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DEVELOPMENT OF A WEIGHING TYPE RAIN GAUGE (WRG)

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INDIA

1994-95

PREFACE

The National Institute of Hydrology, Roorkee, has taken up the development of simple electronic field instruments for hydrological measurements using components available indigenously. Since rainfall is probably the most important and basic single measurement in hydrology, the first instrument to be developed in this series at the National Institute of Hydrology is a rain gauge.

There is an increasing need for detailed time resolution of precipitation measurements, and also for precipitation recordings from remote areas. Although many kinds of recording rain gauges are available worldwide, various errors are associated with these raingauges. Weighing type rain gauge is considered worldwide as accurate and reliable instrument for rainfall measurement.

The report presents the development of a reliable, automated Weighing type Rain Gauge (WRG), using components and systems available indigenously, which is especially suitable for use in remote locations. The instrument development was carried out by Dr V C Goyal, Scientist, and was assisted by the Institute's supporting staff, Messrs P S Das, Prabhat Kumar, and Sonia Bakshi.

(S M Seth)
DIRECTOR

ABSTRACT

For proper management of the available water resources, and for timely forecasting of the natural hazards like floods, droughts, etc., automation in the existing hydrological measurement systems is desired. It is obviously hoped that with these new techniques, the accuracy of observations as well as their time and resolution will increase.

Rainfall measurement is the core of all hydrological measurements. For automated recording of rainfall data, tipping bucket rain gauges are generally used. It has been reported that the tipping bucket mechanism of such rain gauges frequently malfunctions and gives erroneous data, especially during high intensity rainstorms. Weighing type rain gauges are considered worldwide as accurate and reliable.

For the first time in India, an attempt was made to develop a weighing type rain gauge using components and systems available indigenously. A load cell is used to weigh the accumulated rainfall. A collector rim of 205mm dia is used on an outer container from which the water is collected through a funnel into an inner container. The inner container rests on the load cell and is designed to store 10 cm of rainfall. The accumulated rain water, after reaching a preset level, is drained out using a solenoid valve. A microcontroller based data logger controls the sampling and data storage frequency, the operation of the solenoid valve, and stores the measured data alongwith other information in an on-board memory.

The rainfall data from the reported Weighing type Rain Gauge (WRG) and non-recording type rain gauge (ORG) was compared at a site in Roorkee. Results of the initial field testing were encouraging, and are presented in this report.

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1.0 INTRODUCTION

Precipitation amount, intensity, and distribution are primary components of all hydrologic and climatological analyses. Accurate and cost-effective methods of measuring and processing these variables are essential. The rainfall pattern in India has a vast variation. For measurement of these varying rainfall amount and intensities, rain gauges with different measuring capacities and design mechanisms are required.

Rainfall totals have long been recorded by mounting a funnel over a graduated collecting vessel. Later developments led to the autographic recorders and the magnetic tape recorders which counted the number of tips of a collecting bucket (or events) during short time intervals. Recent developments have mostly refined the system of counting the number of tips in case of tipping bucket rain gauges, and designing weighing type gauges in some cases.

An electronic rain gauge can be considered in two parts : the sensor and the electronic module. The sensor generally used is a tipping bucket, which is undoubtedly the simplest method for sensing the rain electrically. Other methods of sensing the rain use drop-counting, weighing or level recording mechanisms.

2.0 REVIEW

2.1 RAINFALL MEASUREMENT TECHNIQUES

Measurement of precipitation with gauges dates back to more than 2000 years. With the development of civilization and science, the demand for intensity of precipitation and its distribution in time increased.

The total amount of precipitation which reaches the ground in a stated period is expressed as the depth to which it would cover a horizontal projection of the earth's surface, if there were no losses by evaporation, percolation or runoff, and if any part of the precipitation fallen as snow or ice were melted (IS, 1983).

2.2 TYPES OF RAIN GAUGES

The basic principle of each type of rain gauge is the same, i.e. the water is collected through a catch of some standard diameter and therefrom it is fed to some measuring mechanism. The types of rain gauges widely used for the measurement of rainfall can be grouped, based on their data storage mode, under the following three broad headings :

1. Non-recording rain gauge,
2. Recording rain gauge, and
3. Storage gauge.

2.2.1 Non Recording Rain Gauge

The non recording rain gauge collects the rainfall through an opening with a funnel, and the depth of rainfall is worked out using a graduated measuring cylinder.

To ensure uniformity of specifications and to maintain required degree of accuracy, rain gauges are standardized for adoption. In India, the India Meteorological Department (IMD) is using the Symon's pattern rain gauge of 5" diameter catch. The standard gauge of the U.S. Weather Bureau consists of an 8" diameter (50.4 sq inch area) receiver with knife edge top. The water is funneled into a measuring tube with 1/10th of the cross section of the receiver. This magnification helps in an accurate measurement of the rainfall depth.

2.2.2 Recording Rain Gauge

The recording rain gauges are used to collect information on the intensity of rainfall in addition to the amount of rainfall. These gauges are equipped with a recording device which gives continuous record of the depth of rainfall with respect to time in form of a curve. The curve on processing gives the following information :

a. Total amount of rainfall,
b. Times of start and cessation of rainfall,
c. Duration of rainfall, and
d. Rainfall intensity.

Three types of recording gauges are widely used. These gauges are distinguished by the mechanism adopted for measuring the depth of rainfall; the time measuring element being common in all the three types. Seth and Ramasastri (1985-86) reviewed a variety of recording rain gauges used in India and other countries.

(i) Syphon type rain gauge

The most widely used syphon type rain gauge consists of a float chamber where a float at the bottom is connected to a syphon chamber, housing a long discharge tube. The recording mechanism consists of a pen attached to the float, and a chart connected to the spring driven clock. As the level of the water rises, the vertical movement of the float is transmitted, by a suitable mechanism, into the movement of the pen on the chart. By suitably adjusting the dimensions of the receiving funnel and the float chamber, any desired scale on the chart can be obtained.

(ii) Tipping bucket type rain gauge

The tipping bucket type rain gauge, being most popular now-a-days, consists of a tipping bucket, a magnet and a reed switch. The magnet is directly attached to the tipping bucket and the reed switch is positioned near the magnet. The water from the catch is funneled into the tipping bucket, and as soon as the bucket becomes full, it tips to the opposite side. The movement of magnet alongwith the tipping bucket causes a contact closure of the reed switch, which is recorded as a pulse signal.

The main advantage of this type of instrument is that it has an electronic pulse output and can be recorded at a distance. Its disadvantages are (WMO, 1994) :

(1) the bucket takes a small but finite time to tip, and during the first half of its motion, the rain is being fed into the compartment already containing the calculated amount of rainfall. This error is appreciable, however, in heavy rainfall,

(2) with the usual design of the bucket, the exposed water surface is relatively large. Thus, significant evaporation losses can occur in hot regions. This will be most appreciable in light rains, and

(3) because of the discontinuous nature of the record, the instrument is not satisfactory for use in light drizzle or very light rain. The time of beginning and ending of rainfall cannot be determined accurately.

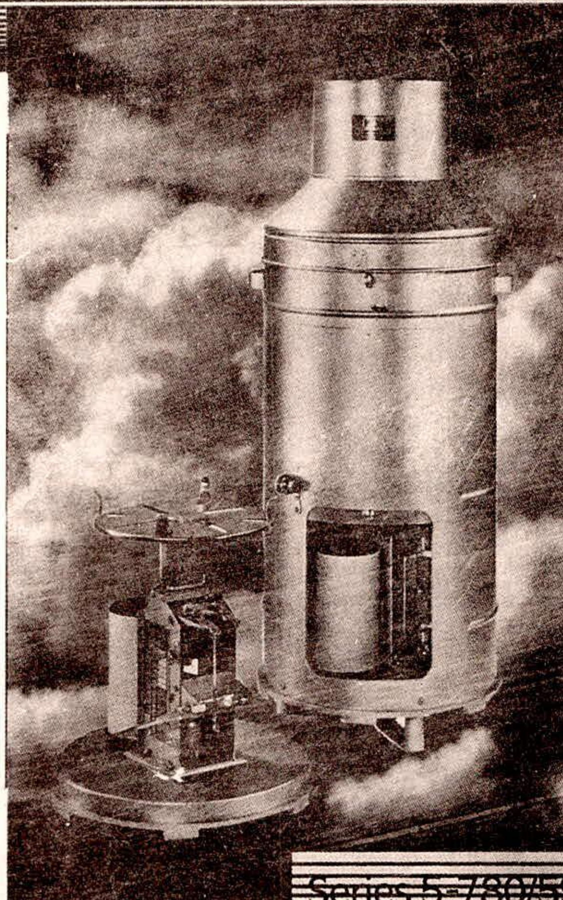
(iii) Weighing type rain gauge

In this type of rain gauge, the weight of a receiving can plus the precipitation accumulating in it is recorded continuously, either by means of a spring mechanism or with a system of balance weights. Thus, all precipitation is recorded as it falls.

The time element in these gauges consists of a high quality clock, chart drum and set of gears. The gauge element consists of a spring or lever balance with a platform on which a bucket rests. The spring is connected to the recording pen by means of appropriate linkage. The compression of the spring and weight of water in the bucket are precisely calibrated. The incoming rain caught by the receiver is funneled into the bucket which compresses the spring. The compression of the spring is transmitted to the pen which covers a distance proportional to the depth of water received by the bucket. The gauges are generally equipped with reversal mechanism which reverses the direction of the pen after it touches the margin of the chart.

Belfort's Universal Precipitation Gauges provide a potentiometric output corresponding to the weight of the accumulated rainfall. A precision gear train is used to produce a resistance change proportional to the amount of rainfall received.

UNIVERSAL PRECIPITATION GAGE



Series 5-780/5915

RECORDING AND TRANSMITTING

BUILT-IN RECORDER

RUGGED, ALL-WEATHER DESIGN

HIGH ACCURACY

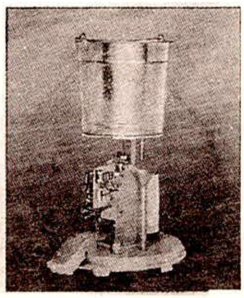
OVERFLOW PROTECTION

CORROSION RESISTANT CONSTRUCTION

UNATTENDED RECORDING UP TO 35 DAYS

POTENTIOMETRIC OUTPUT FOR DATA LOGGING OR REMOTE RECORDING

The Universal recording & transmitting precipitation gage converts the weight of collected precipitation into the equivalent depth of accumulated water in conventional units of inches or millimeters. An 8-inch (20.3cm) diameter, knife-edge orifice collects all forms of precipitation.



Rain travels through a funnel into the galvanized weighing bucket. The funnel is removed during the winter season to collect snow. When sub-freezing temperatures are expected, anti-freeze is added to the bucket.

A dual traverse system is used to record the accumulated precipitation on a rotating chart. Half of the gage capacity is recorded by the upward traverse of the pen, which is dampened by a dash pot, and the other half is recorded by the downward traverse. This dual traverse system permits extended gage capacity without sacrificing chart resolution. Gage capacity of 12 inches (300 mm) is standard, but other gage capacities also available.

Potentiometric output is available for the purpose of transmitting data. A precision gear train produces a resistance change proportional to the amount of rainfall received.

Plate 1. Weighing Rain Gauge, by Belfort Instrument Company, USA

A new type of weighing rain gauge, manufactured by a Swedish firm, namely InSitu, measures weight of the accumulated rainfall with a load cell connected to a data logger, and the precipitation is calculated from the increase in weight. Since the entire collecting device is weighted, rain is measured as soon as it reaches the collector surface and there are no wetting losses.

(iv) Drop counting rain gauge

The drop counting type rain gauge makes use of the principle of counting the drops formed by the rain water as it forms nearly identical drops while passing through a fixed nozzle into air or some types of oils. The instrument is quite elaborate in its layout and design, and needs expensive electronics. The instrument may be used when high resolution (10 seconds interval onwards) rainfall rate measurements are required (Sreedharan,1989-personal communication).

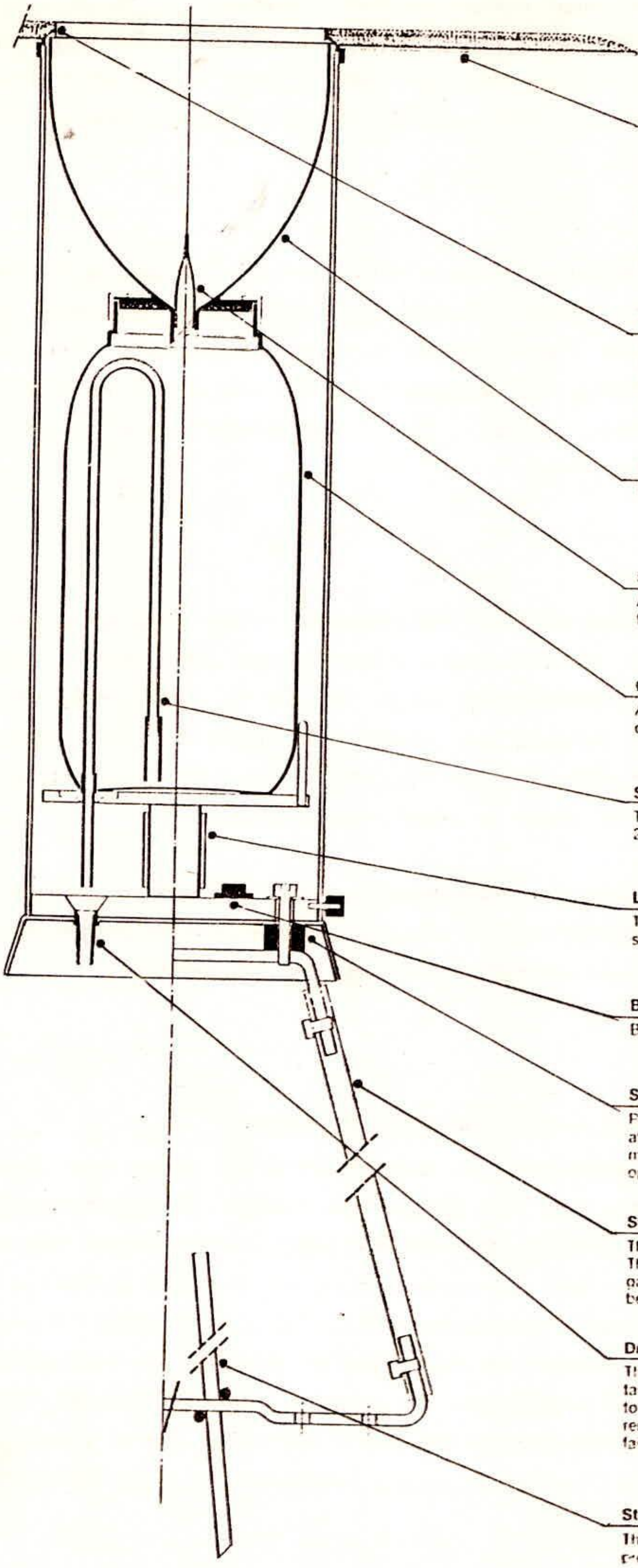
2.2.3 Storage Gauges

In remote and inaccessible areas where it is not practicable to take observations every day or week, gauges with larger capacities called storage gauges are generally used. The observations may be taken after every month, season or year for which the instrument is designed. These are generally standard rain gauges with bigger size of containers to hold more precipitation. The container is provided with some type of oil which can form a thin film on the surface of water to avoid evaporation losses.

The movement of a float, bucket, or weighing mechanism can also be converted into an electrical signal and transmitted by radio or wire to a distant receiver where recordings may be made from a number of rain recorders on data logging equipment.

3.0 LIMITATIONS OF COMMONLY USED RAIN GAUGES

Different kinds of measurement errors are associated with the syphon type, tipping bucket type and even weighing type rain gauges. For example, in syphon type rain gauge, some amount of water is required to uplift the float which is evaporated if there will be the gap of longer period between two consecutive rains, which creates an error in the measurements (WMO, 1982). Secondly, accountability of rainfall is not possible if it occurs during the draining out of water, although, the time period of draining the water may be short, but, the error percentage will depend upon the intensity of rainfall (Sevruk, 1987). Similarly, the error percentage increases with the intensity of rainfall; as due to insufficient capacity of bucket, the increased frequency of tipping increases the error (Simic and Maksimovic, 1994).



Flange
Patented wind shield in the form of a level flange which gives an undisturbed wind field above the aperture of the gauge. This implies that the trajectories of the raindrops will be undisturbed and that the correct amount of rain falls in the funnel.
The flange is covered with a specially developed surface material which absorbs, without splashing, the raindrops which fall outside the collection area.

Edge
An area-defining edge of small height is integrated in the flange. Only water adhering to the inner surface of the edge remains unweighed and constitutes the minimal wetting loss.

Funnel
Funnel with a shape which minimizes splashing losses

Screen
A screen which prevents larger particles from falling into the vessel and clogging the siphon.

Collecting vessel
A stable polyethylene container with a 5 l capacity which corresponds to 200 mm rain.

Siphon
The siphon automatically empties the container when 200 mm of rain have become accumulated.

Load cell
The load cell with an output signal which can be measured by many data-loggers on the market.

Bubble level
Bubble level for positioning of the gauge.

Suspension
Polyurethane bushings which are compressed with attachment screws whereby the weighing platform is mounted, levelled and attached to the stand in the same operation.

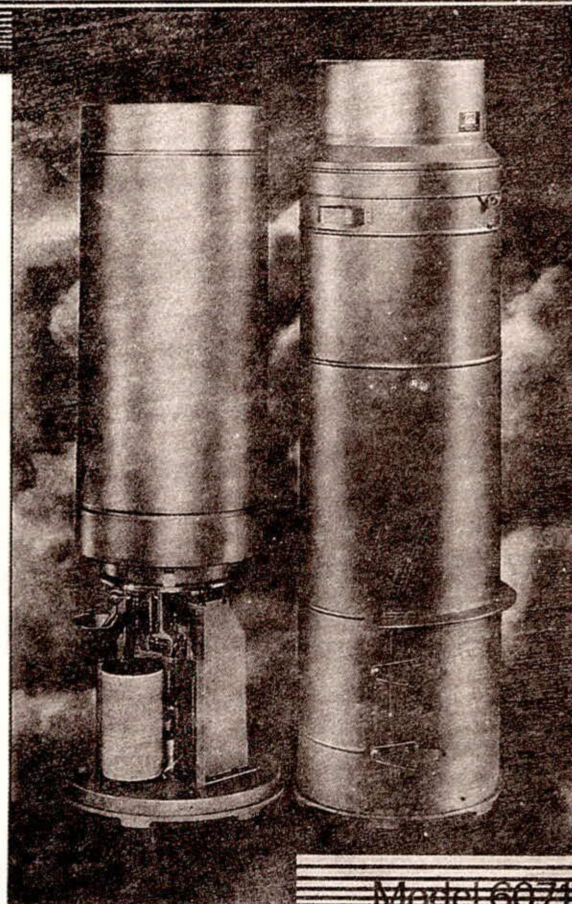
Stand
The stand provides a stable base for the weighing unit. The stand does not need to be horizontal since the gauge is assembled and levelled after the stand has been put in place.

Drain
The drainage pipe can be linked to an external tank. A tank of this kind with suitable size enables precipitation to be evaluated also during periods when the data recording system has not operated, e.g., owing to logger failure.

Stabilizing rods
The stand is held in place by means of metal rods pressed into the soil.

Plate 2. Load Cell Type Weighing Rain Gauge, by InSitu, Sweden

HIGH CAPACITY PRECIPITATION GAGE



Model 6071

LARGE CAPACITY FOR LONG-TERM OPERATION IN REMOTE AREAS

11.314" (28.7 cm) DIAMETER TEFLON-COATED COLLECTOR TO PREVENT SNOW-BRIDGING

RUGGED WEIGHING MECHANISM WITH WIDELY SPACED SPRING SUPPORTS

WEIGHING MECHANISM DAMPED TO REDUCE VIBRATION FROM WIND GUSTS

EQUIPPED WITH OVERFLOW PROTECTION

LARGE HINGED DOOR PROVIDES CONVENIENT ACCESS TO CHART DRIVE AND ZERO ADJUSTMENT

The Model 6071 rain gage extends the capacity of Belfort's weighing rain gages to 30 inches (750mm) of precipitation. Three different configurations are available: with chart recording, with potentiometric ouput, or both. All gages feature large capacity, with built-in overflow protection in the event that maximum capacity is exceeded.

These gages are ideally suited for remote unattended operation. Heating is not required to melt frozen precipitation and a large teflon-coated collector prevents "snow-bridging" over the orifice. The chart recording Model 6071 operates for up to one month on a single chart. The potentiometric ouptut Model 6071P can operate unattended until full capacity is reached, and it is compatible with most dataloggers. The Model 6071PR includes both chart recording and potentiometric output.

Plate 3. Storage Gauge, by Belfort Instrument Company, USA

India being a big country, some regions experience very less rainfall while others receive very high rainfall. Accordingly, rain gauges suitable for use in different rainfall conditions are required. Therefore, there is a strong need to develop rain gauges using advanced instrumentation techniques which are free from the above mentioned errors and are able to satisfy the need of the region/area concerned.

Also, the advanced type rain gauges in use are required to be imported from foreign countries thereby causing a loss of valuable foreign currency. Also, generally difficulties are encountered in their maintenance. Therefore, indigenous development of these equipment is essential to save the foreign currency and to fulfil our specific needs.

4.0 DEVELOPMENT OF WEIGHING TYPE RAIN GAUGE (WRG)

4.1 DESIGN

The instrument developed is based on a weighing mechanism. A load cell is used to weigh the accumulated rain water. The accumulated rain water, after a preset level, is drained out using a solenoid valve. A collector rim of 205 mm dia is used on an outer container from which the water is collected through a funnel into an inner container. The inner container rests on the load cell and is designed to store 10 cm of rainfall. The solenoid valve is operated to drain out the accumulated water when either the inner container becomes full or after a pre-specified time, whichever is earlier.

Initially, after designing a weighing type sensor using a strain-gauge based load cell, a commercially available data logger (CR10 of Campbell Scientific, USA) was used with the sensor for measuring and recording the rainfall data. Extensive laboratory and field tests were carried out with this set up (Kumar et al., 1993). Later, a microcontroller (Intel's 80C31) based data logger was designed in-house using indigenously available components. Again, the laboratory and field experiments were carried out. The design presented in this report is that of the indigenous data logger, and is shown in figure 1. The detailed specifications of the main electronic components used in the WRG are given in Appendix-1.

4.1.1 Central Processing Unit (CPU)

The heart of the electronics system is a CMOS single chip 8-bit microcontroller (Intel's 80C31). This chip has on-board 128 X 8 bit RAM, 32 programmable I/O lines, and two 16 bit timer/ counters. In addition, it has five interrupt sources, a programmable serial port, and a special power control mode.

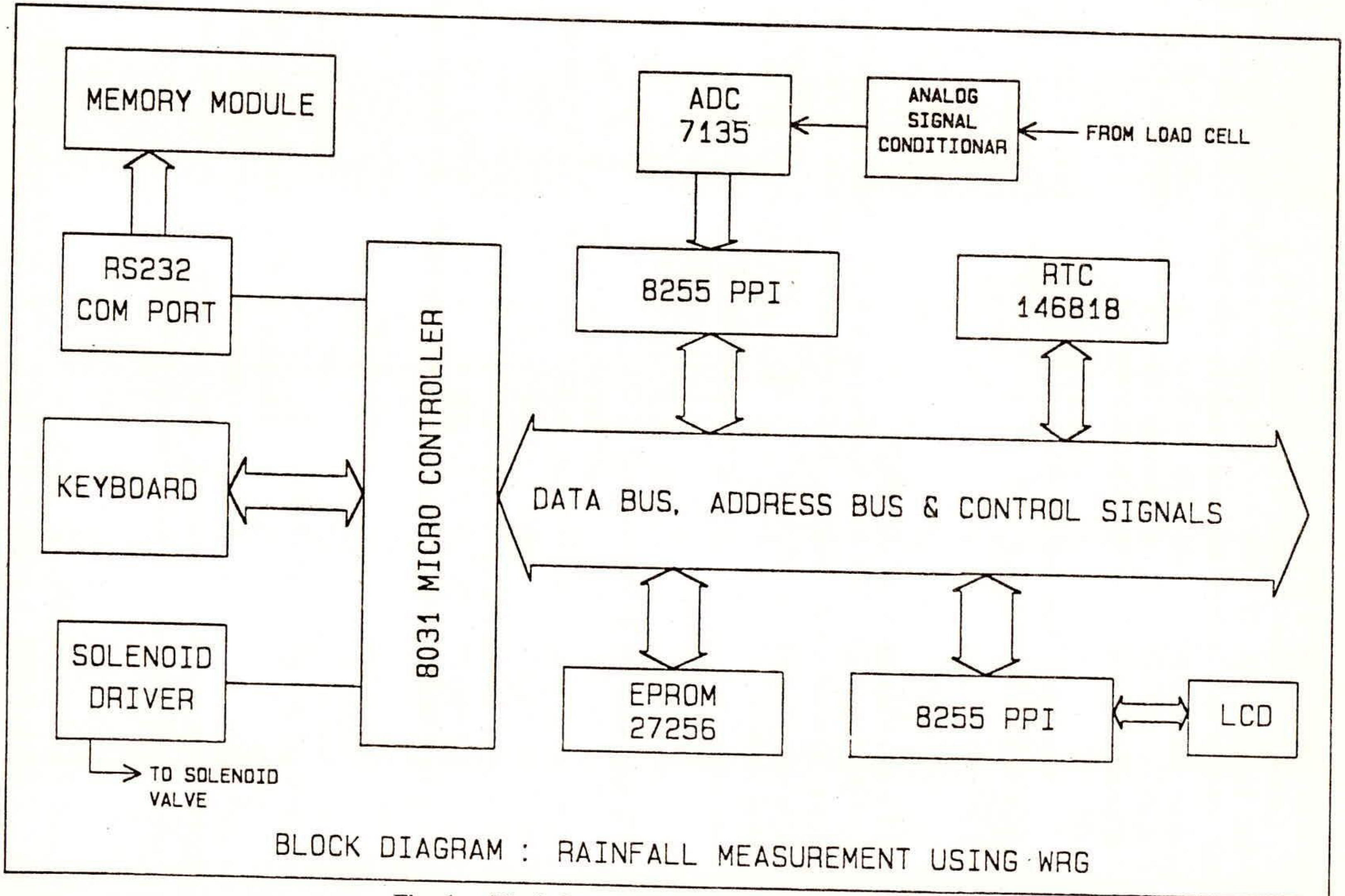


Fig. 1. Block Diagram of Rainfall Measurement Using WRG

4.1.2 Analogue-to-digital Converter (ADC)

Analogue to digital conversion is performed by a stable low-power CMOS chip (ICL 7135). The Intersil ICL 7135 precision A/D converter, with its multiplexed BCD output and digit drivers, combines dual-slope conversion reliability with ±1 in 20,000 count accuracy. The converter has a conversion speed of 0.1 to 15.0 conv/sec with a power dissipation of 1000 mW max. All necessary active devices are contained on a single IC, with the exception of display drivers, reference and a clock.

The analogue voltage from the load cell is applied to the A/D converter. The digital information from the converter is accessed by the microcontroller utilizing the I/O control circuitry.

4.1.3 Micro-controller Based LCD Display

The LCD display used in the instrument is based on a built-in dot matrix LCD controller, with which it is possible to display RAM data for 80 characters (80 X 8 bits), and an easy interface with 8 bit MPUs. The chip also has a built-in oscillator circuit and internal automatic reset circuit at power ON. With these versatile facilities, this chip has been used for direct interface with the 80C31 microcontroller.

4.1.4 Solid State (RAM) Memory

The on-board memory is primarily Random Access Memory (RAM). The 62C256 CMOS static RAM is a 32,768-word (32K) by 8-bit memory with low power consumption. The 62C256 operates on a single +5V power supply, and is well suited for use in microprocessor systems and other applications where fast access time and ease of use are required. An MK48TO8 RAM (8Kx8-bit) with RTC and battery backup is also used for storing the calibration constants and getting the real time and date, with memory retention facility.

4.1.5 Input/output Interface Circuit

The input interface basically involves conditioning of the signal from the load cell. The millivolt signal from the load cell is amplified and filtered before it is fed to the ADC. The output interface consists of a solenoid driver, which provides the required signal to a solenoid valve from the I/O port of the microcontroller.

4.1.6 I/O Control Signals

The data logger is programmed to control the whole operation of the WRG. This involves providing the excitation signal for the load cell, 12VDC, 1A supply for the solenoid valve, besides various control signals for these peripheral devices.

The complete data logging circuitary comprise different sections, namely CPU card, analogue card, keyboard & display card, memory module, and power supply card. All these cards were designed using a software package 'PCAD'. After deciding the basic circuit diagram for these sub-sections, schematic diagrams were prepared. The components placement on the card are decided next. Then, the PCB layout is prepared using 'Auto-routing' facility of the PCAD. Finally, for 2-layer cards, three sets of layouts are prepared providing details of the 'component side', the 'solder side', and the 'drilling details'. For single-layer cards, the component and solder details are prepared on a single layout. The PCB details for the main sub-systems designed for the WRG are provided in Appendix-2.

4.2 OPERATION

Recent developments in microprocessor technology have made possible a better type of small computer, one with not only the CPU on the chip, but RAM, ROM, Timers, Counters, UARTs, Ports, Clock circuit, and other common peripheral I/O functions also. The microprocessor has become the 'microcontroller', which is essentially a complete small computer. Like a microprocessor, a microcontroller is meant to fetch data, perform limited calculations on that data, and control its environment based on those calculations (Ayala, 1991). With a view to design a general purpose data logger based on the state-of-art technology, with compact and power-efficient design, it was decided to use a microcontroller for the data logger.

The reported system uses a 8031 microcontroller alongwith other required peripheral chips, such as 8255 Programmable Peripheral Interface (PPI), MK48TO8 Real Time Clock (RTC), ICM 7135 12-bit Analogue- to-Digital Converter (ADC), a few digital ICs, signal conditioning circuitary.

A 4x4 key matrix and a 20x4 intelligent LCD display are used for programming and display purposes, respectively. The measured data is stored in an 128kB memory module through a RS232 serial communication port. The monitor programme in 8031's assembly language, which controls the complete operation, is stored in a 32Kb EPROM (27256). The microcontroller controls the sampling and data storage intervals, operation of the solenoid valve, and stores the measured data alongwith the date and time in the memory module.

The complete sensor assembly of the WRG is shown in figures 2a & 2b. It consists of an outer container with 205mm dia and 500mm height; an inner container of 175mm dia and 190mm height, and a load cell of 10kg capacity. A 1/2" solenoid valve, 12V DC

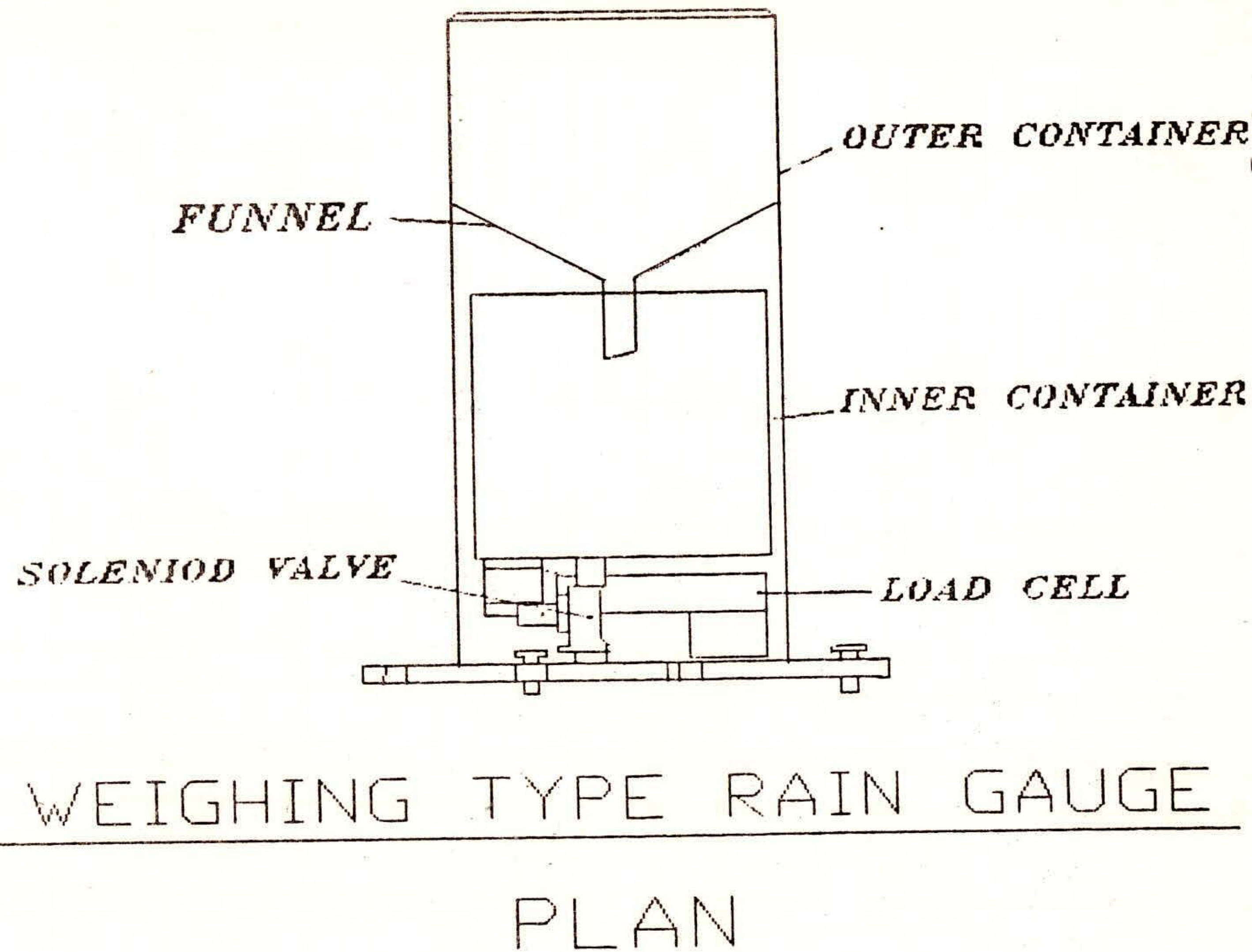


Fig. 2a. Plan View of WRG

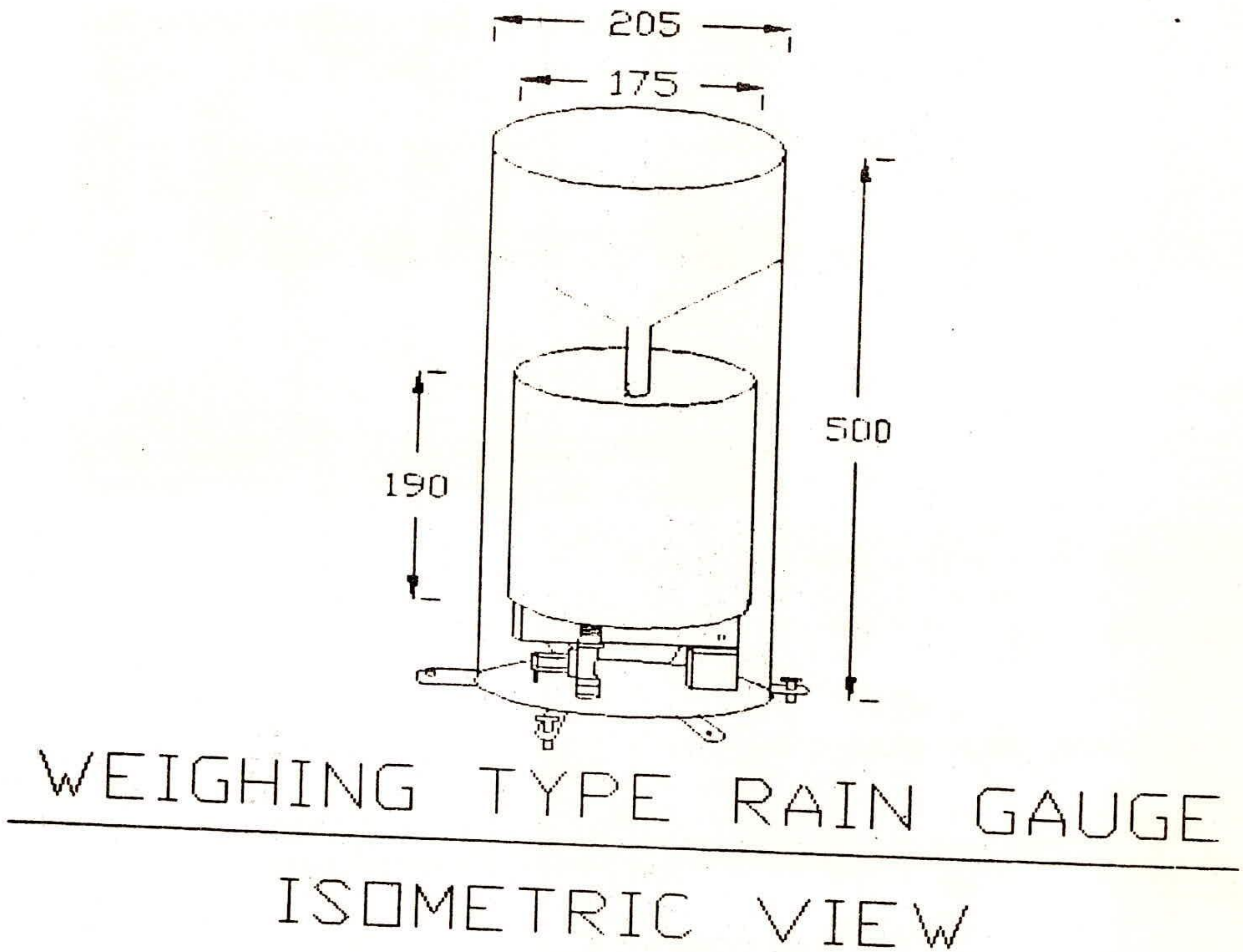
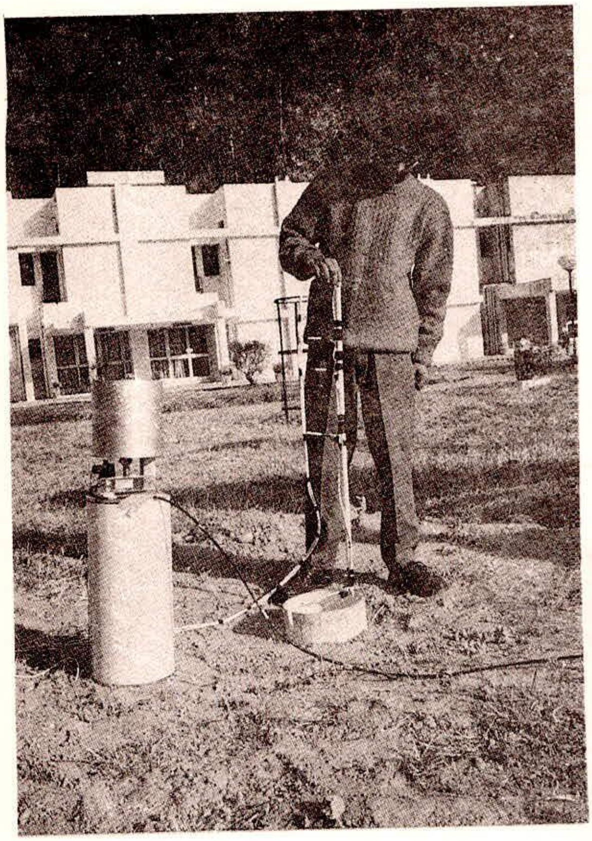


Fig. 2b. Isometric View of WRG



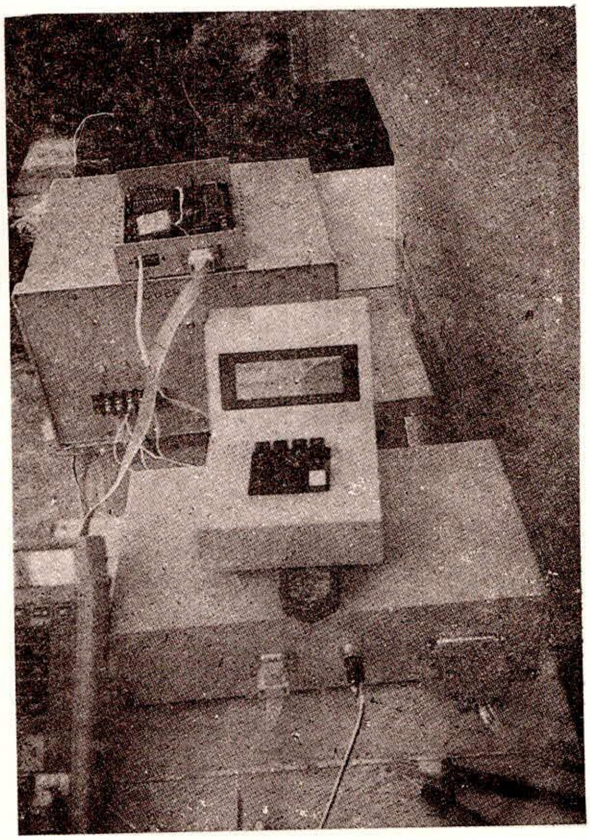


Plate 4. (Left) Field installation of WRG, and (Right) Microcontroller based data logger developed at NIH

operated of normally open type, is used to drain out the accumulated water from the inner container. An aluminium base plate with suitable mounting and leveling arrangements is used for mounting the outer container. The specifications of the mechanical systems used in the WRG are given in Appendix-3.

4.3 SOFTWARE FEATURES

The Intel's 80C31 micro-controller CPU is the heart of the hardware design. The software, written in 8031's assembly langauge, controls the overall measurements. The WRG is operated using instructions as shown in the flow chart (Fig 3). The process starts by initializing the system's peripherals. When a 'start' command is detected from the keyboard, data from the load cell (weight) is obtained through the Analogue-to-Digital Converter (ADC) on completing the sampling interval. This data is then multiplied with the calibration constant to convert the weight into mm of rainfall. The rainfall data alongwith the date and time, is stored in memory module through a serial communication port until the accumulated rain water reaches a volume corresponding to 100mm of rain.

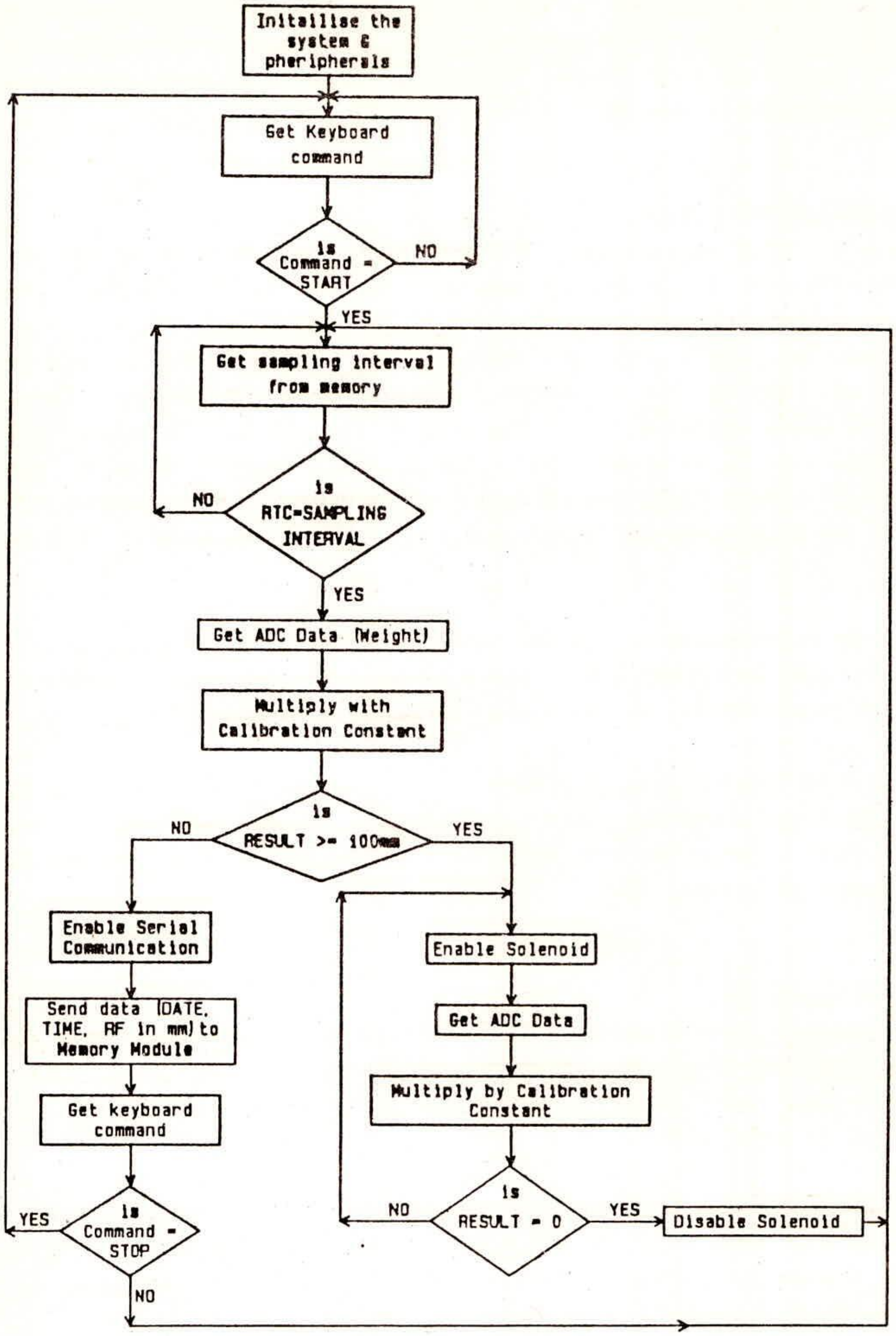
When the accumulated water in the inner container reaches a volume corresponding to 100mm of rainfall, the solenoid valve is operated. Again the ADC data is monitored, and when the accumulated water is completely drained, the solenoid valve is closed.

The complete system is halted on receiving a 'stop' command through the keyboard. In this case, the system is reset and waits for the keyboard command as 'start' and, then, the complete cycle is repeated. The system starts collecting data from the load cell and adds the present value to the previous reading.

4.4 INSTALLATION

The instrument should be located in the observatory, as per norms specified by the IMD.The instrument should be carefully secured with the help of well set foundation keeping the gauge exactly vertical with receiver edge horizontal. This should be precisely checked with the help of a spirit level.

The rain gauge can also be mounted on a pipe. The pipe on which rain gauge is to be mounted should be of 5/4" to 3/2" outer diameter and should be firmly grouted in a concrete platform, or it may be a vertical arm of a tower; after mounting the rain gauge, the receiver top should be checked by spirit level.



FLOW CHART RAINFALL MEASUREMENT USING WRG

Fig. 3. Flow Chart of Rainfall Measurement Using WRG

5.0 FIELD TESTING AND RESULTS

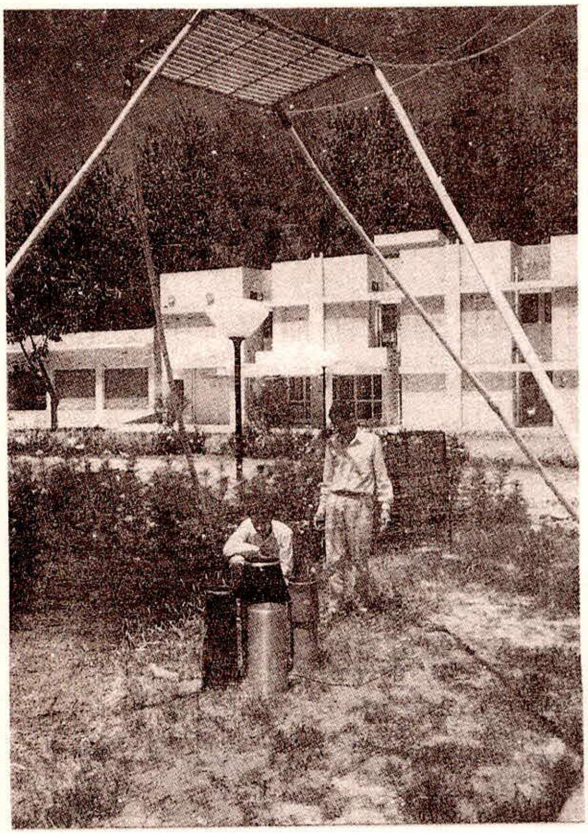
A prototype of the instrument, using an available 10 Kg load-cell and solenoid valve was fabricated in July, 1994. The operation and accuracy of the load cell based weighing mechanism was tested in the lab using an imported data logger (model CR10 of Campbell Scientific, Inc., USA) available in the Institute. The weighing meachanism alongwith the CR10 data logger was installed in the Institute's Observatory site in August, 1994. A Hitachi make SMf battery (12V,7AH) and solar panel based battery charging system was used for the power supply.

During operation of the instrument, it was found that the solenoid valve malfunctioned once, and did not return to close position, thereby consuming a lot of battery capacity. The solenoid valve was then replaced by another valve with suitable specifications.

When the solenoid valve was activated on reaching a threshold capacity of the collected rain water in the container (10 cm rainfall at present), the data logger kept record of the measured data every second so as to account for the rainfall data during the draining period. After initial tests, this feature was introduced through an instruction of the CR10 data logger. The results are presented in figure 4. Subsequently, a 8031 microcontroller based data logger was developed and tested for use with the sensor.

The WRG, with the in-house developed 8031 microcontroller based data logger and the weighing sensor, was again tested and compared in April, 1995 with an ORG and a SRRG using a rainfall simulator in the Institute's campus. Three sets of experiments were conducted at the same site. Due to high wind speeds, and changing wind directions, at the time of conducting the experiments, a significant variation in the catch of the three rain gauges was observed. Results obtained during the field testing are as follows :

Set #	RAINFALL AMOUNT (in mm)			TIME DURATION
	ORG	SRRG	WRG	(Minutes)
I	144	----	127.9	09
II	103	103	110.1	10
III	87.8	104	102.47	12



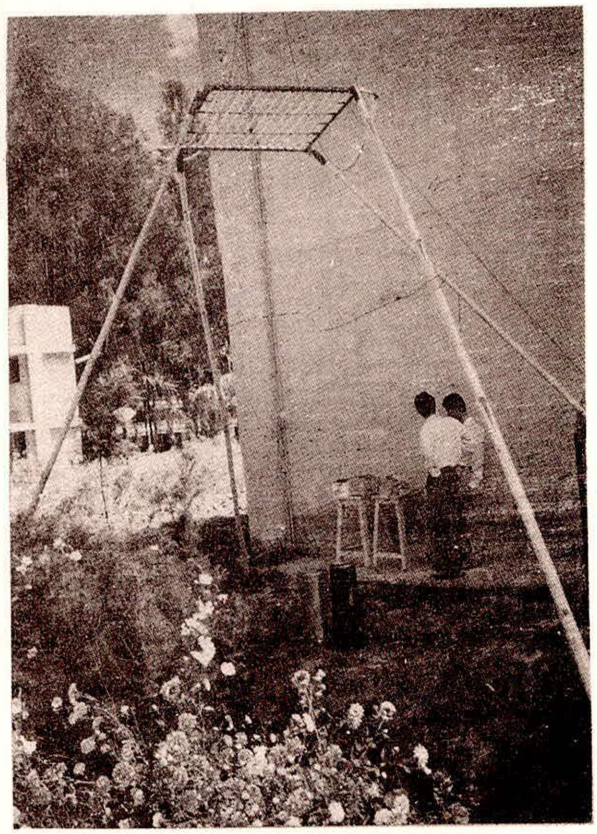


Plate 5. Field testing of WRG using rainfall simulator

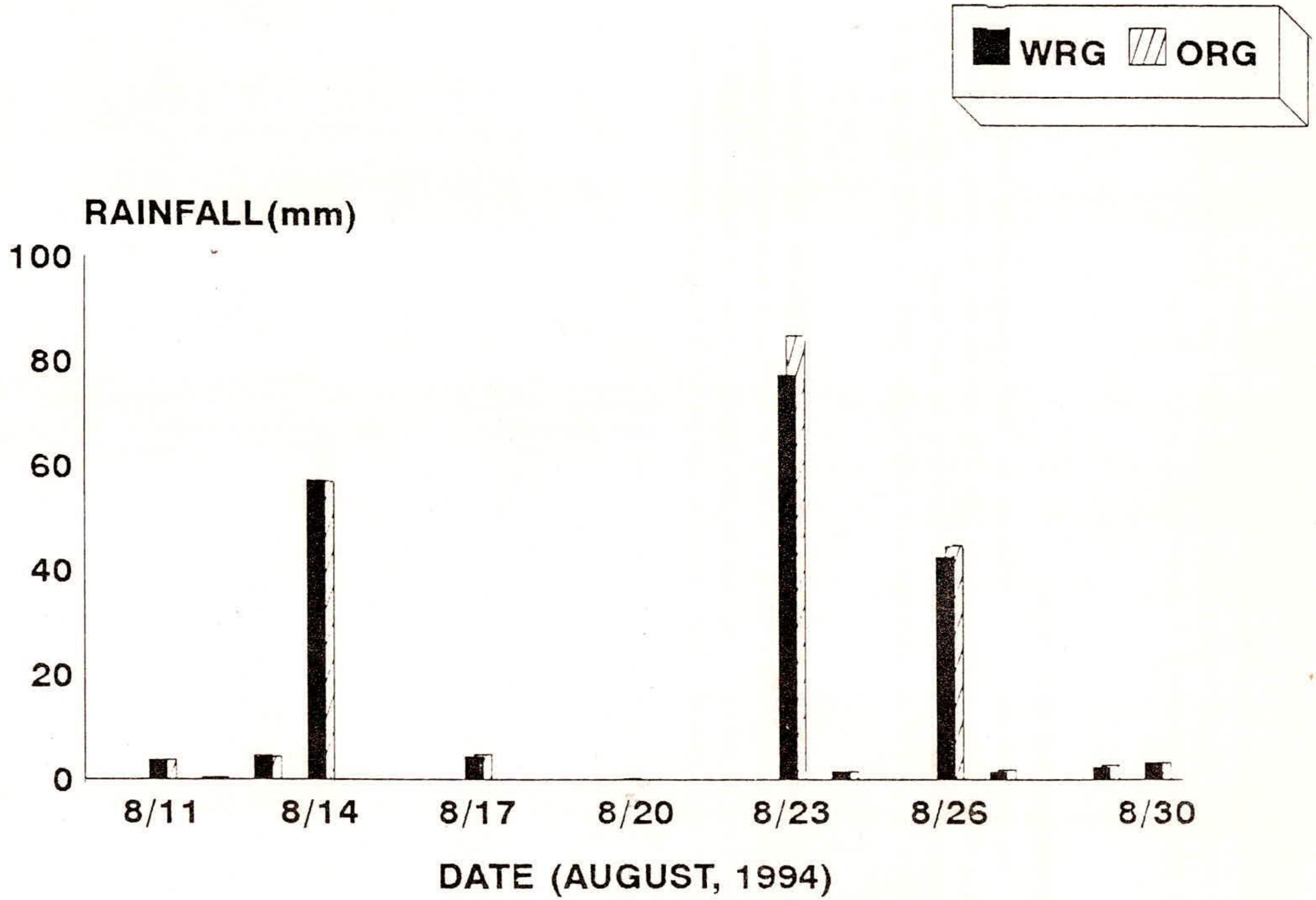


Fig. 4. COMPARATIVE DATA OF WRG AND ORG

6.0 COST

The approximate cost of the WRG is Rs 37,000/- (Appendix-4). The development cost of the prototype unit has been approximately Rs 55,000/-, which could be drastically reduced when these units are produced commercially.

7.0 CONCLUDING REMARKS

A weighing type rain gauge with electronic data logging circuitary was designed and tested in the laboratory as well as in the field. The complete unit is battery operated and consumes approximately 300mA during operation. The field testing confirmed an accuracy of less than 0.1mm of rain when compared with standard ORG and SRRG type rain gauges used in the country.

Further, efforts are being made to reduce the effect of environmental factors (e.g. air temperature, humidity) on the load cell. In order to improve the accuracy of the instrument, and to reduce its power consumption, the data logging circuitary is being re-designed. It is planned to conduct further rigorous field tests with the WRG during future monsoon seasons.

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SPECIFICATIONS OF ELECTRONIC COMPONENTS USED IN DEVELOPMENT OF WRG

CPU 80C31

CMOS Single chip 8-Bit control oriented CPU with RAM & I/O

1. 128 X 8 bit RAM
2. 32 Programmable I/O lines
3. Two 16 bit timer/ counter
4. Five interrupt source
5. Programmable serial port
6. Special Power control mode.

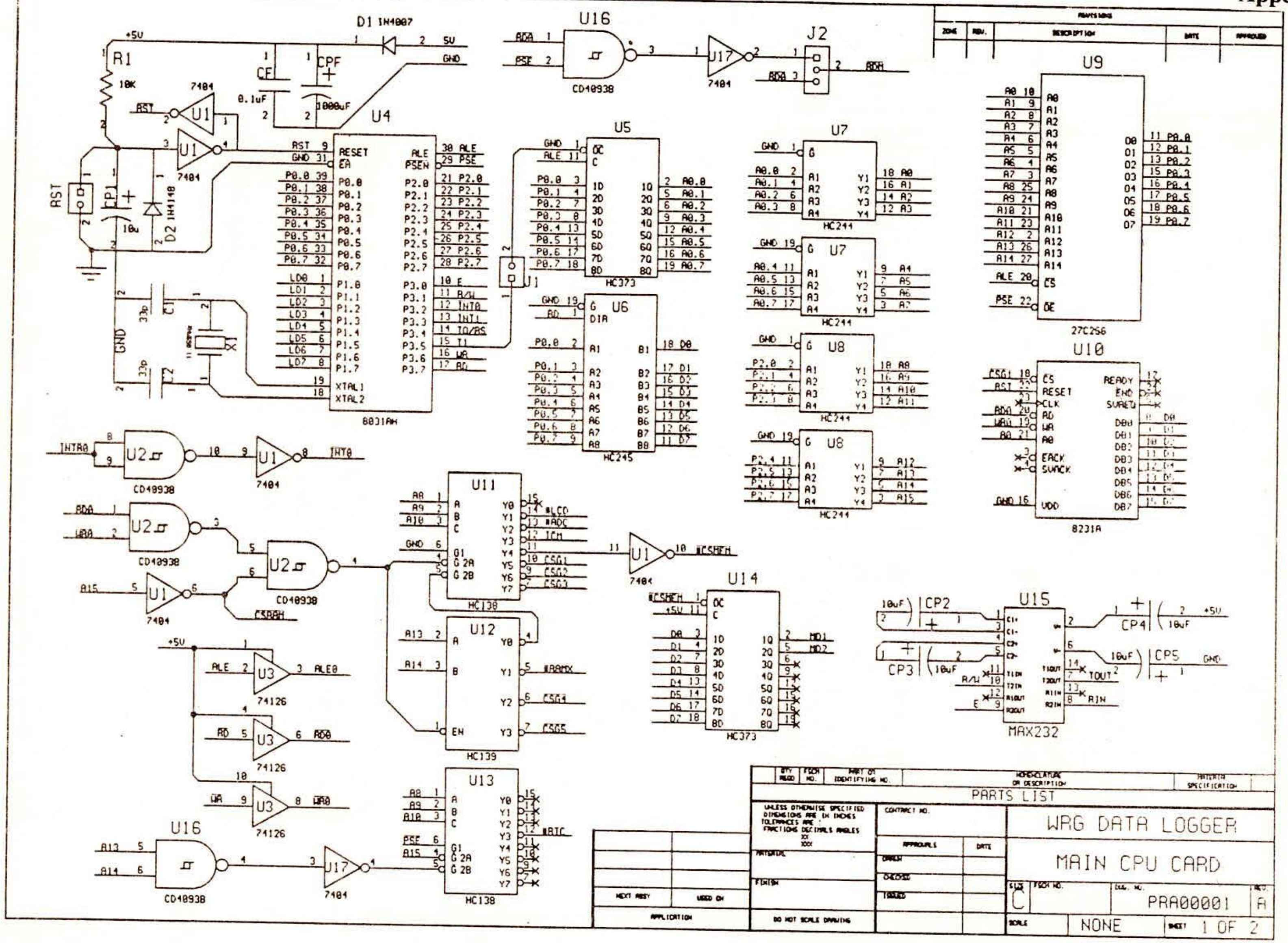
A/D CONVERTER ICL 7135

1. Accuracy $\pm$ 1 count over entire $\pm$20,000 counts
2. Zero reading for zero input
3. 1 pA typical input current
4. True differential input
5. True polarity at zero count for precise null detection
6. Single reference voltage
7. Over range and Under range signals available
8. Six auxiliary I/O are available for interfacing to microprocessors.
9. Multiplexed BCD output versatility
10. Conversion speed .1 to 15 conv/sec
11. Power dissipation 1000 mW max.

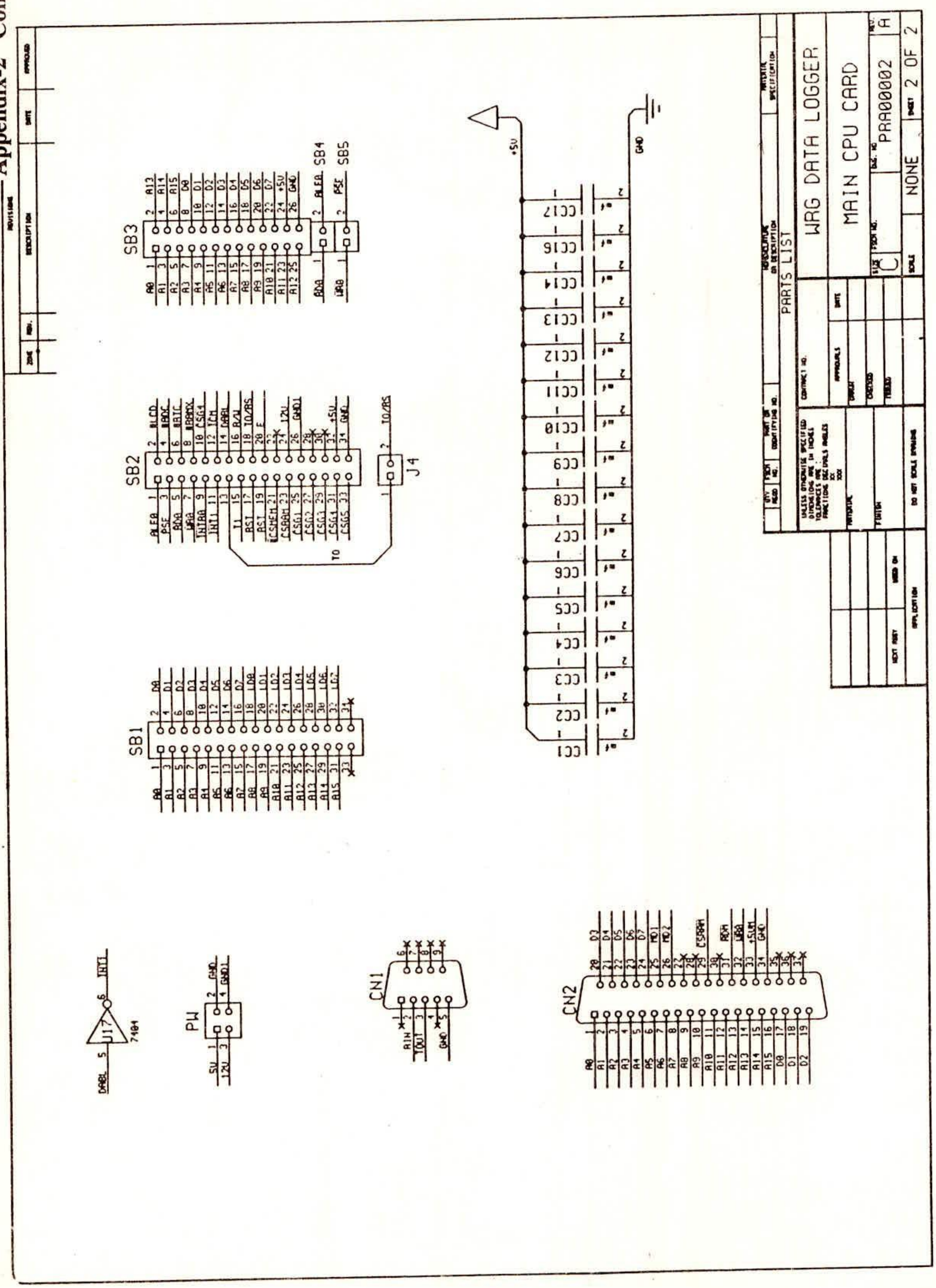
INTELLIGENT DISPLAY (20x4 LCD)

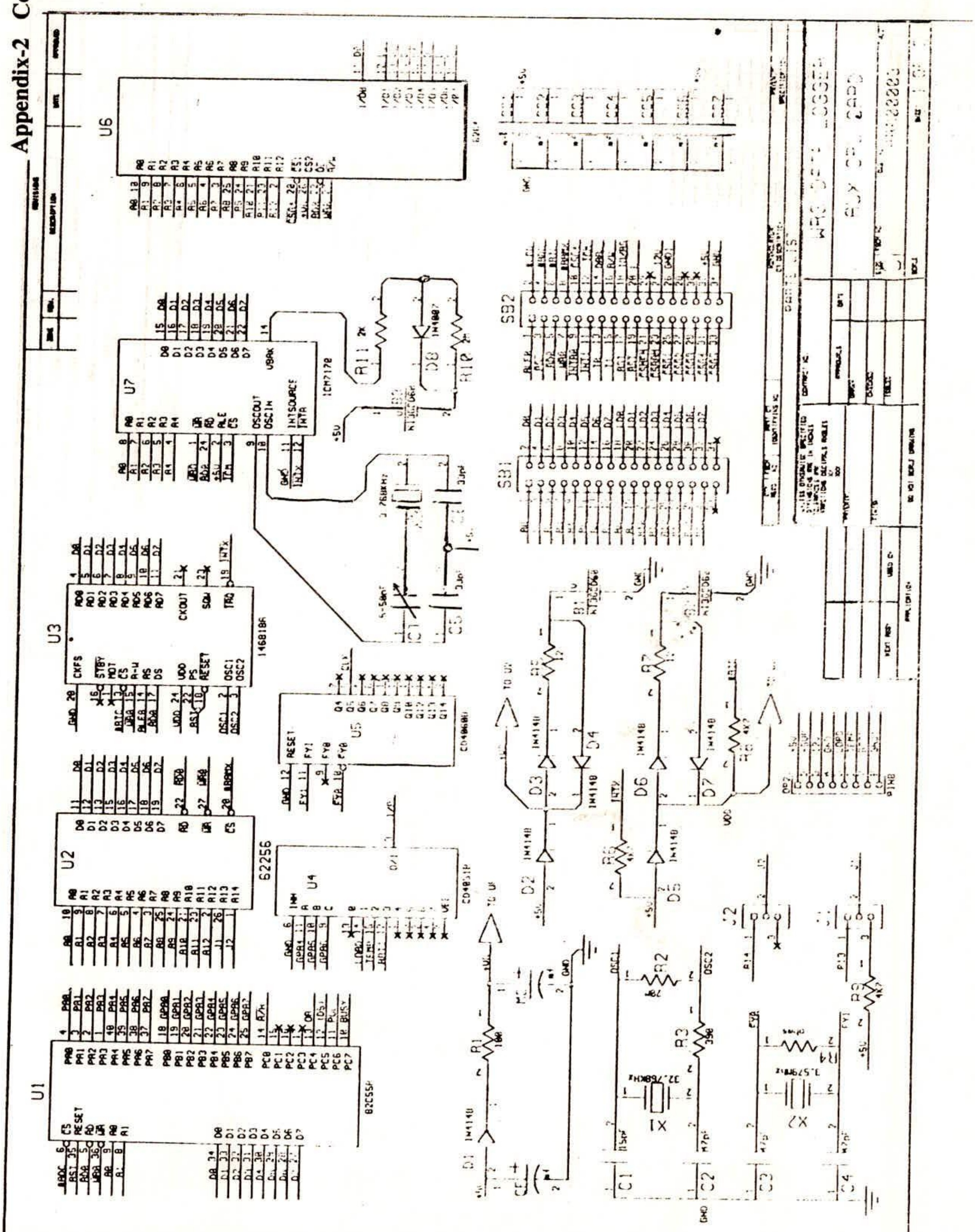
1. Easy interface with 8 bit MPU
2. Built in dot matrix LCD controller with font 5X7 or 5X10 dots.
3. Display data RAM for 80 characters (80 X 8 bits)
4. Built in oscillator circuit.
5. Internal automatic reset circuit at power ON.
6. Direct interface with microcontroller 80C31.

Appendix-2

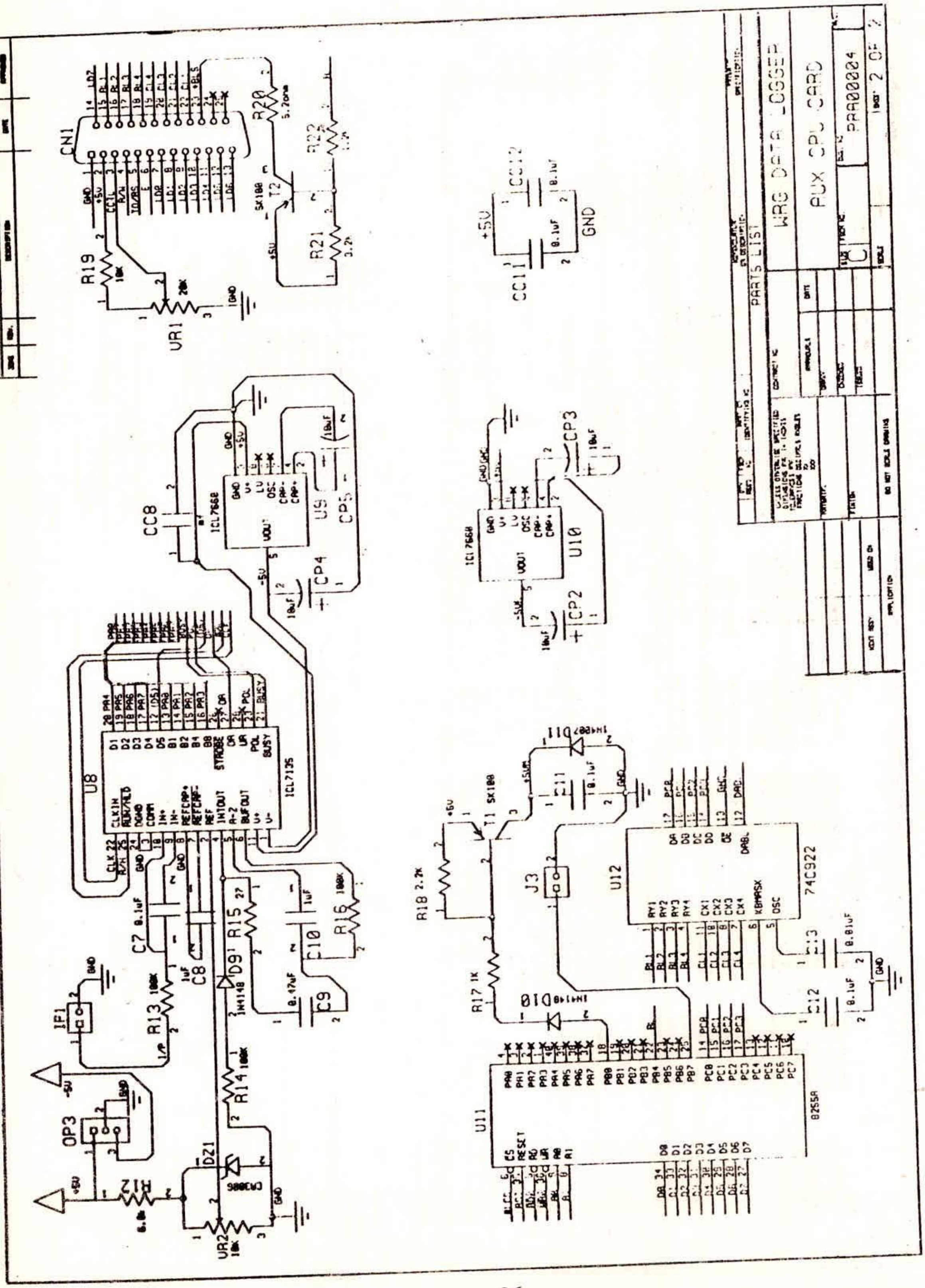

WRG DATA LOGGER
MAIN CPU CARD
PRA00001
PARTS LIST
NONE
1 OF 2
U4
8031AH
U5
HC373
U6
HC245
U7
HC244
U8
U9
27C256
U10
8231A
U11
HC138
U12
HC139
U13
U14
U15
MAX232
U16
CD4093B
U1
7404
U17
U2
U3
74126
J1
J2
R1
10K
D1 1N4007
D2 1N4148
CPF
1000uF
CF
0.1uF
CP1
C1
C2
33p
CP2
CP3
CP4
CP5
10uF
RST
GND
+5V

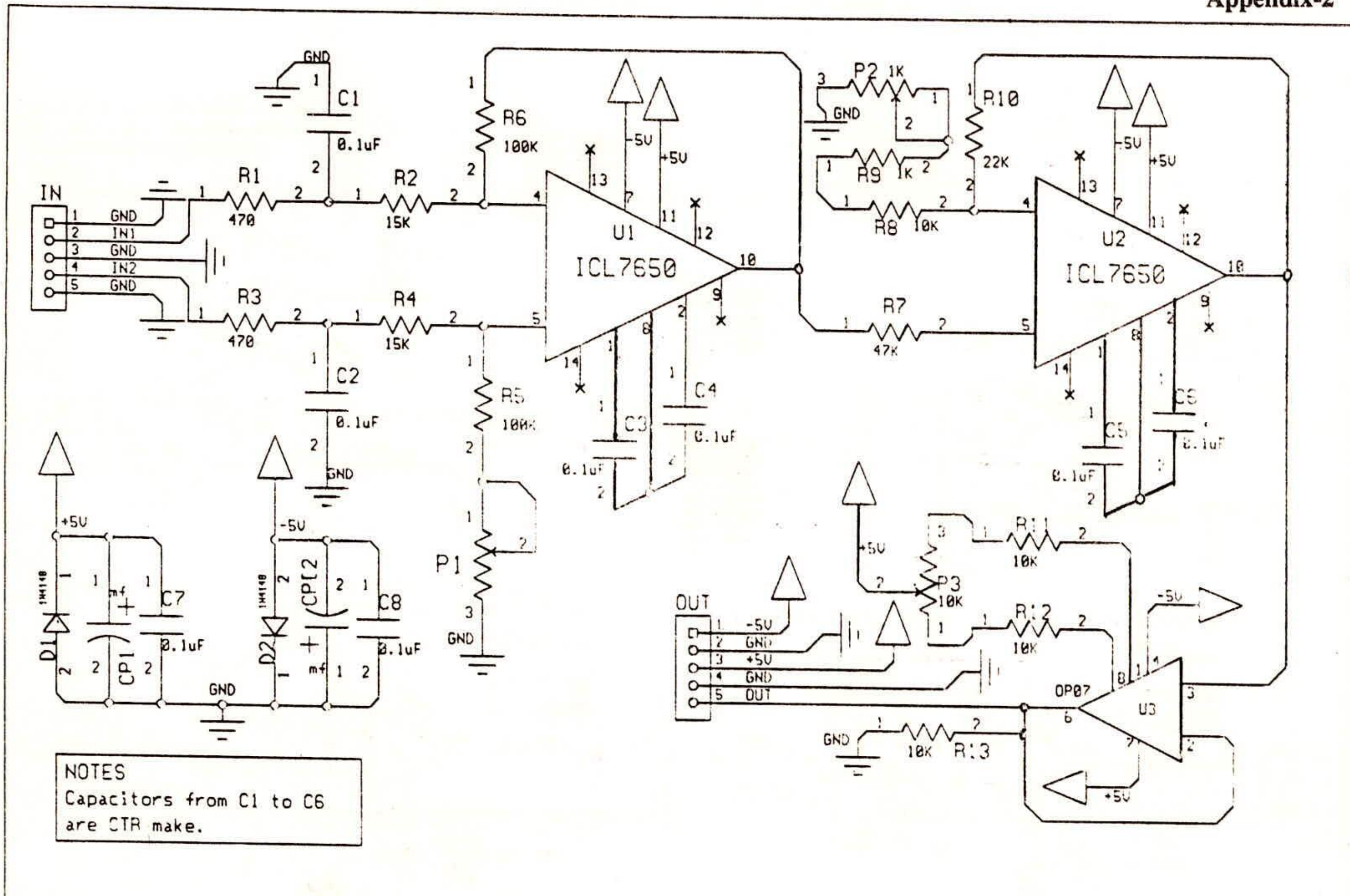
Appendix-2 Contd...



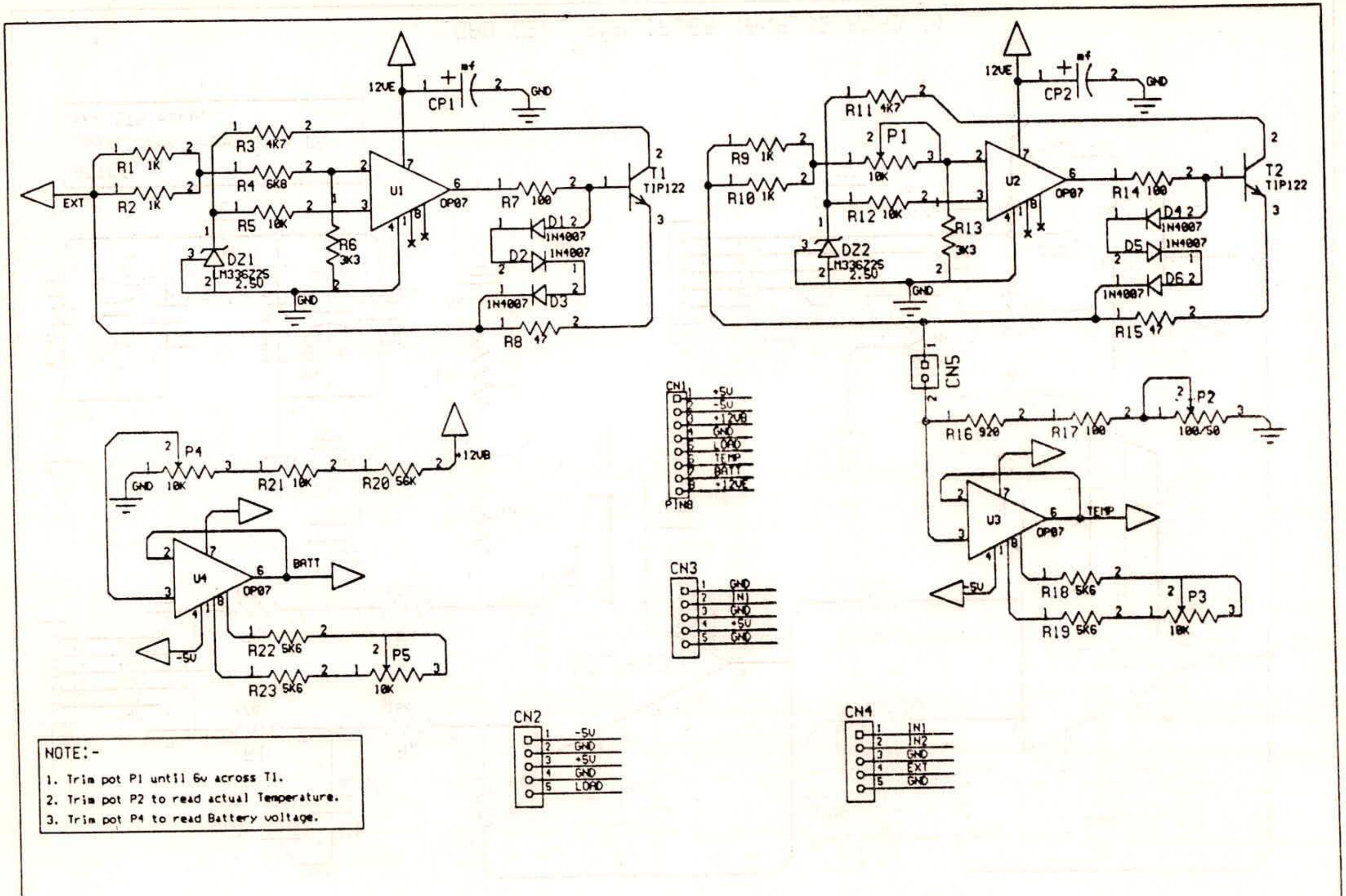

U1
U2
U3
U4
U5
U6
U7
82C55A
62256
146818A
ICM7170
SB1
SB2
X1
X2
R1
R2
R3
R4
C1
C2
C3
C4

Appendix-2 Contd...





LOAD CELL AMPLIFIER (ANALOG ACRD I)



ANALOG AMPLIFIER/EXCITATION SECTION (ANALOG CARD II)

Appendix-3

SPECIFICATIONS OF WRG SYSTEMS

SENSOR

Catch dia.	205mm
Overall height	500mm
Resolution	0.1 mm
Material	Aluminium

LOAD CELL

Type	Strain gauge
Capacity	10 Kg
Accuracy	0.03%
Excitation	10 Volts DC

INNER CONTAINER

Height	190mm
Diameter	175mm

SOLENOID VALVE

Type	Normally closed
Power supply	12 Volts DC
Opening	1/2"

COST OF WRG COMPONENTS

1.	Inner and outer containers	2,000/-
2.	Load cell (10 Kg)	4,000/-
3.	Solenoid valve	1,000/-
4.	Electronic circuit	10,000/-
5.	SPV module & battery, with charger	8,000/-
6.	Software development & PCB designing	10,000/-
7.	Cabinets	2,000/-
	Total Rs	37,000/-

DIRECTOR	: S M SETH

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