track of the developmental activities being undertaken elsewhere in the world. For continuous updating of the existing technology, a well equipped research laboratory has been established at the Project site. The laboratory is staffed by well qualified engineers trained abroad under the Project. Thus, the necessary environment for development of similar near infra-red microprocessor based instruments has been created in the country.

iii) Applications of Project Results

The Grain Analyser developed under the Project can be utilised in a number of applications to benefit the agricultural community by increasing the quality of agro-dairy products in the country through

a) monitoring of grain quality during storage,

b) monitoring the quality of grains being brought for sale to the agricultural markets in the country. This will help in gradation and price fixation of the grains ;

Besides the instrument can be used in agricultural research institutions all over the country to check the quality of grain produce in various parts of the country. New methods e.g adding a particular type of fertiliser to improve the protein content can then be suggested by these research institutions and the result can be monitored by checking the protein content of grain samples by the instrument.

VI. FINDINGS

i) Projects of this nature are of high relevance, particularly to countries like India which are largely dependent upon agriculture as a base for their economic development.

ii) During implementation of the UNDP Project, a well equipped laboratory with well trained staff got established. With the assistance provided by UNDP, it was possible to develop a Grain Analyser capable of measuring protein and moisture content in cereal grains. During the process of development, various problems were encountered, solutions to which were found through inhouse R&D of ESPL which has a strong base in the field of electronics and computers design and also through exchange of information with local as well as foreign sources. The successful development of the instrument besides creating expertise in this area has also been able to generate a high degree of confidence in the group for undertaking similar other projects. This has thus paved way for undertaking development of many more such sophisiticated instruments.

iii) The techno-economic benefits expected from the field trials provided an outlet for creating awareness about the product in the relevant segment of the market. As a result, the Project has till date evoked lot of interest and enthusiasm among the potential users thereby adding to its demand in the ultimate analysis.

iv) The support provided by UNDP in this area which is of great relevance to the country has been considered as a matter of prestige by the Company. This, along with successful development of the instrument, has boosted Company's image considerably in other areas of its market.

v) Having been the first company in India to introduce micro/mini computers and data acquisition & control systems based on state-of-the-art technology, the development of this instrument once again based on the latest & contemprory technology and for the first time in the country added yet another dimension to compony's countrywide corporate image of being the 'High-tech pioneers'.

vi) In its endeavour to create high -tech environment by introducing products based on latest technology-contemprory to that available in international market the company created a strong R & D base for computer hardware and software including separate software for real time applications. To keep pace with international developments in the area ,this base got further strengthened both in terms of sophisticated equipment and the technical expertise through the training and development of manpower under the project.

VII. RECOMMENDATIONS

i) Due to the interaction, the Project Authorities had, particularly with the local sources and the response which was thus received during the implementation of the Project, it is felt that UNDP must support development of similar front line technology products. Such front line technology projects should be undertaken through UNDP assistance because of :

a) Ready access to the latest and innovative technology as available in the advanced countries.

b) Immediate availability of effective channels for exchange of information with the concerned centre of excellence elsewhere in the world.

c) Ready availability of assistance in terms of men, materials, and money which are so very vital for successful completion of the Projects. Now,since a well equiped laboratory,with trained personnel and suitable expertise is available at ESPL, it is recommeneded that there should be a mechanism for constant interaction of ESPL with UNDP for implementation of similar projects.

ii) It is strongly recommended that in order to enable the third world countries to reap the benefits of such intensive technology development efforts, a suitable mechanism for dissemination of knowledge must be evolved by UNDP.

iii) Although the Project has been able to create sufficient base for further development in this area, it is strongly recommended that UNDP should continue to play an active role at least in the exchange of information so that Project authorities remain upto date with latest developments taking place on the international scene. One of the mechanisms recommended could be through the constant exchange of personnel.

iv) A suitable mechanism should be evolved by UNDP to assess the impact made through the development of this technology and the benefits accruing from the commercialisation of the technology.

ANNEXURE I

ELECTRONIC SUB-SYSTEM DESCRIPTION

The electronic sub-system is divided into following three printed circuit boards and a power supply unit as can be seen in Diagram I.

1. Amplifier and Detector PCB
2. Analog to Digital Converter PCB
3. Microprocessor based Memory and Control PCB
4. + 14 V Power Supply (SMPS)

A brief description of these PCB's is given below:

1. Amplifier and Detector PCB:-

The electromagnetic radiation after passing through the blocking filter is allowed to fall on the grain sample enclosed in a sample compartment. The diffusely reflected light is picked up by two lead sulphide detectors mounted at an angle of 45 degrees. These detectors are fixed on an aluminium block mounted on the amplifier and detector PCB. Since lead sulphide detectors are extremely sensitive to temperature, these are cooled by thermoelectric cooling units mounted on the Aluminium block which serves as a heat sink. The temperature of the detector is sensed by a thermistor mounted on the heat sink. The lead sulphide detectors convert the weak light signal into electric signal. As this signal is extremely weak, it is further amplified and converted into log 1/R by a logarithmic amplifier. The temperature control system is also mounted on the PCB. The first amplifier and the log amplifier are temperature controlled by this control system. All the amplifiers use F.E.T. input linear integrated circuit (771) for better performance and S/N ratio.

2. Analog to Digital Converter PCB

The amplifier and detector PCB is connected to the analog to digital converter PCB by a 20 pin connector. The log 1/R analog signal is given to a 12 bit "successive approximation" analog to digital converter IC working in bipolar mode with an input signal range of +/- 10V. All the A/D timing signals are also generated in this PCB with the help of two nos. CA 311 and an optical source and sensor assembly. An optical encoder wheel having very fine metal etchings is fixed on the circumference of the rotating filter wheel. As the filter wheel rotates, the alternate black and white etchings pass through the slit of the optical source and sensor assembly.

This results in generation of timing pulses. With the help of an index pulse on the encoder, the position of the filter from the time they are in front of the light beam to the time they are blocked from the beam can be fixed. Each filter is rotated by an angle of 36 degree in front of the light beam and in this period, one hundred pulses are generated by the encoder or in other words 300 readings are taken in one rotation. These pulses from the optical encoder are shaped by two numbers 311 integrated circuits and provide the read/write pulses for the analog to digital converter. To synchronise the microprocessor to the A/D converter, these pulses are further shaped by monostable multi vibrators and fed to the microprocessor card along with the 12 bit digital signal.

This PCB also contains the filter wheel motor control circuit and the regulated + 5.0 V d.c. supply for the quartz halogen lamp. Two numbers IC 3524 pulse width tracking regulators form the basis of + 5V logic power supply and the lamp power supply. The ± 15 V power supply is generated by MC 1568 dual regulator integrated circuit.

3. **Microprocessor Memory and Control PCB:-**

The Microprocessor Unit uses a 8 bit microprocessor 'INTEL 8085' for processing of the large amount of spectral data input from A/D PCB. The software program in assembly language is contained in 4K byte EPROM chip mounted on the PCB. Two 5101 RAM IC's (256 x 8 bit) are used for storing the calibration constants and the wavelength values at which readings are to be taken. They also serve as a scratch pad for the software program. The RAM's are provided with a separate + 3 V d.c. supply from alkaline cells to prevent erasure of calibration constants at switch off. This card also contains the digital display with the display logic circuit and the buzzer. It also contains seven no. of L.E.D.s which light up to indicate the status of the instrument. The software program controls the working of the instrument including the keyboard and the amplifier card. The spectral data is input to RAM and is processed by the microprocessor according to the linear multiple regression equation program stored in the EPROM. This PCB is connected with the help of a 44 pin connecter to the Analog to Digital Converter PCB and through a 10 pin connector to the keyboard.

4. **Power Supply Unit:-**

A + 14V Switching Mode Power Supply Unit is the main d.c supply for the analog to digital converter card from where all the other supplies are generated. The -250V d.c. supply for the lead sulphide detectors is generated using a d.c. to d.c. converter (+5V/250V).

ANNEXURE II

OPTICAL SUB-SYSTEM DESCRIPTION

The Instrument works on the principle that all constituents in a compound are capable of absorbing electromagnetic radiation. Also each constituent has a unique Absorption Band or in other words absorbs light of a particular wavelength only which is characteristic of the molecular structure of that constituent. Therefore, measurement of this absorbed wavelength can serve as a signature of the presence of a particular constituent in a compound. It has been observed that the absorption of light by a particular constituent in the sample is directly proportional to the concentration of that constituent provided the path length of light remains constant. This is given by Beer's Law as:-

$$Ai = \log \; 1/Ti = aibc$$

Where 'Ai' is light absorption at a particular wave length; 'Ti' is the percent of light transmitted through the grain sample; 'ai' is the absorption co-efficient for a particular constituent i.e a constant; 'b' is the path length of the light; and 'c' is the concentration.

As it is relatively difficult to measure the light transmitted through the solids, instead the diffused portion of the light reflected from the sample is measured and collected. This is the light which is first absorbed by the sample and then reradiated diffusely in all directions. Now Beer's Law is modified as:-

$$Ai = \log \; 1/R = aibc$$

Where R is the percent reflected radiation.

It has been shown that water, protein and oil have unique absorption wavelengths in the near infra-red region of the spectrum e.g. water has absorption bands at 1.45 and 1.94 um, protein has absorption band at 2.06, 2.18, 2.30 um and oil has absorption bands at 1.725, 2.35 and 2.345 um.

Out of these,the best possible wavelengths are selected by statistical analysis on a computer where absorbance by the desired component is maximum compared to other constituents and also there is minimum interference from other physical effect like particle size effect etc. The cereal grain analyser measures the protein and water contents at selected wavelengths of 1.94,2.05,2.14 and 2.25 um and uses narrow band interference filters in a tilting filter system described later in this annexure.

The light absorption `Ai' is thus measured at these specific wavelengths and a linear multiple regression analysis equation is solved to predict the percentage composition. The linear regression model used is the straight line model.

$$\text{i.e. } Y = C0 + C1\,(X)$$

Where Y is the percent composition of a particular compound, X is the independent variable i.e. the absorbed light radiation measured earlier. C0 and C1 are calibration constants obtained by statistical analysis of a large number of samples by plotting the sample chemical results on Y axis and the instrument reading on the X-axis. C0 is the intercept of the straight line and C1 is the slope of the straight line.

OPTICAL SUB-SYSTEM OF THE CEREAL GRAIN ANALYSER

The optical diagram of the Cereal Grain Analyser is shown in DIAGRAM II. The Grain Analyser is used for the simultaneous determination of moisture and protein in cereal samples. Infra-red spectroscopy technique is used for this purpose.

A quartz halogen lamp coupled with a reflector, focusses the radiation in the front focal plane of a collimating quartz lens. The parallel beam of light after passing through a monochromator consisting of three narrow band pass (10 nm) interference filters of central wavelength 2.08 um, 2.19 um and 2.32 um, a broad band pass blocking filter, and two quartz glass windows, falls perpendicularly on the sample. A pair of leadsulphide detectors are positioned at 45 degrees to the sample to receive the diffused reflected light from the sample.

The principle is that the effective center wavelength of the filter shifts towards shorter wavelength as the filter is tilted in the light beam. The wavelength allowed to pass is governed by the following equation.

$$\lambda = \frac{\lambda_0 (N^2 - \sin^2\theta)^{\frac{1}{2}}}{N}$$

Where λ = Wavelength at Angle θ
λ_0 = Wavelength at Angle 0° (Normal)
N = Refractive Index

Wavelength scan of NIR region is obtained by rotating a multi-filter wheel mounted on a position detector encoder.

The standard interference filters used in the instrument and their scanning ranges are given below:-

Filter No.	Pulse Point	Filter in normal position	Scanning Range(NM)	Constituents
1.	223-232	2080 NM	1901-2080	Moisture
2.	566-665	2190 NM	2000-2190	Protein
3.	899-998	2320 NM	2210-2320	Protein C.M.

ANNEXURE III

TECHNICAL SPECIFICATIONS OF THE OPTICAL SUBSYSTEM ARE:

i)	Halogen lamp of Tungsten Filament	= 6V/10W
ii)	Collimating lens:	
	Focal Length	= 32 mm
	Diameter	= 34.9 mm
	Central Thickness	= 13 mm
	Radious of curvature (R1)	= 31.002 mm
	Radious of curvature (R2)	= 31.002 mm
	Material used	= Quartz Glass
iii)	Interference Filters:	
a)	Central Wave Length	= 2080 nm
	Half Band Width	= 10 nm
b)	Central Wave Length	= 2190 nm
	Half Band Width	= 20 nm
c)	Central Wave Length	= 2302 nm
	Half Band Width	= 20 nm
iv)	Encoder Disc	
	Frequency	= 500 slits/Circle
v)	Quartz Windows:	
1.	Diameter	= 54 mm
	Thickness	= 1.2 mm
2.	Diameter	= 35 mm
	Thickness	= 1.2 mm
vi)	Infra- red-Broad Band Pass Filter (Blocking Filter):	
	Central Wave Length	= 2150 nm
	Half Band Width	= 61 nm
	Cut on Wave Length	= 1750 nm
	Cut off Wave Length	= 2530 nm
	Peak Transmission	= 80%

CAPITAL EQUIPMENT UNDER THE PROJECT — ANNEXURE IV

DATE	P.O.NO.	QTY	DESCRIPTION
09/20/82	15-2K00554	1	(MODEL 192) PROGRAMMABLE DIGITAL MULTIMEYER WITH TRMS AC OPTION
10/05/82	15-2-K0565	1	ROTOFORMER(RF450)AXIAL LEAD CUT&FORM MACHINE(230V 50HZ)FIXED BW-202.
10/05/82	15-2-K0565	1	STRIPPER/CUTTER HAND TOOL(HAND WIRE STRIPPER)PSC-1 DE-0006.
10/05/82	15-2-K0565	1	PSE-1 STRIPPER CABLE DE-0003.
10/05/82	15-2-K0565	1	PRINTED CIRCUIT BOARD HOLDER (WY-40) DE-0014.
10/05/82	15-2-K0565	1	WS3 FORMER WITH TRANS/CAP KIT D-109 LW901(CUTTER&FORMER LEAD MANUAL)
10/05/82	15-2-K0565	1	STRIPPER FLAT 230 VOLT 50HZ(D109,WIRE STRIPPER) DE-0045
10/05/82	15-2-K0565	1	WHL,FYB PAIR 1/4*1/4(335AH 640FL)
10/05/82	15-2-K0565	1	TP3 CUTTING & BENDING TOOL(TOOL COMPONENTS LEAD BENDING).
11/03/82	15-2-K0682	1	U BIX V3R COPYING M/C WITH A DRUM,UNIVERSAL & A-4R CASSETTE
11/03/82	15-2-K0682	5 SETS	U BIX V3 COPY KIT DEVELPR(900G),TONER(225*4)&OTHER ACCESSORIES
11/03/82	15-2-K0682	1	U BIX V3 DRUM (EXTRA)
11/03/82	15-2-K0682	126PCS	SPARE PARTS .
11/23/82	15-2-K0737	1	SPL CALIBTOR(PORT DIG MULTIMTR CALIBTR W/RECHARGBL BAT PACK MODL515A)
11/23/82	15-2-K0736	1	CAROUSEL S-AV2050 SLD PROJECTOR
11/23/82	15-2-K0736	1	CAROUSEL S-AV2050 SLD PROJECTOR
11/23/82	15-2-K0736	1	REMOTE CONTROL W/4M CABLE(CRSL RMT CNTRL).
11/23/82	15-2-K0736	1	RETINER F3.5 85MM LENS 66121(PRJN RTINR LNS 85MM).
11/23/82	15-2-K0753	1PCE	GRAIN MOST DETECTOR MODEL G-6/56-E MODEL G-6 W/56-E DBL DISC ELECTDE
11/23/82	15-2-K0753	1PCE	N-121 GRAIN THERMOMETER.
11/23/82	15-2-K0753	1PCE	CARRYING CASE #1502 (G-6).
11/23/82	15-2-K0753	1PCE	# 830-2 10" PROD (BALED HAY).
11/23/82	15-2-K0753	1PCE	# 830-3 18" PROD (HAY IN MOWS).
11/23/82	15-2-K0753	1PCE	# 830-3 36" PROD(HAY IN MOWS).
11/23/82	15-2-K0753	1PCE	# 831 SHORT PIN PROD(CHOPPED HAY,HAY IN WINDROWS).
11/23/82	15-2-K0753	1	# 832 LONG PIN PROD(SEED+GRAIN IN BAGS).

11/23/82	15-2-K0753	1PCE	H-3 ELECTRODE HANDLE
12/23/82	15-2-K0707	1	LOGIC KIT 10529-A (HEWLITT PACKARED)
12/23/82	15-2-K0707	1SET	10 CARDS PCBs 10529-20005-2(16 PIN)(AS A ACCESSORY WITH LOGICKIT)
12/23/82	15-2-K0707	1	ASSEMBLED CARD PCB 10529-600017(AS A ACCESSORY WITH LOGIC KIT)
12/23/82	15-2-K0707	1	ASSEMBLED CARD PCB 10529-60004-2(AS A ACCESSORY WITH LOGIC KIT)
12/23/82	15-2-K0707	1	MANUAL OF KIT (AS A ACCESSORY WITH LOGIC KIT)
12/23/82	15-2-K0707	1	LOGIC PROBE 545A (AS A ACCESSORY WITH LOGIC KIT)
12/23/82	15-2-K0707	1	CURRENT TRACER 547A (AS A ACCESSORY WITH LOGIK KIT)
12/23/82	15-2-K0707	1	LOGIG PULSER 546A (AS A ACCESSORY WITH LOGIC KIT)
12/23/82	15-2-K0707	1	LOGIC CLIP 548A (AS A ACCESSORY WITH LOGIC KIT)
01/05/83	15-2-K0620	1	MODEL 8001 19" HIGH RESOLUTION COLOUR GRAPHIC TERMINAL.
01/05/83	15-2-K0754	1	MODEL V-581 PLATO VAC-KIT.
01/05/83	15-2-K0754	1PCE	01-0030 MUFFLER(ACCESSORY WITH VAC-KIT)
01/05/83	15-2-K0754	1PCE	010032 HANDLE COLLECTOR.
01/05/83	15-2-K0754	1PCE	01-0033 COLLECTOR GLASS.
01/05/83	15-2-K0754	1PCE	01-5000 TIP CLEANER.
01/05/83	15-2-K0754	1PCE	01-7200 HEATER/COLLECTOR ASSEMBLY.
01/05/83	15-2-K0754	1PCE	01-9995 HOOK UP KIT,AIR.
01/05/83	15-2-K0754	1PCE	01-9996 FILTER,AIRLINE
01/05/83	15-2-K0897	1	MICROPTIC VISUAL AUTOCOLLIMATOR TA-121.
01/05/83	15-2-K-897	1	SURFACE PLATE STAND 142/22(ACCESSORY WITH AUTOCOLLIMATOR.
01/05/83	15-2-K0897	1	SET OF EIGHT ANGLE GAUGES.
01/05/83	15-2-K0897	1	LAMP TRANSFORMER FF2.
02/14/83	15-2-K1102	1	MODEL101 CEREAL GRAIN ANALYSER,+ ACCESSORIES,CYCLON SAMPLE MILL-1312
03/12/83	15-2-D01401	1	RLC DIGIBRIDGE W/100 HZ AND 1KHZ TEST FREQUENCIES 1658-9800.
03/31/83	15-2-D01334	1	256 MULTI-BUS RAM MODULE WITH ERROR CORRECTION.
03/25/83	15-2-D01469	2SET	GRAPHIC CONVERSION BOARD FOR TELEVIDIO 910+ TERMINAL R.G.1000 & TV61

05/23/83	15-2-K0517	1	7704A OSCILLOSCOPE SYSTEM.
05/23/83	15-2-K0517	1	7A22 DIFFERENTIAL AMPLIFIER.
05/23/83	15-2-K0517	1	7A24 DUAL TRACE AMPLIFIER.
05/23/83	15-2-K0517	1	7B85 DELAYING TIME BASE.
05/23/83	15-2-K0517	1	7D02 LOGIC ANALYSER (OPTION 01,OPTION 03).
05/23/83	15-2-K0517	1	PM101 GENERAL PURPOSE PERSONALITY MODULE.
05/23/83	15-2-K0517	1	MODEL3 OPT-01 SCOPE MOBILE CART WITHOUT POWER MODULE.
05/23/83	15-2-K0517	2+2	010-6055-01 PROBE P6055,10X,60MHZ+010-6056-03 PROBE P6056 10X,3.5GHZ
05/23/83	15-2-K0517	1	464 OPT.A1 100MHZ PORTABLE STORAGE OSCILLOSCOPE.
05/23/83	15-2-K0517	1	TM 506 MAINFRAME FOR SIX PLUG INS(POWER MODULE)
05/23/83	15-2-K0517	1	DC504 COUNTER/TIMER
05/23/83	15-2-K0517	1	PG508 PULSE GENERATOR.
05/23/83	15-2-K0517	1	PG501 PULSE GENERATOR.
05/23/83	15-2-K0517	1	DM 501A DIGITAL MULTIMETER
06/10/83	15-2-K0967	2	CROMEMCO D.P.U BOARDS
06/10/83	15-2-K0967	2	CROMEMCO M.C.U. BOARD
06/10/83	15-2-K0967	2	CROMEMCO 256 MSU BOARD
06/10/83	15-2-K0967	1	CROMEMCO 512 MSU BOARD
06/10/83	15-2-K0967	2	CROMEMCO CSO SERIAL PARALLEL INTERFACE BOARD
06/10/83	15-2-K0967	2	CROMEMCO QDRT COMP. BOARD
06/10/83	15-2-K0967	2	CROMEMCO WD I BOARD
08/16/83	15-3-K0238	1	606-3 POWERLINE DISTURBANCE ANALYSER S/N 172209293
08/16/83	15-2-K0238	1	OPT101 FOR SERIES 606(ACCESSORY WITH POWERLINE DISTURBANCE ANALYSER)
08/16/83	15-2-K0238	1	OPT102 FOR SERIES 606(ACCESSORY WITH POWERLINE DISTURBANCE ANALYSER)
11/19/83	15-3-B0904	1	HERMES TOP808 ELTRIC TYPWRIT+CONNECTABLE CARBON RIBON&LIFT OFF TAPES
12/11/84	15-4-B0637	1	SOLDERING EQUIPMENT AND TOOLS.
12/31/84	15-4-C0723	2NOs.	PRECESION COLOR DATA DISPLAY BARCO CDCT 5137NP SN.10213,10214.

12/31/83	15-4-B0556	1	MODEL 29A PROM PROGRAMMER 16K*8-RAM 220V/50HZ,SRC/CRC/OPT SN.5400683
12/31/84	15-4-B0556	1	UNIVERSAL PROGRAMMING MODULE AIN-FL,MOS,CMOS/PROMS
09/20/85	15-4-B0683	1NOs.	TOOL KIT,SOLDERING IRON.
02/08/85	15-4-C0204	1	HP-64100A MICRO-PROCESSOR DEVELOPMENT STATION
02/08/85	15-4-C0204	1	941 FLOPPY DRIVE AS.
02/08/85	15-4-C0204	1	64853AF ASSEMBLER 8086
02/08/85	15-4-C0204	1	64222A 8086 EMU.SUBSYSTEM
02/08/85	15-4-C0204	1	64156S 32K EMULATOR MEM.SUBSYS. SN.2350A03821
02/08/85	15-4-C0204	1	64302A CHAN INT ANA SN. 2350A03821
02/08/85	15-4-C0204	1	64500S PROM PROGRAMMER W/271
02/08/85	15-4-C0204	1	64100AF OPER.SYS. MINI FL.
02/08/85	15-4-C0204	1	64163A 32K EMUL.RAM SN.2246A02343.
08/12/87	15-6-C0872	1	ELECTRIC BALANCE MODEL HC22
11/05/86	15-5-C1526	1	64249A 68010 EMUL.POD.
11/05/86	15-5-C1526	1	64845AF ASSEMBLER AND LINKER FOR THE 68010-MICRO-PROCESSOR
01/18/87	15-6-C1373	1SET	FOSS LET COMPLETE SYSTEM INCLUDING HOMOGENIZER & SPARE PARTS
03/09/87	15-6-C1333	1SET	KJELTEC SYSTEM 1(DIG.SYS.6 ,1002 DISTL.UNIT),BASIC ACCESSORIES
07/17/87	15-7-C0286	2EACH	CRIMPING TOOL-1.TWIN LEAF HANDZANGE 2.RANGIERH-HANDZANGE.
04/18/87	15-6-C1443	2	DIGITAL MULTIMETER STDM-501A.
04/18/87	15-6-C1443	4	ST01002T100 PROBE VOLTAGE FLUKE 40KV.
04/18/87	15-6-C1443	1	60 MHZ DUAL TRACE OSCILLOSCOPE ST 2215A
04/18/87	15-6-C1443	2	ST010660101 PROBE,TEMP.
04/18/87	15-6-C1443	1	STTM 503 VERSORGUNGSEIN HEIT FUER 3E1 220V VERSION
05/24/87	15-' C1584	1	64203S 8085 EMUL. SBSY.,64840AF ASMBR 8080/85,64151A MEMCONTLR
07/17/87	15-7-C0429	1	VIDEO PATTERN GENERATOR , CROMA-1000
07/17/87	15-7-C0429	2SET	VIDEO SIGNAL DISTRIBUTOR, CROMA-101
07/17/87	15-7-C0429	1	SWITCH ANALYSER,CROMA MODEL-650
07/17/87	15-7-C0206	2PKG	VELOSTAT WORK STN.(PRT.NOs.8030,1854,8210,3043,3040,2212,2222,2202)
05/24/87	15-6-C1584	1	64960A EMULATOR/MEMORY CABLE(2NOs),64152S 32K EMUL.MEM.SYSTEM
07/17/87	15-6-C1193	1SET	NIR SPECTROMTR MODEL70/7700 WITH ALL ACCES,PRINTER(1NO),PLOTTER(1NO)
07/17/87	15-6-C1193	1	TREBOR MODEL 50A N.I.R.ANALYSER WITH ALL REQUIRED INTERCONNECTIONS

ANNEXURE V

TECHNICAL SPECIFICATIONS OF CEREAL GRAIN ANALYSER

1.	Parameters to be Measured	: Protein, moisture in Cereal Grains.
2.	Range of Measurement	: Protein : 8% to 20% Moisture: 8% to 16%
3.	Operating Temperature	: 0 Degree C To 40 Degree C
4.	Precision	: Standard Deviation on repeat readings of the same sample better than .1%
5.	Power Requirement	: 50 C/s, 220V A.C.
6.	Warm up Time	: Approx. : 15 Minutes
7.	Accuracy	: 0.35

ANNEXURE VI

Gram : KRISHIPUSA
Phone : 5 8 7 2 8 5

भारतीय कृषि अनुसंधान परिषद
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
गेहूं निदेशालय

WHEAT PROJECT DIRECTORATE

ALL INDIA COORDINATED WHEAT IMPROVEMENT PROJECT
(AICWIP)

ICAR

Dr.S.K.DUGGAL
Principal Investigator(Quality)

भारतीय कृषि अनुसंधान संस्थान
Indian Agricultural Research Institute
नयी दिल्ली-११००१२
NEW DELHI-110012

June,1987

The Cereal Grain Analyser (NIR) for moisture and protein determination in cereals developed by Electronic Systems Punjab has been tested in this Lab from 18th to 22nd May,1987. It is giving SE± 0.35 accuracy against Kjeltec Auto analysis. Its repeatability is within SD 0.11.

S.K.Duggal
8.6.87

(S.K. DUGGAL)

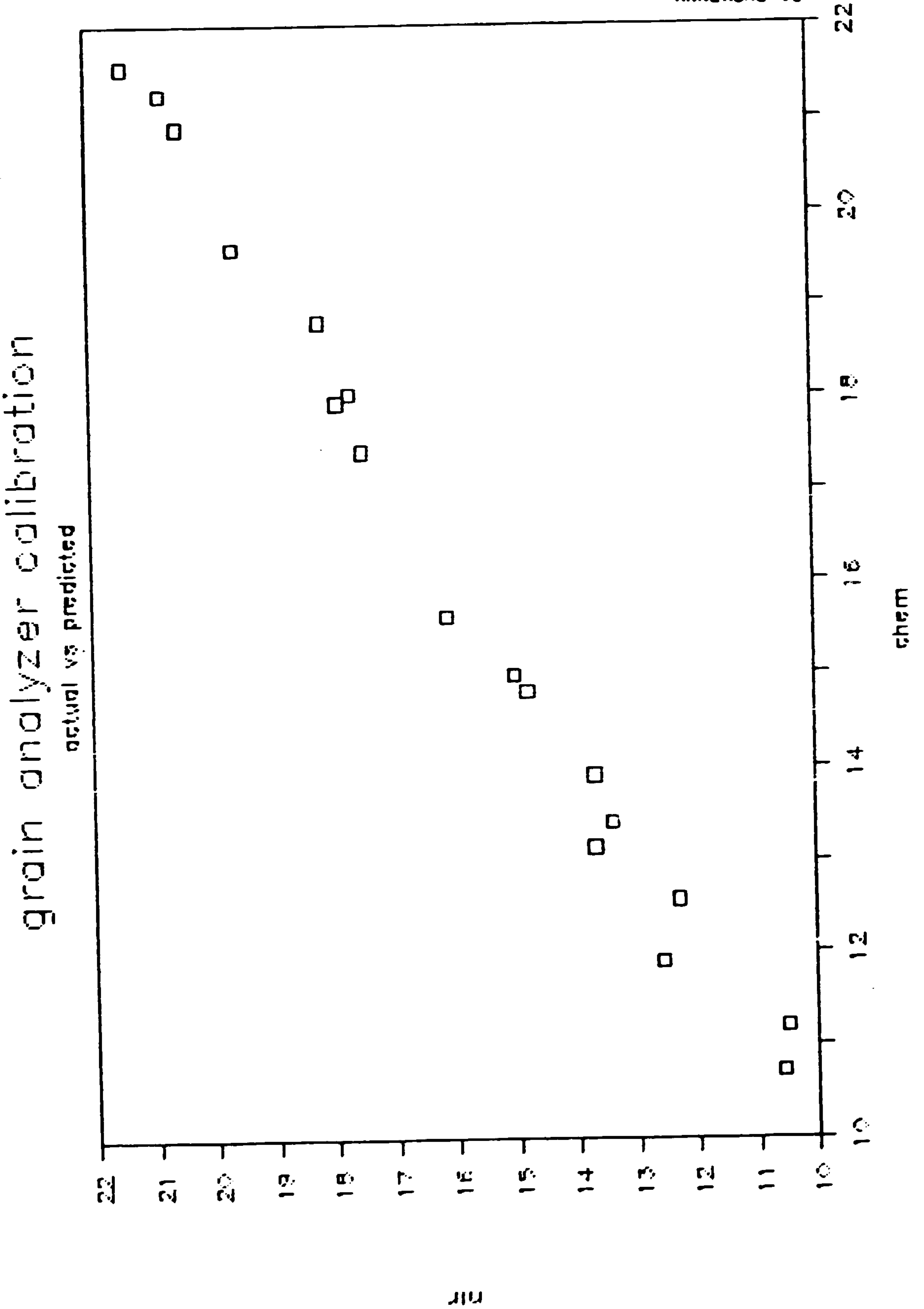
Certificate regarding performance of the Instrument

ANNEXURE VI

%PROT CHEM	%PROT NIR	% D
12.56	12.3	-0.26
10.72	10.6	-0.12
11.2	10.5	-0.7
11.9	12.6	0.7
13.4	13.4	0
13.13	13.7	0.57
21.55	21.4	-0.15
14.8	14.8	0
20.9	20.5	-0.4
17.4	17.5	0.1
18.02	17.7	-0.32
13.9	13.7	-0.2
17.92	17.9	-0.02
14.98	15	0.02
21.26	20.8	-0.46
15.62	16.1	0.52
18.8	18.2	-0.6
19.6	19.6	0

Prediction of Percent Protein content in unknown sample based on calibration at IARI.

ANNEXURE VI


grain analyzer calibration
actual vs predicted
chem
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ANNEXURE VII

The Cereal Grain Analyser can be used as a Milk Analyser with the following modifications:-

1. **INFRARED LIGHT SOURCE:-**

   Instead of tungsten halogen lamp, the nernst filament source will be used. It is a most energy efficient light source for the spectral region of milk analysis and covers the range 5 um to 10 um.

2. **INFRARED FILTERS-**

   The following wavelengths will be used in milk analyser, therefore, the infrared filters used in cereal grain analyser will be replaced by these wavelength filters to get the milk analysis wavelengths.

   C.W. 'Protein' - 6.46 um
   C.W. 'Fat' - 5.73 um
   C.W. 'Lactose' - 9.6 um
   H.B.W. = 10nm each filter
   % T = 60% for each filter.

   Where
   C.W. = Central Wavelength
   H.B.W.= Half Band Width
   % T = Percent Transmission

3. **MILK SAMPLE CELL (CUVETTE):-**

   A special kind of milk cell will be required to analyse the milk in transmission mode. The milk sample to be analysed will be placed in milk cell. The milk cell of 40 um path length with calcium fluoride windows, is most suitable to analyse the milk in MIR (Middle Infrared Region). The block diagram of milk cell (Cuvette) is attached herewith.

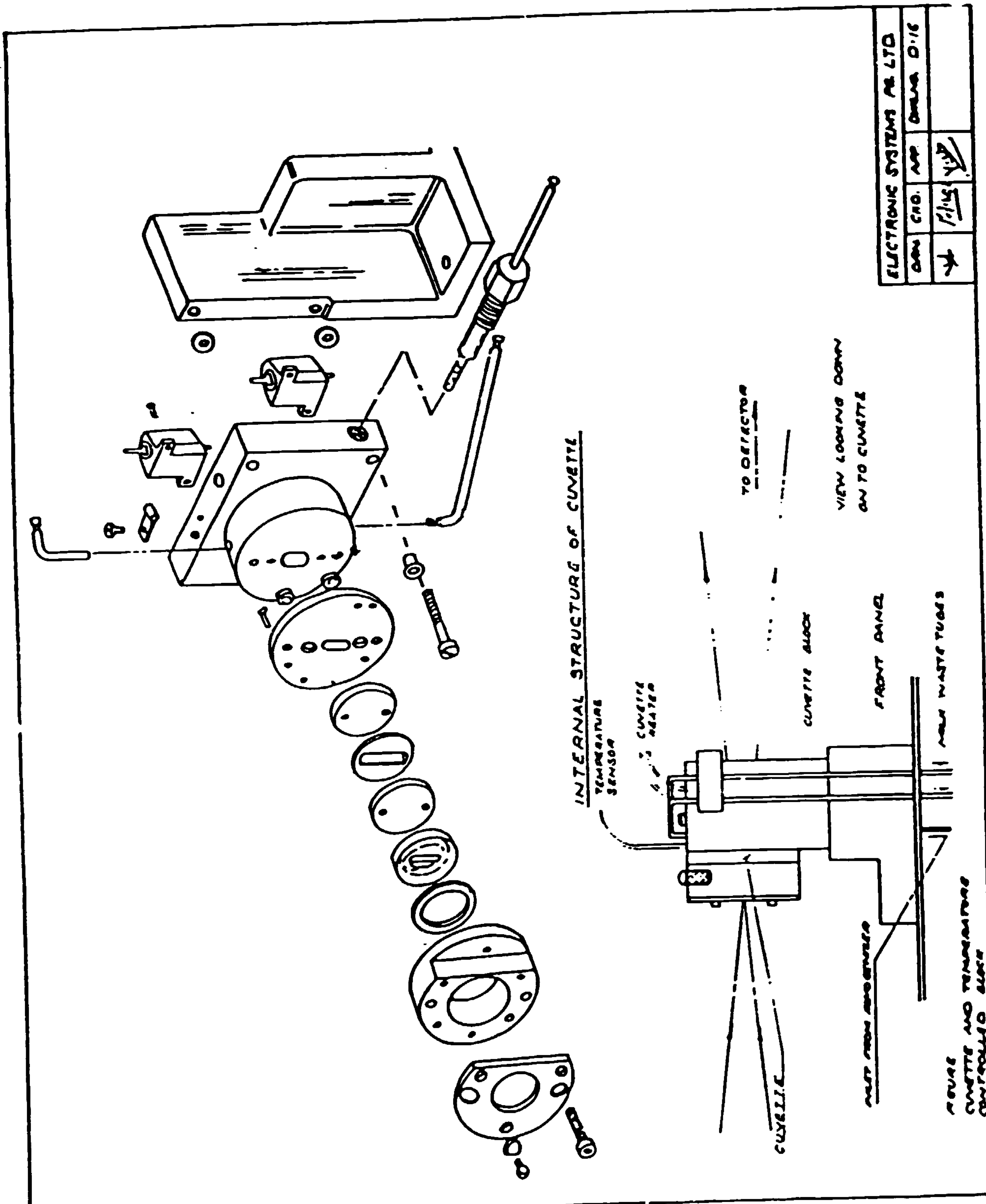
4. **HOMOGENIZER:-**

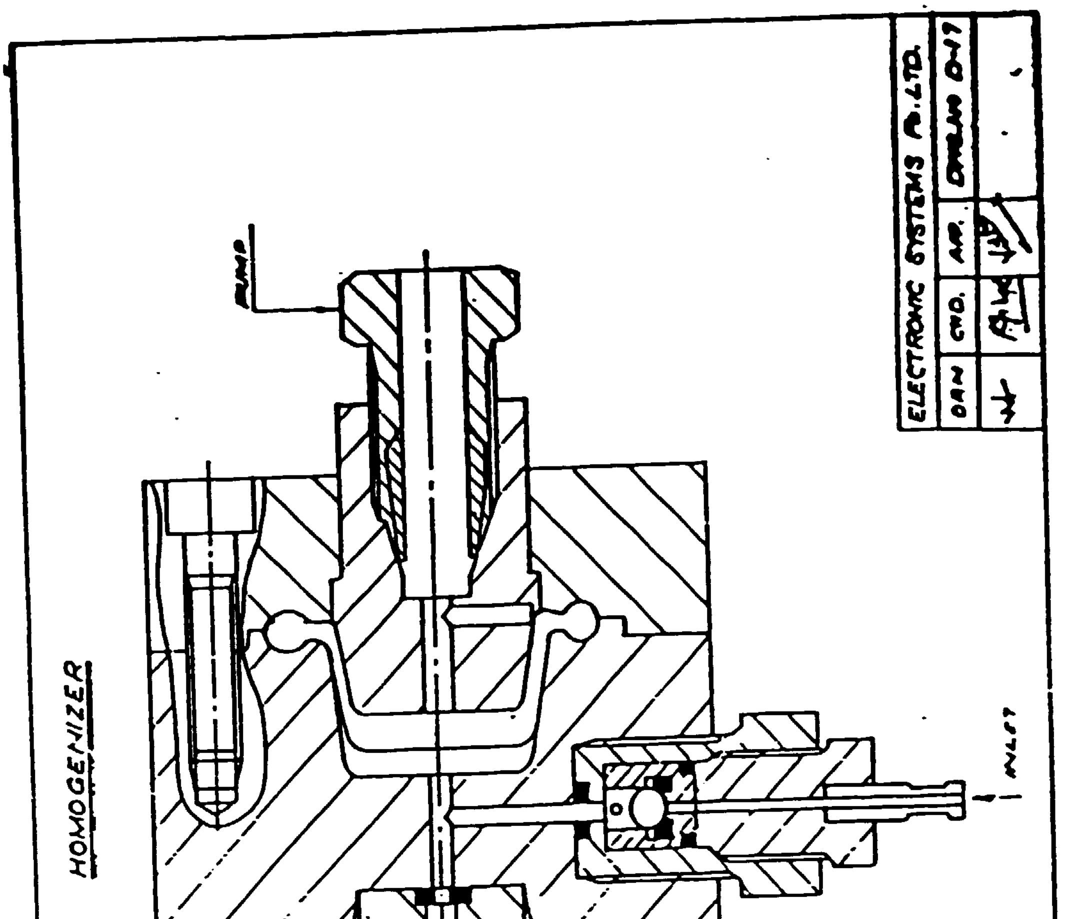
   Before analysis of milk can begin, it is first homogenized by a mechanical device called 'Homogenizer'. The Homogenizer will be used to break down the larger fat globules to diameters of less than 3 um, thereby eliminating the problem of scattering of IR energy.

5. **INFRARED DETECTOR:-**

   Instead of pbs detector used in cereal grain analyser, the pyroelectric detectors will be used to detect the middle infrared radiation passing through the milk cell. It may be noted that in milk analysis is done in the middle Infra red region (MIR).

By employing the above modifications in the cereal grain analyser, and keeping the electronic circuitry same, it can be used as a milk analyser.


INTERNAL STRUCTURE OF CUVETTE
TEMPERATURE SENSOR
CUVETTE HEATER
TO DETECTOR
CUVETTE BLOCK
FRONT PANEL
MILK WASTE TUBES
VIEW LOOKING DOWN ON TO CUVETTE
CUVETTE
FIGURE
CUVETTE AND TEMPERATURE CONTROLLED BLOCK
ELECTRONIC SYSTEMS PR. LTD


HOMOGENIZER
PUMP
INLET
OUTLET
ELECTRONIC SYSTEMS Pt. LTD.
DRN
CHD.
APP.

ELECTRONIC SYSTEMS PUNJAB LIMITED - A COMPANY PROFILE

ESPL-Ushering in a Computer Culture

Electronic Systems Punjab Limited, a State Government Enterprise (a wholly owned subsidiary of Punjab State Industrial Development Corporation) commenced operations in October 1980 with the objective of developing, manufacturing, and supplying Mini/Micro Computer Systems for different applications. April 1983, the Company began production and heralded an era of High Technology. The Company is proud of its contribution to the ongoing endeavours of ushering in computer culture in the country.

Internationally Matched... Made Here...

At ESPL, the maxim has always been `nothing but the state-of-the-art´, comparable to the latest, worldwide. No wonder the pioneering product line:

* Super Micro 32-16/32 bit Micro Computers using MC 68010/68020 Processors based on IEEE 696 bus with UNIX Operating System

* Super Micro 32V-32 bit Micro Computers using MC 68010/68020 Processors based on VME bus with UNIX Operating System

* Super Chip PC-XT/AT-the-IBM-PC compatible with MS DOS/XENIX/UNIX Operating Systems

* Data Acquisition and Control Systems based on Distributed Processing Technique in technical collaboration with WESTINGHOUSE ELECTRIC CORPORATION of USA for Power and Industrial Applications

* SCADA & Energy Management System for LDC in collaboration with WESTINGHOUSE SYSTEMS LIMITED, UK

* High Speed Modems for Data Transmission and Network Management in collaboration with RACAL-MILGO INTERCONTINENTAL of USA-the world leaders in data communication products, systems and services

* Microprocessor based Agro-Dairy Instruments (developed under UNDP assistance)

...Manufactured by the Most Advanced Production, Testing and Quality Assurance Infrastructure...

For the production of High-Tech Products ESPL has created modern and advanced facilities which match the international standards in manufacturing and quality assurance. The thorough Quality Control Certification process through which every system passes at all levels of manufacturing guarantees performance to meet the specifications

Among the modern manufacturing and testing facilities installed at ESPL, (at a value of over Rs. 30 Millions) in an airconditioned and anti-electrostatic environment are:

* Wave Soldering Machine

* CAD Systems for designing PCBs

* Fairchild Fault-Finder FS-333 for in-circuit performance testing of assembled PCBs

* Dynamic and Static Burn-in-Systems for environmental testing, for eliminating PCB infant mortality and for ensuring reliability

* Performance Test System for performance monitoring of assembled PCBs

* Automatic Test & Repair Stations for Integrated Systems

* Automatic Calibration System for analog boards

* Peripheral Exerciser and Test Systems

* Microprocessor Development System (M.D.S.)

Furthermore, the entire infrastructure and facilities are constantly being upgraded to keep pace with rapidly growing technology.

...Matched by an Efficient After-Sales Service Network...

Even fully-featured products are incomplete without comprehensive support. ESPL can and will service all your needs-before and after the sale.

ESPL's three-tier cus.omer support network already ensures more than 95% uptime for ESPL's Super Micro Systems.

* ESPL's field engineers are located throughout the country. They are qualified and highly experienced in all areas of computer system-hardware and software. Each one of them is supplied with necessary test equipment, spare parts and specialised tools;

* Regional Customer Support Centres are staffed with specialists who can help solve many complex problems.

* Technical specialists at our Head Office provide further back-stopping support to the Customer Support Enginers and Customer Support Centres in the event of peculiar problems.

ESPL has an experienced faculty which regularly organises "Customer Training Seminars". These seminars combine presentations with hands-on instructions which help customers in solving their common operational problems.

ESPL's field engineers act with speed and alacrity in resolving problems. Quite simply because ESPL believes in customers getting full benefit of capabilities built into every product. For timely availability of spares/back-up equipment, specialised air courier services are deployed to enable our engineers take corrective action in a matter of hours.

...For an Ever Expanding Base of Customer Installations...

Having a clear edge over others in installing 68010/68020 UNIX based systems, ESPL is breaking new grounds in broadening its user segment base. Some of our prestigious and satisfied customers:

Department of Electronics, Department of Science & Technolog, BHEL, NALCO, NTPC, Vizag Steel Plant, Bhilai Steel Plant, State Electricity Boards, Indian Navy, IAMR, AIR, BBMB, CSIR, NIDC, Indian Army, General Insurance, Nationalised Banks, R&D Organisations, Universities, IIT's, Regional Engineering Collges, Commercial Organisations. And many more are on their way to join the ESPL family.

...And With Our Confidence to Serve you on a Turn-key Basis...

Today, ESPL has the competence backed by confidence to serve you on turn-key basis covering.

* Working out your total requirements
* Hardware installation and commissioning
* System Software with complete Documentation

* Customer training for optimum use of the system
* Application software packages to provide complete solutions
* Deputation of staff on round -the-clock basis at your premises
* Efficient After-Sales Services

Foreign Collaboration

ESPL has foreign collaboration with:-

* Westinghouse electric corporation U.S.A. for Data Acquisition & Control Systems
* Racal Milgo Intercontinental for manufacture of microprocossor based modems required for networking of computers for data communications.

  ESPL has recently entered into technical collaboration with the company for the manufacture of complete range of modems required for the networking of computers for data communicating.

In addition ESPL has the technical back up from the following:

* Cromemco Inc. U.S.A. for Mini/Micro Computer Systems.

* Ironics Inc. U.S.A. for Super Micro 32 V Computer Systems

Our Success Factor

ESPL has a dedicated team of highly motivated qualified professionals on its rolls because it believes that in addition to advance production, testing and quality control processes, what matters is the people who man the cpompany. To these professionals goes the credit of rapid indigenisation and diffusion of technology.

Performance targets set are closely monitered and reviewed. Modern management techiniques and an open-door policy encourages both upward and downward communication filling every employee with pride in the organisation. Fuelling the motivation to do better still, to keep pace with tomorrow------today.

Training is an essential part of personnel policies and many of the young engineers have had training and hands-on-experience abroad so that the Company can remain ahead.

While technology changes at a rapid pace worldwide, ESPL endeavours to continuously upgrade its powers. May be, we have not yet ventured into the bio-chip but who knows perhaps even that is at hand.

Turnover of the Company and its Future Projections

The turnover of the Company during the year 1986-87 was Rs.200 Millions as compared to Rs.100 Millions during the preceding year thereby registering a growth rate of 100%. The target for the year 1987 - 88 is Rs. 350 Millions. It would be pertinent to bring out that the during the first full year of its working, the Company declared a dividend of 8%.

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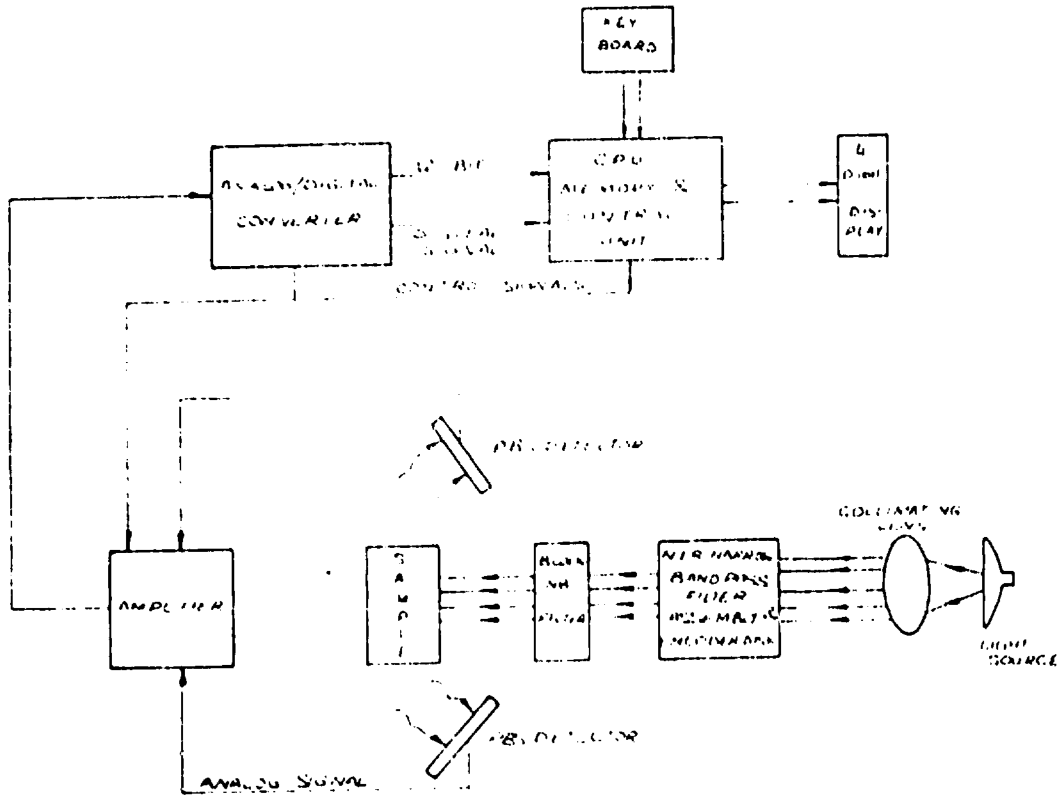
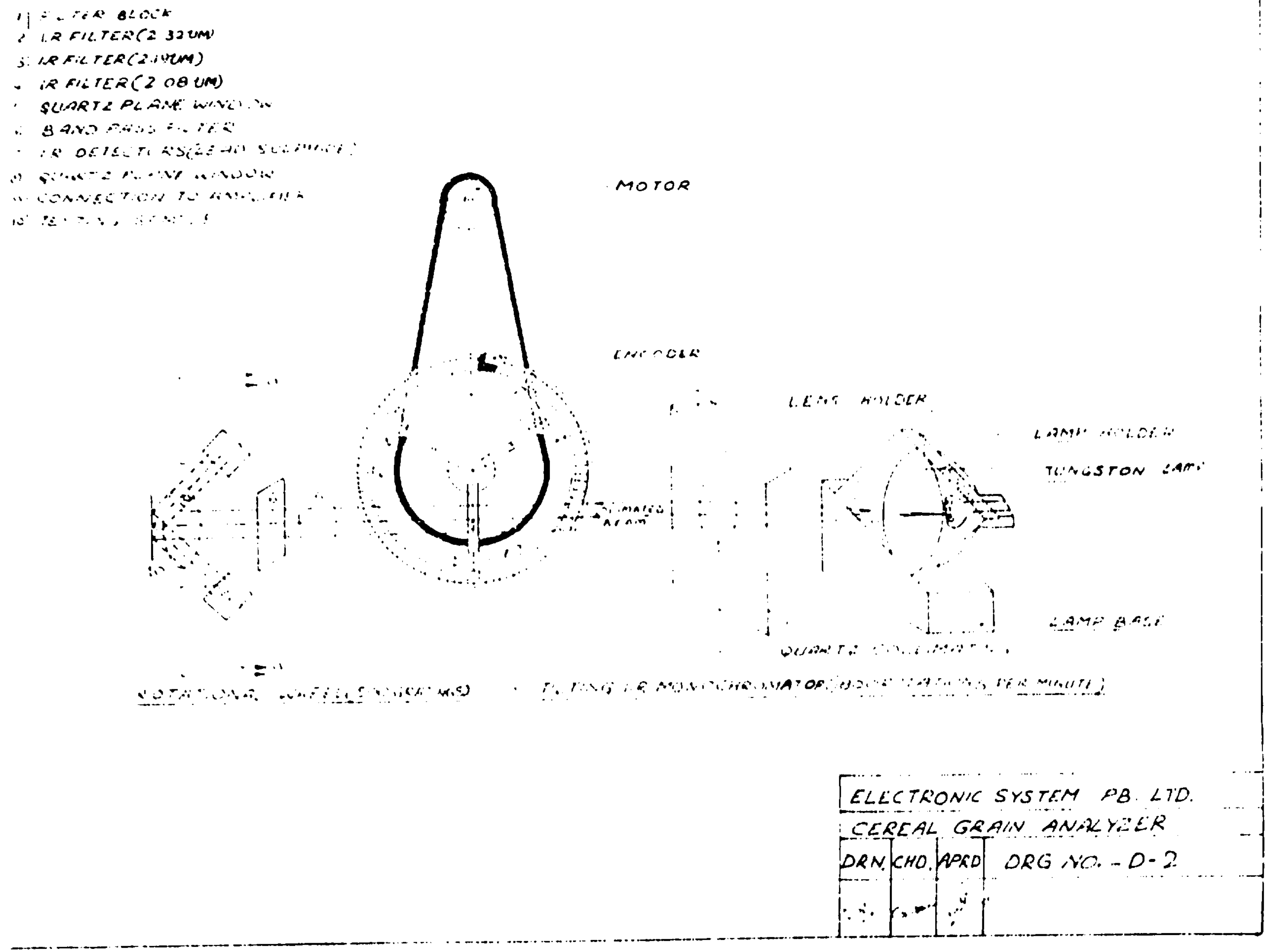
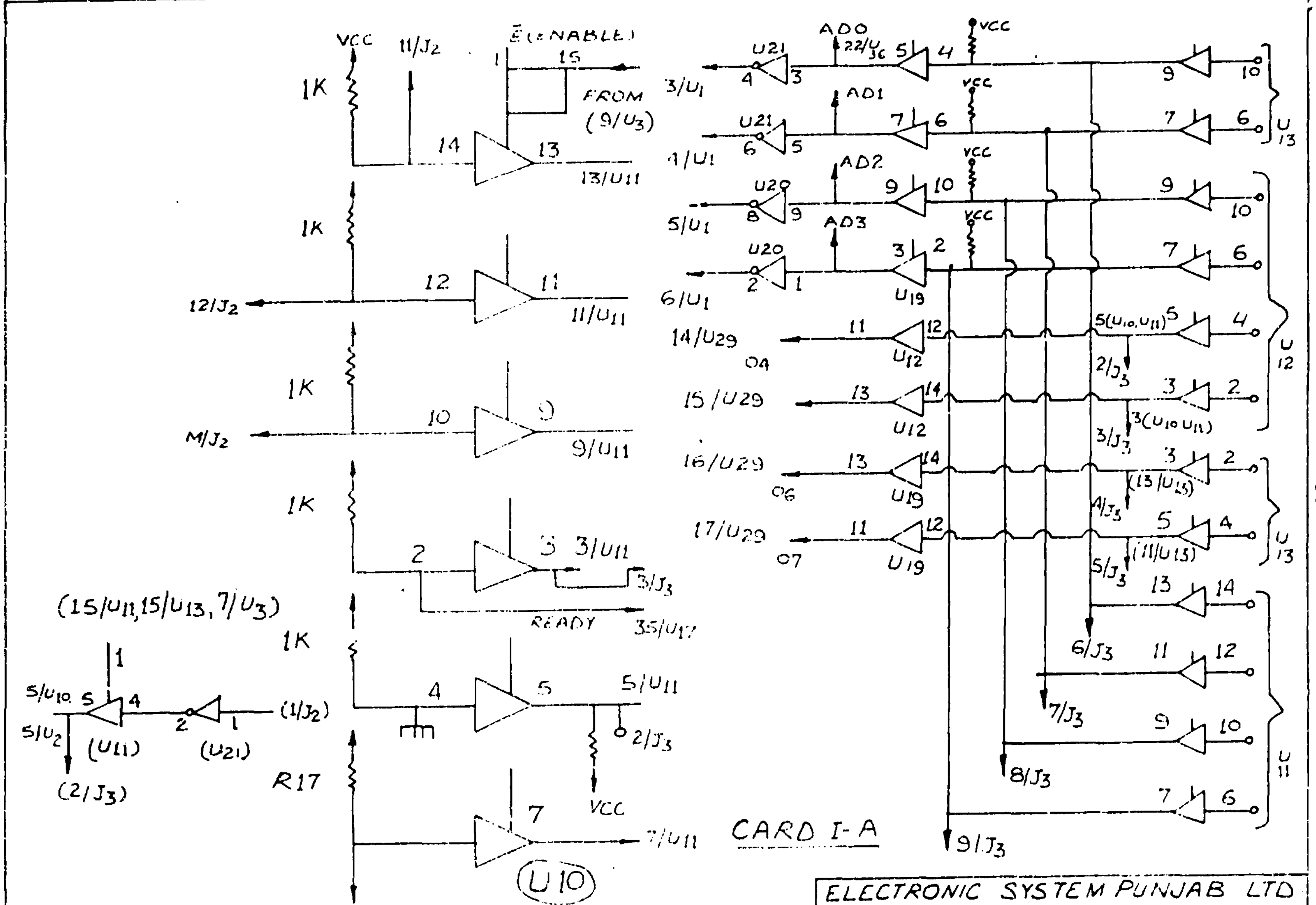
BLOCK DIAGRAM OF CEREAL GRAIN ANALYZER



ELECTRONIC SYSTEM PUNJAB LTD			
CEREAL GRAIN ANALYZER			
DRN	CHD	APRD	DRG NO
[illegible]	[illegible]	[illegible]	D-1

OPTICAL LAYOUT DIAGRAM OF CEREAL GRAIN ANALYZER

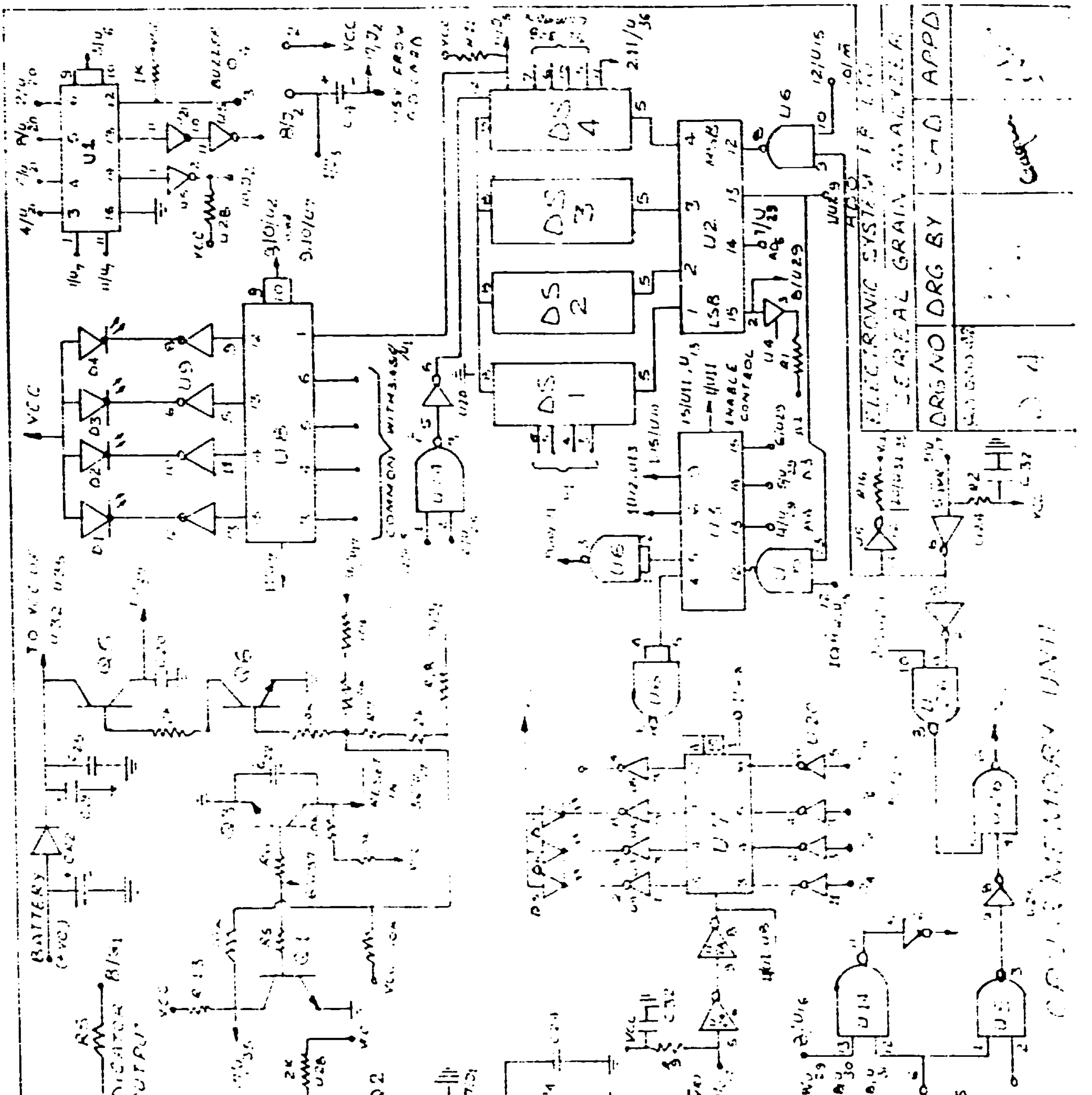


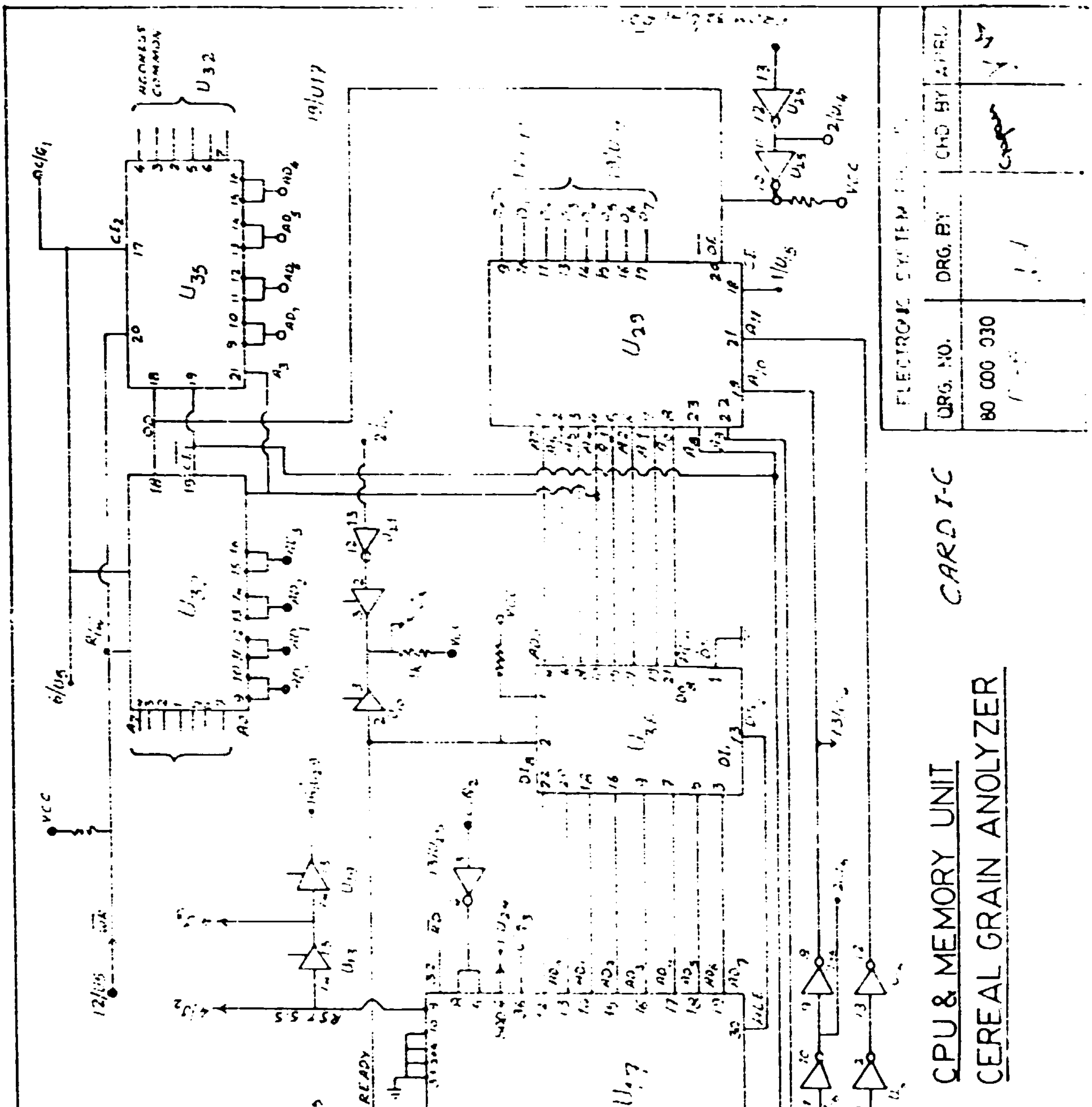


ELECTRONIC SYSTEM PUNJAB LTD			
DRN.	CHD	APRD	CEREAL GRAIN ANALYZER
			80 000 020

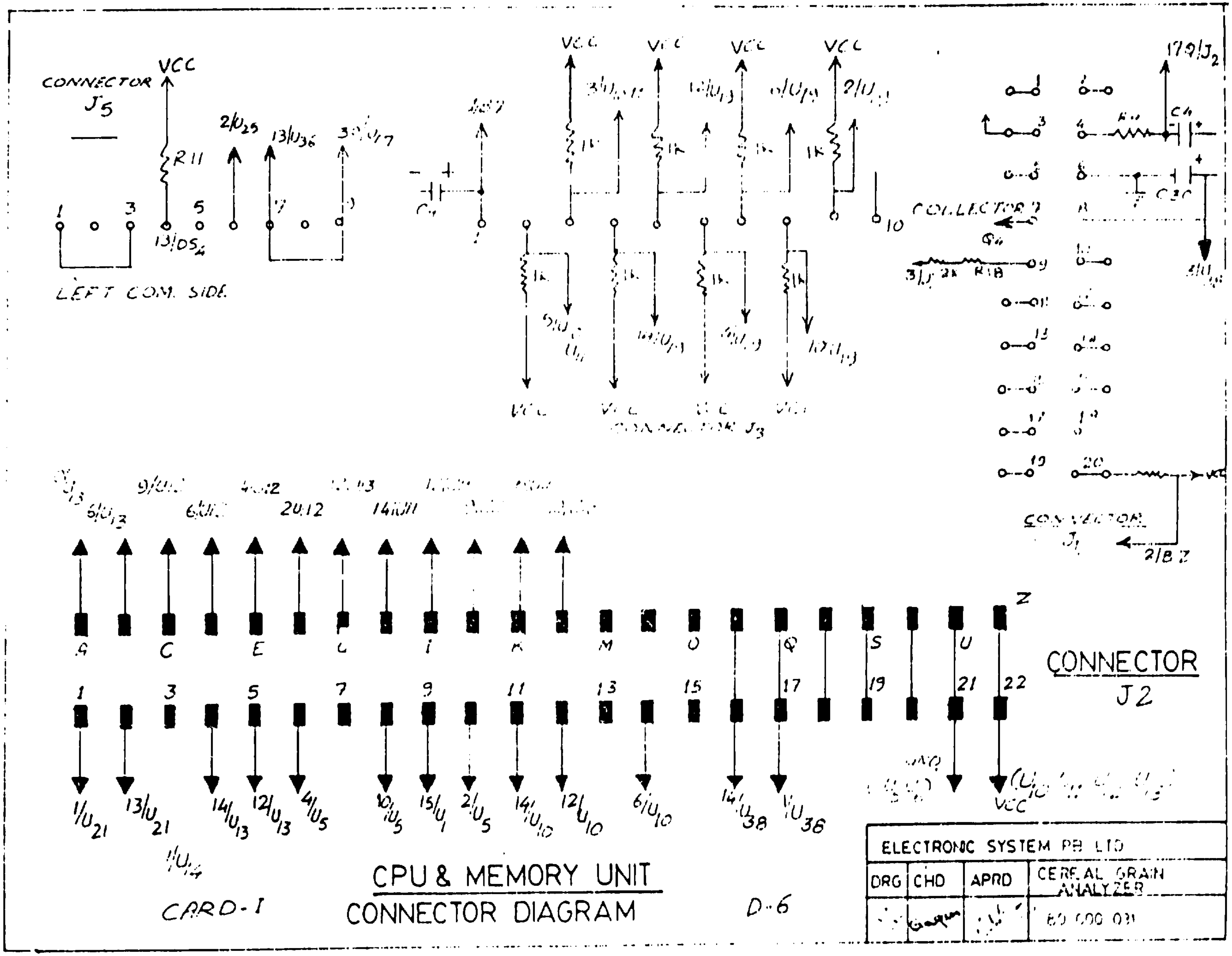
D-3

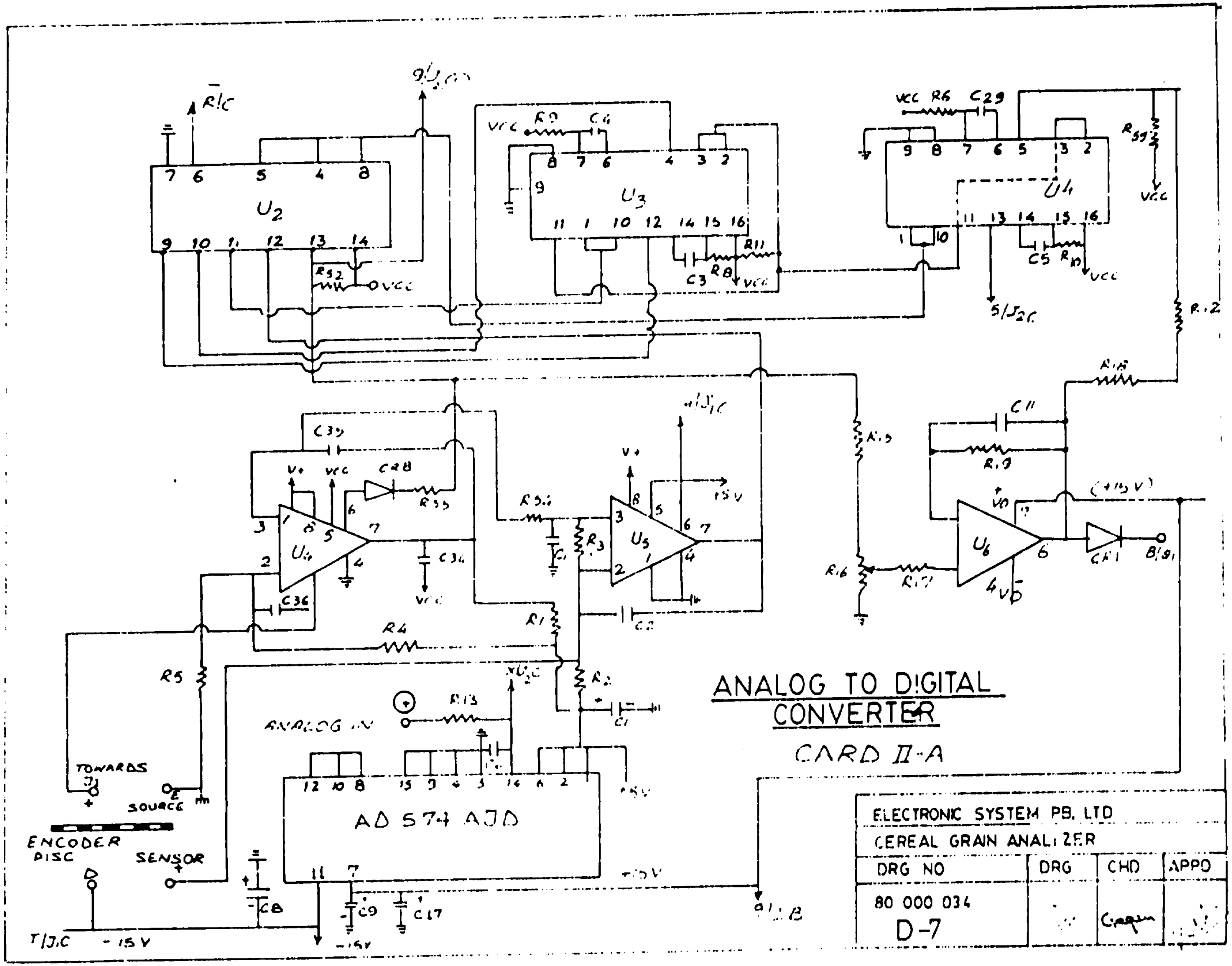
CPU & MEMORY UNIT


MC 3423
INDICATOR OUTPUT
BATTERY
VCC
DS 1
DS 2
DS 3
DS 4
LSB
ENABLE CONTROL
COMMON WITH 3.3K
ELECTRONIC SYSTEM
CEREAL GRAIN
DRG NO
DRG BY
APPD
CARD 1B

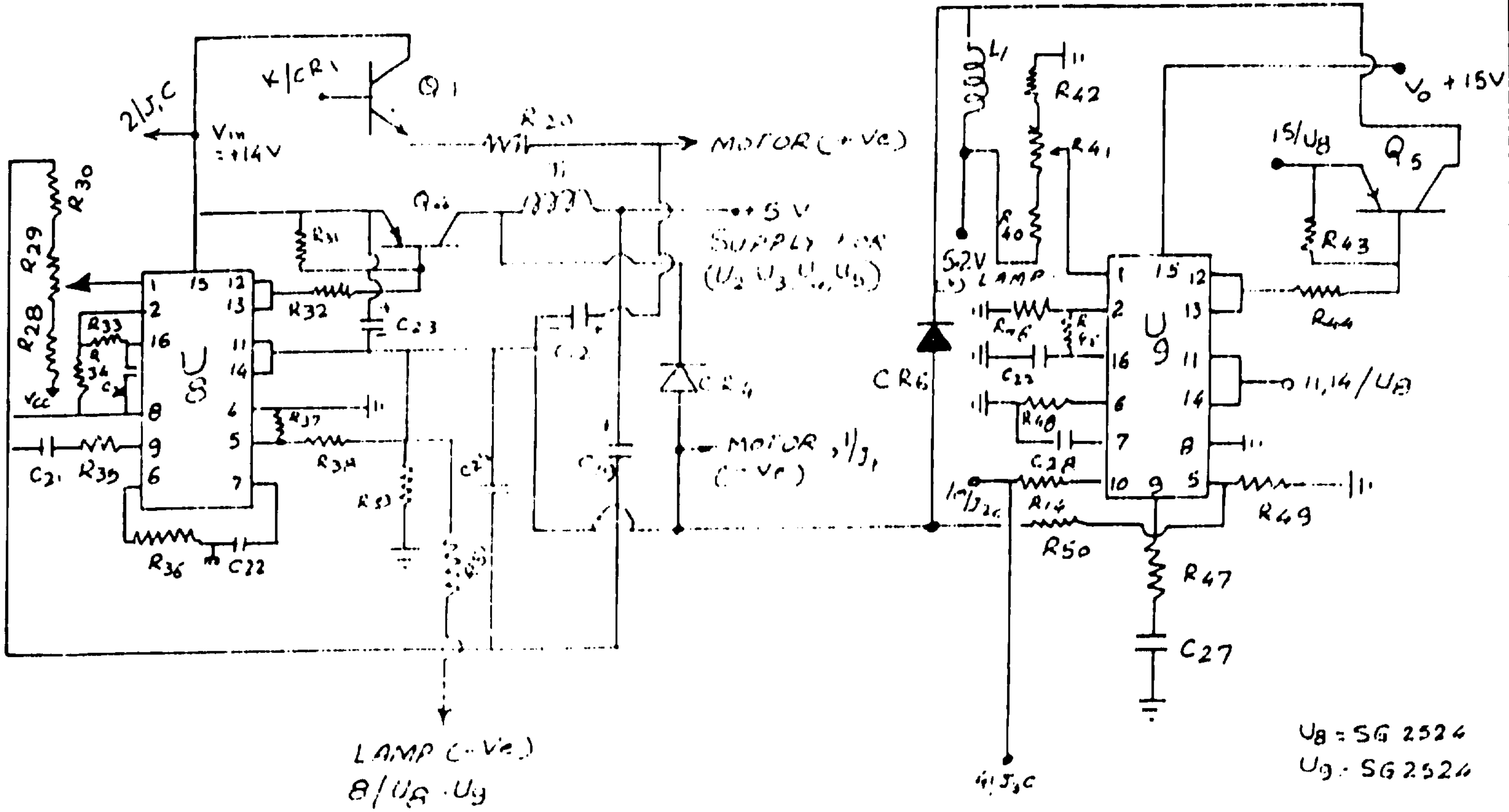


CPU & MEMORY UNIT
CEREAL GRAIN ANOLYZER
CARD I-C
DRG. NO.
80 000 030
DRG. BY
CHD BY
U35
U29
U32
READY
VCC


CONNECTOR J5
VCC
R11
LEFT COM. SIDE
CONNECTOR J3
COLLECTOR
R18
C4
CONNECTOR J1
CONNECTOR J2
VCC
CPU & MEMORY UNIT
CONNECTOR DIAGRAM
CARD-I
D-6
ELECTRONIC SYSTEM PB LTD
DRG
CHD
APRD
CEREAL GRAIN ANALYZER



ANALOG TO DIGITAL CONVERTER
CARD II-A
ELECTRONIC SYSTEM PB. LTD
CEREAL GRAIN ANALIZER
DRG NO
DRG
CHD
APPD
80 000 034
D-7
AD 574 AJD
U2
U3
U4
U5
U6
ENCODER DISC
SENSOR
TOWARDS
SOURCE
ANALOG IN
T/J.C
-15V



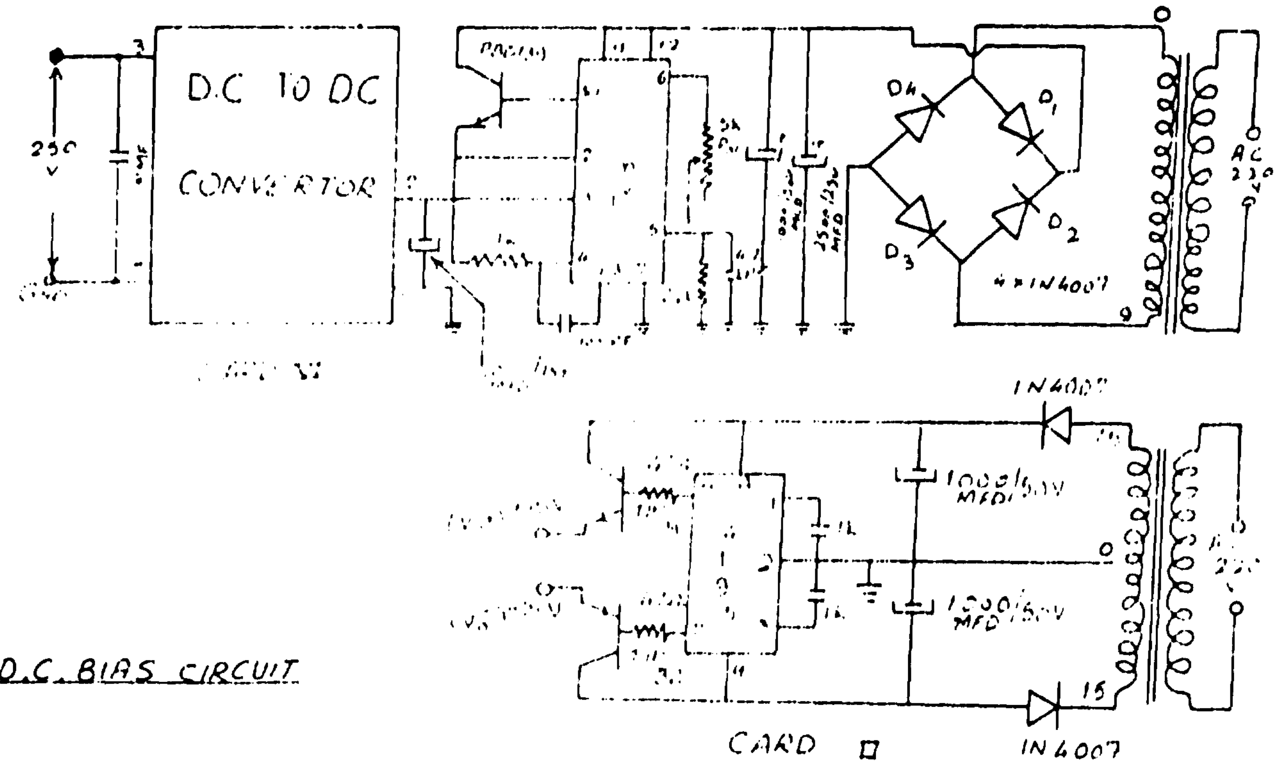
REGULATING PULSE WIDTH MONITORS

+5V LOGIC P. SUPPLY

+5.2V LAMP SUPPLY CARD II-B

ANALOG TO DIGITAL CONVERTER

ELECTRONIC SYSTEMS PB. LTD			
CEREAL GRAIN ANALYZER			
DRG. NO.	DRG. BY	CHD	APPD.
80 000 033 D-8			



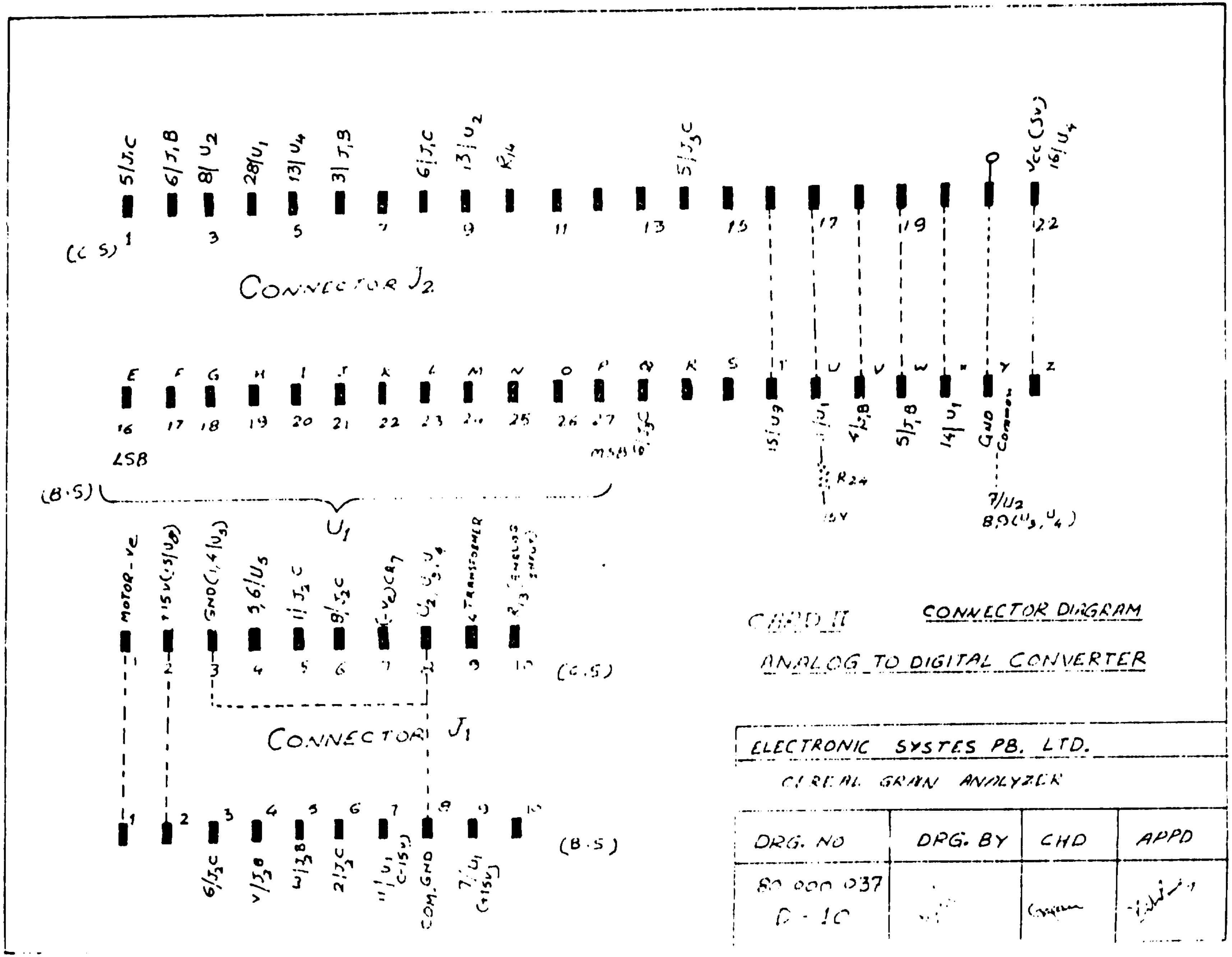
PBS DETECTOR D.C. BIAS CIRCUIT

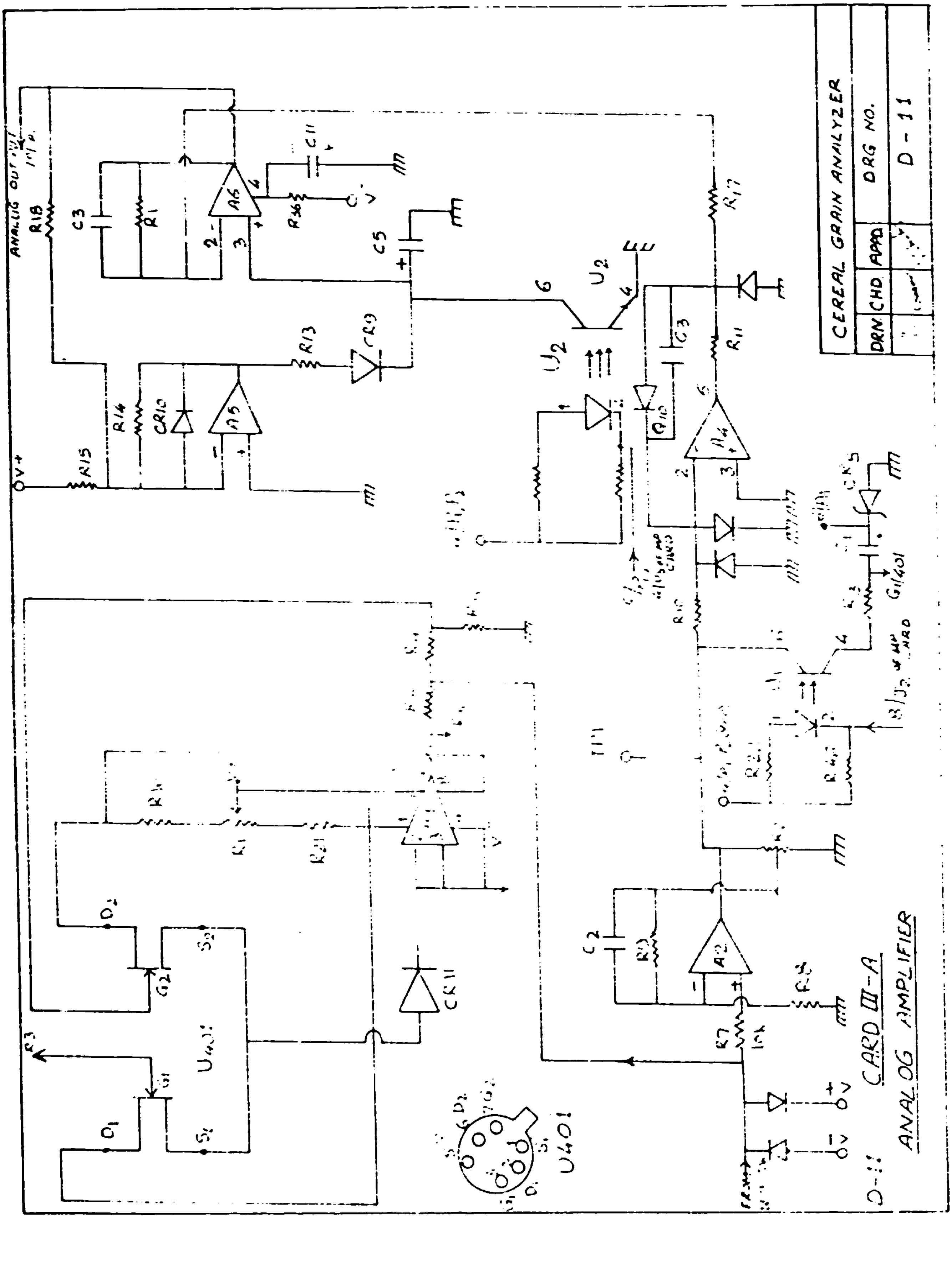
±15V OPAMP P. SUPPLY

ANALOG TO DIGITAL CONVERTER

CARD II-C

ELECTRONIC SYSTEMS PB. LTD.			
CEREAL GRAIN ANALYZER			
DRG. NO.	DRG BY	CHD	APPD
80 000038 D-9			


CONNECTOR J2
CONNECTOR J1
U1
LSB
MSB
(B·S)
(C·S)
R24
CARD II
CONNECTOR DIAGRAM
ANALOG TO DIGITAL CONVERTER
ELECTRONIC SYSTES PB. LTD.
CEREAL GRAIN ANALYZER
DRG. NO
DRG. BY
CHD
APPD
80 000 037
D - 10


CEREAL GRAIN ANALYZER
DRN
CHD
APPD
DRG NO.
D - 11
CARD III-A
ANALOG AMPLIFIER
ANALOG OUT PUT
R18
C3
R1
A6
C11
R36
C5
U2
R17
R11
C3
A4
R14
CR10
A5
R13
CR9
R15
V+
CR5
G1401
C2
R3
A2
R8
R7
CR11
U401
D1
D2
S1
S2
G1
G2
+V
-V