BUREAU OF SUGAR EXPERIMENT STATIONS
QUEENSLAND, AUSTRALIA

FINAL REPORT ON PROJECT 89/7
TO THE NATIONAL IRRIGATION RESEARCH FUND

AN INITIAL EVALUATION OF SURGE IRRIGATION AS A MANAGEMENT TOOL FOR THE BURDEKIN SUGAR INDUSTRY

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SUMMARY

Conventional furrow and surge irrigation were compared during the growth of second and third ratoon sugarcane crops on a duplex soil in the Lower Burdekin district.

Data collection was severely hampered during this investigation by the prevailing weather. Crop yields produced by both irrigation systems were almost identical.

Surge irrigation reduced pumping times by 15.7-23.5% compared with conventional irrigation, thus reducing irrigation costs directly by these percentages. Further savings would result from lower maintenance on pumping equipment. Soil moisture distribution along the furrow and 'out times' for irrigation sets were more uniform for surge irrigation than conventional irrigation.

1. OBJECTIVES

To evaluate surge irrigation of sugarcane by comparing it to conventional irrigation for cane yield, water advance and uniformity of irrigation, runoff volume, and pumping costs.

2. METHOD

2.1 Trial design

Two fields of uniform length containing sufficient rows for three irrigation sets were chosen for the trials. Total pump output was used by each irrigation set. Two irrigation sets were used for surge irrigation and one for the conventional system.

Uniform soils and a single cane variety were needed for yield comparisons in the adjacent surge and conventional irrigation sets. The layout of the field trials is shown in Figure 1.

The growers involved in the field trials were using surge valves for a short time prior to the start of this project.

2.2 Surge valves

Two 250 mm P & R surge valves were provided on loan for this evaluation by Rodney Industries, Geebung, Brisbane, and Gary Furlong Agencies, Ayr. The P & R surge valves used in this evaluation have a preset program on the control chip. Surge times are then calculated and regulated as a function of the irrigation out-time determined previously for conventional furrow irrigation of the field. There is scope for adjusting the out-time set by a manual override switch if the furrow advance is considered to be too slow or too fast.

The system results in equal pulse times for each irrigation set on either side of the valve. For maximum benefit from use of the valve, it is necessary to have irrigation sets of equal row length.

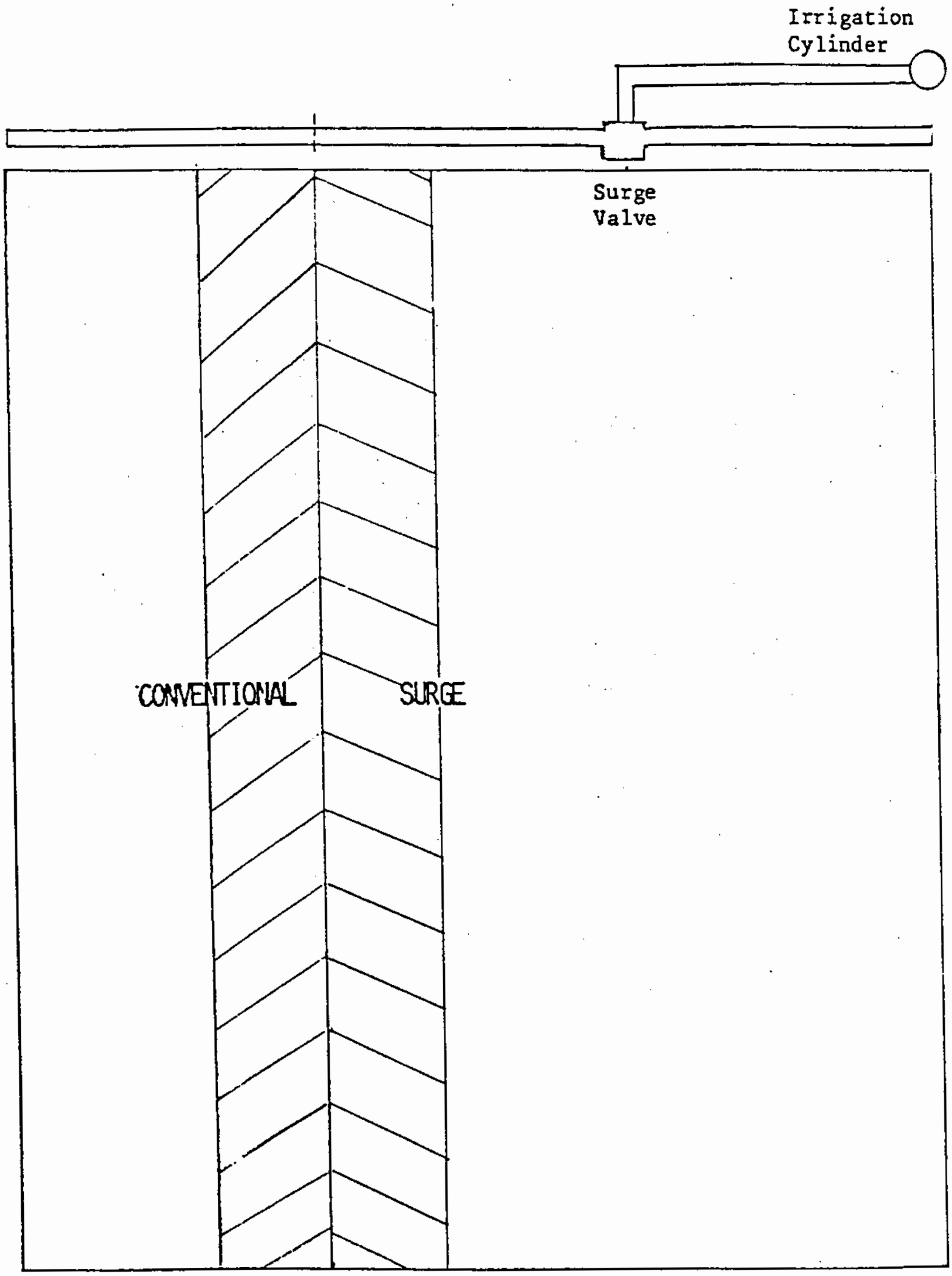
2.3 Furrow inflow

For three outlets in each irrigation set, water was collected over three timed intervals. Furrow inflow was calculated as the mean of these measurements.

2.4 Furrow advance measurement

Water-activated timer clocks were used to measure rate of advance of irrigation water along the furrow. Two types were used, as illustrated in Plates 1 and 2. One (Plate 1) relied on the advancing water completing the electrical circuit, the other (Plate 2) on mechanical activation. Plate 1 units were based on a design of Humphreys et al (1985) while Plate 2 units were developed by McShane, QDPI, Ayr (pers comm). Seven or eight timers were used per measured furrow.

Figure 1
Layout of Field for
Surge Irrigation Evaluation



2.5 Moisture distribution

Soil moisture distribution along the furrow was determined by gravimetric soil sampling three days after cessation of irrigation. Gravimetric soil moisture content was measured in 200 mm increments down the profile to 800 mm depth.

2.6 Visit to Dawson-Callide Valley

The value of surge irrigation on cotton crops was assessed during a three-day visit to the Dawson-Callide region.

All cotton growers who had used or were still using surge valves were interviewed and use of the valves inspected. Discussions with the local QDPI Extension Agronomist and cotton growers' consultant supplemented these interviews and inspections.

3. RESULTS

Rainfall severely restricted data gathering in this investigation as indicated in Figure 2 and progress reports. Only rainfall events in excess of five millimetres are shown in Figure 2. In late November, 1989 a severe storm broke within two hours of the commencement of irrigation. The 154 mm rain in 3.5 hours resulted in high volume flows down the furrows permanently or temporarily damaging furrow advance timer units, requiring their replacement or repair.

3.1 Cane yield

Adjacent ten row by 900 metre plots (1.37 ha) from the conventional and surge irrigated sections were harvested (Figure 1). Cane yields for the irrigation treatments were: conventional 88.4 t ha^{-1}, surge 85.7 t ha^{-1}.

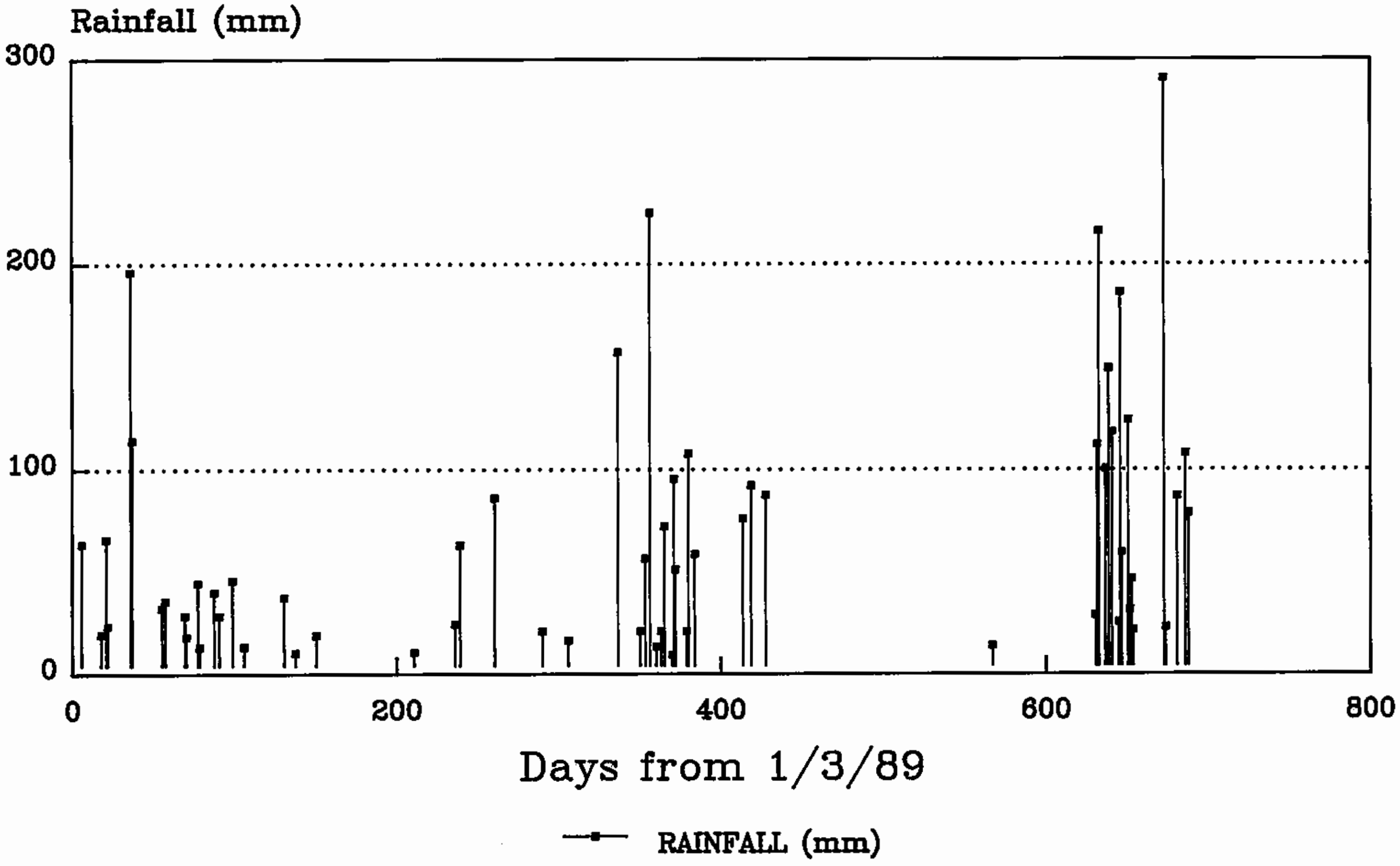
The 2.7 t ha^{-1} difference in yield does not indicate a significant reduction in yield under surge irrigation. The field was laser-levelled to improve irrigation management prior to the plant crop, and some soil settling occurred during the crops prior to trial establishment. An area six rows wide, 45 m long towards the tail-end of the weighed, surge-irrigated plot was affected by this soil settling. Crop stooling and growth in this section of the plot were weaker and consistent with the effects caused by periods of temporary waterlogging. This reduced growth could account for the yield difference between treatments.

3.2 Furrow inflow rates

When used with layflat polythene irrigation fluming, inflow rates of approximately 1.5 L sec^{-1} to each furrow are necessary to ensure adequate filling of the fluming and more even distribution of irrigation outflows on each irrigation set (Alemi and Goldhamer (1988), Stone pers comm (1989)).

Figure 2 — RAINFALL:BURDEKIN

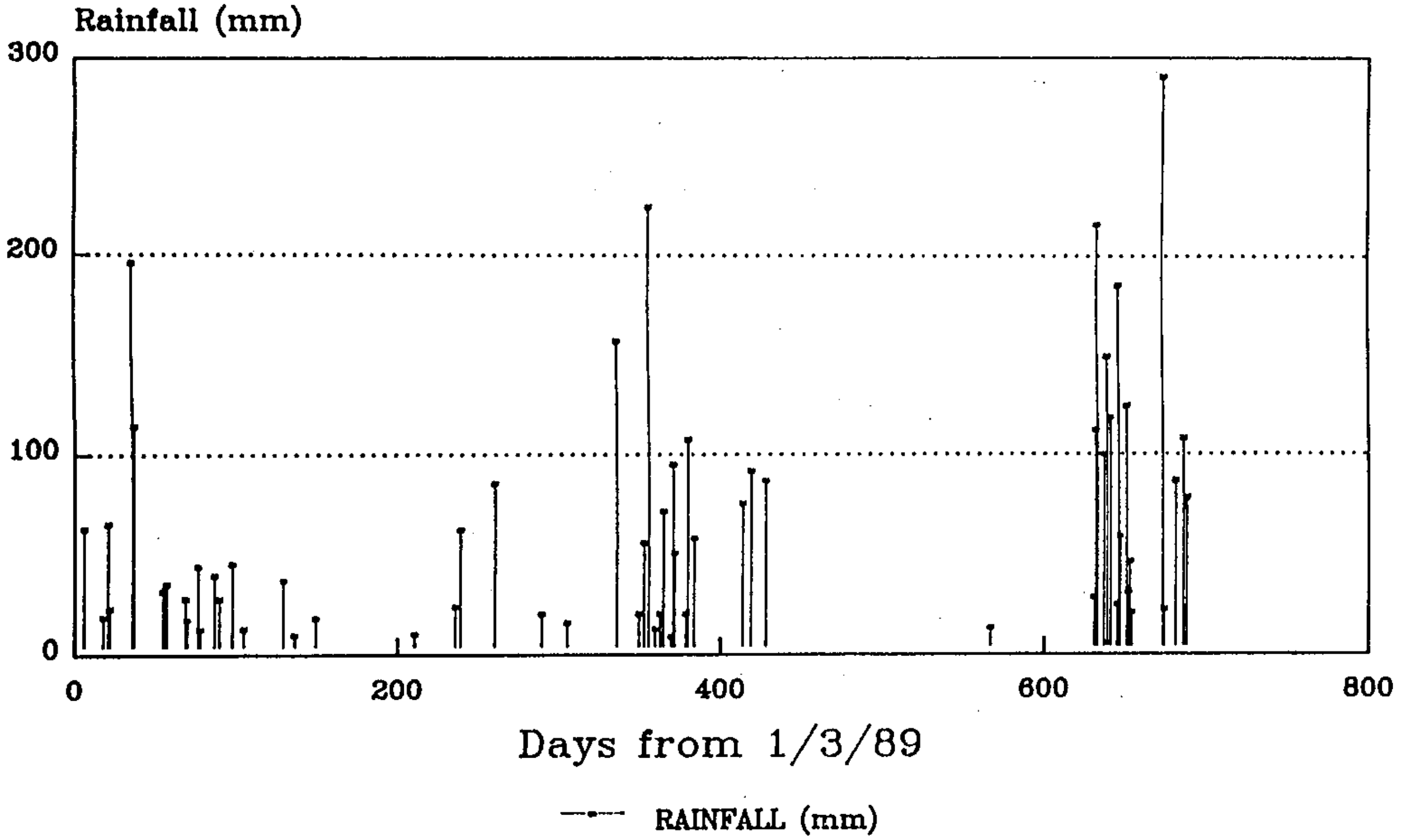
SUGAR EXP'T STATION 1/3/89–31/3/91



DAY 1 = 1/3/89

Figure 2 – RAINFALL:BURDEKIN

SUGAR EXP'T STATION 1/3/89–31/3/91



DAY 1 = 1/3/89

Irrigation set size must be adjusted to meet this requirement and use supply capacity.

Inflow rates for these series of measurements, as determined from samples of each irrigation set, are shown in Table 1.

Table 1

Water inflow rates (L sec $^{-1}$) for conventional and surge irrigation sets on three occasions

Conventional	Surge
1.54 ± 0.04	1.60 ± 0.01
1.81 ± 0.09	1.73 ± 0.05
1.43 ± 0.03	1.62 ± 0.03

3.3 Water advance patterns

Results of furrow advance measurements in randomly selected furrows are shown in Figures 3 and 4 for both systems. The plots of mean cumulative elapsed time against distance from input <u>per irrigation set</u> illustrate the difference between conventional and surge systems for equivalent irrigated areas.

Figure 3: Conventional vs surge : Furrow advance patterns – Second ratoon crop
Consolidated soil

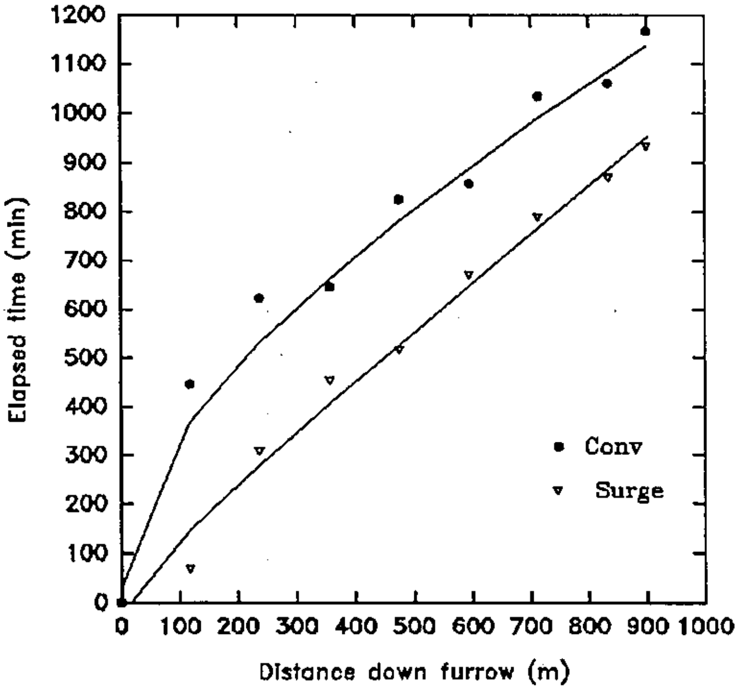
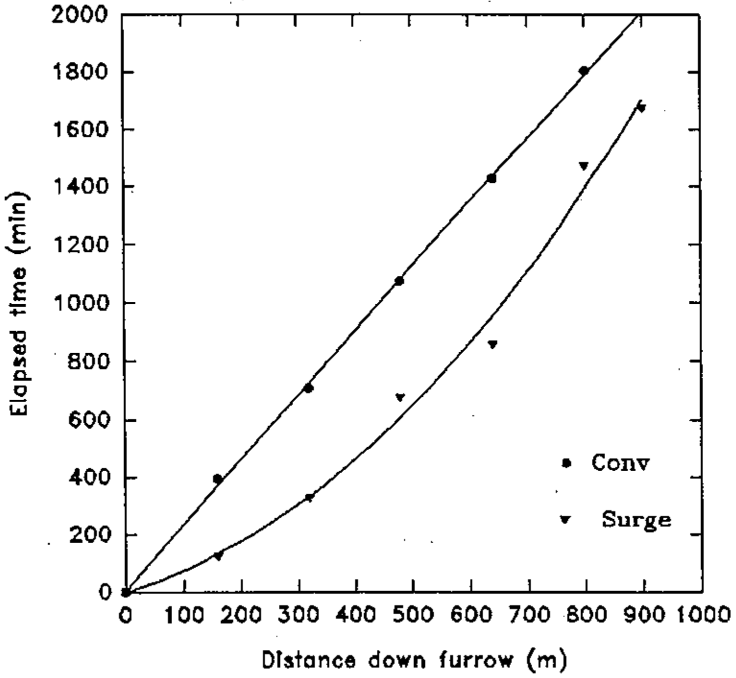
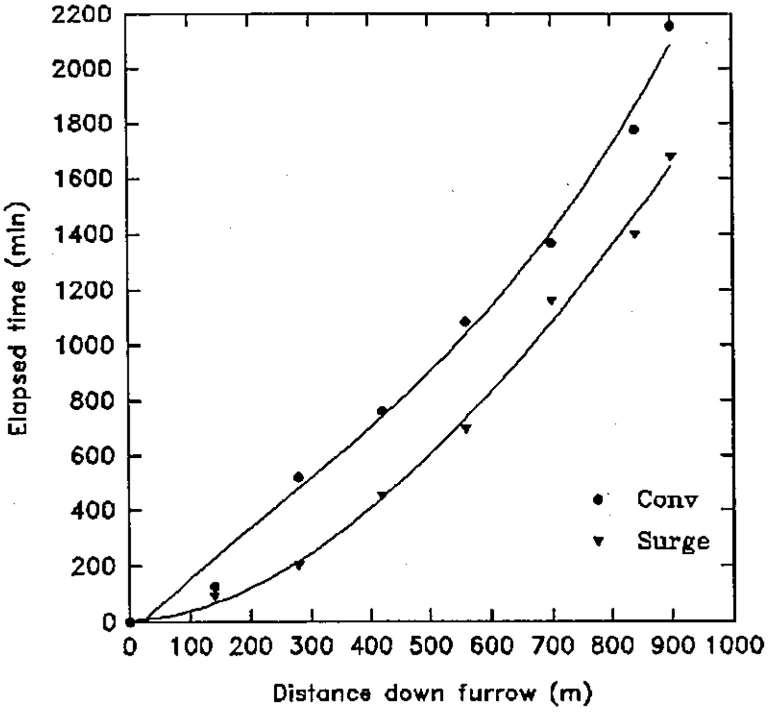


Figure 4: Conventional vs surge : Furrow advance patterns – Third ratoon crop

a) Unconsolidated soil



b) Consolidated soil



In each case, the total elapsed time per irrigation set is lower for the surge than the conventional system. Reductions in elapsed time ranged from 16.5% to 22.3% in the monitored irrigations. The increase in application efficiency was least 16.5% for the first post-cultivation irrigation when the soil was unconsolidated. The rate of advance under surge was greater than for the conventional system at all furrow positions.

This higher application efficiency is in good agreement with that reported by Israeli (1988), Alemi and Goldhamer (1988) and USDA Soil Conservation Service (1986), but the magnitude of the improvement was less than that recorded by Goldhamer et al (1987), Stallman (1987), and Huf (1989).

Additional measurements of elapsed times for each system, when crop size and habit precluded detailed measurement, ranged from 15.7 to 23.5%. These savings translate directly into an equivalent reduction in pumping time and water use. For the data presented in Figures 3 and 4, the savings in pumping times per hectare are 0.66, 0.94, and 1.36 hours respectively. Using the mean of this data and an average cost of $22 per ML (Canegrowers, Burdekin Office) for irrigation water pumped in the Burdekin Delta, the cost saving from the use of surge irrigation amounts to $5.50/ha/irrigation.

For an average Burdekin sugarcane farm of 65.5 hectares irrigated 10-12 times per crop, the potential savings in irrigation costs are substantial. Lower maintenance costs for pumping equipment would also be incurred using this system.

The rate of water advance varied between furrows within each irrigation system. This variation was a function of (a) inflow rates, (b) depth of topsoil, and (c) maintenance of furrow grades after soil levelling. This variability within systems is illustrated in Figure 5, and was greater for conventional than for surge irrigation. Purkey and Wallender (1988), Stallman (1987) and the USDA Soil Conservation Service (1986) made similar observations.

3.4 Uniformity of soil wetting pattern

Mean soil moisture to 800 mm depth showed less variation along the furrow under surge than conventional irrigation (Figure 6). Soil moisture to 600 mm showed a similar result. Better soil moisture distribution along the furrow is one of the principal advantages claimed for surge irrigation. These results support this claim and are consistent with previously published reports (Israeli (1988), Purkey and Wallender (1988), Stallman (1987), and USDA Soil Conservation Service (1986)).

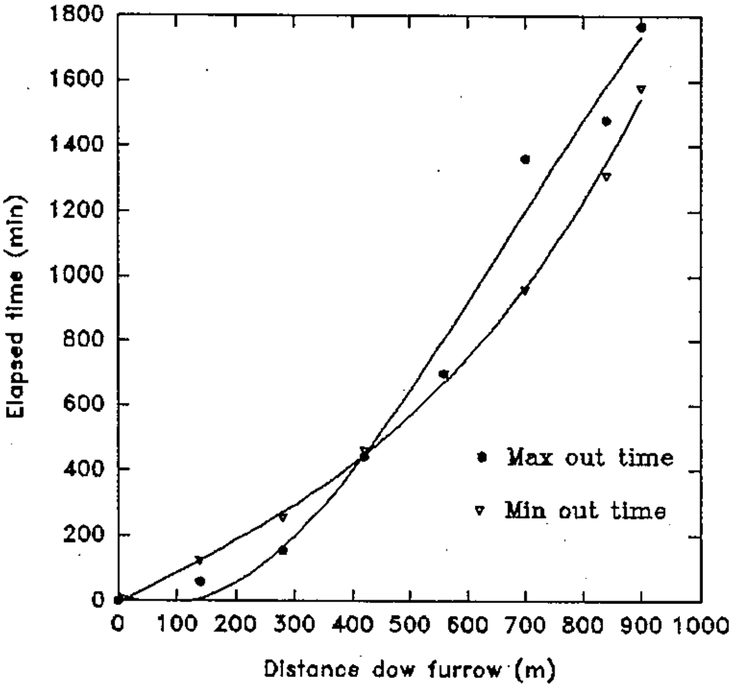
3.5 Run-off

Common irrigation practice in the Burdekin is to minimise run-off from fields by placing a 0.2-0.3 m bank across the tail end of the fields.

Excess water from completed furrows moves laterally into adjacent furrows where water advance has been slower, thereby reducing tail water and the total irrigation time for the set. This excess water backs up 30-50 m depending on field slope.

Figure 6: Variability within irrigation system for furrow advance

a) Surge system



b) Conventional system

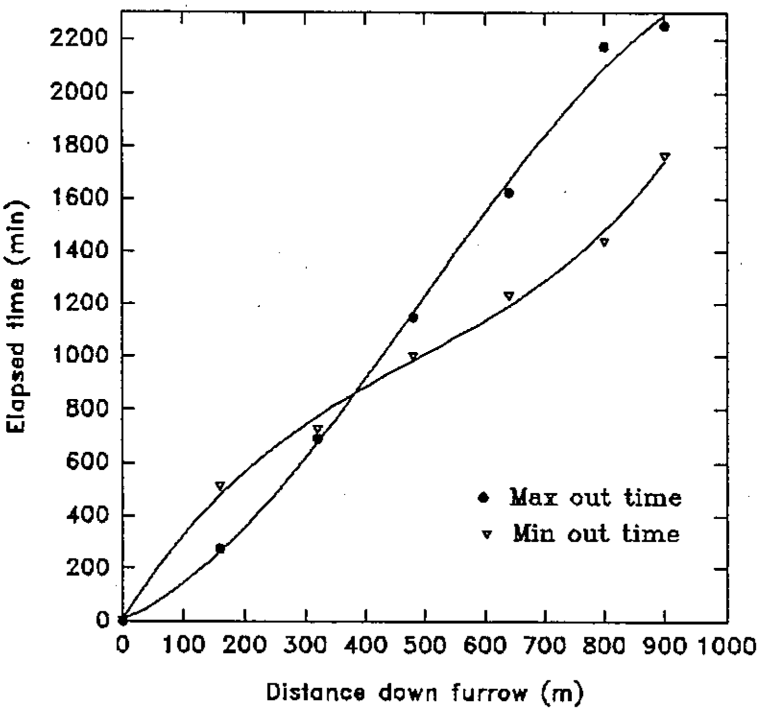
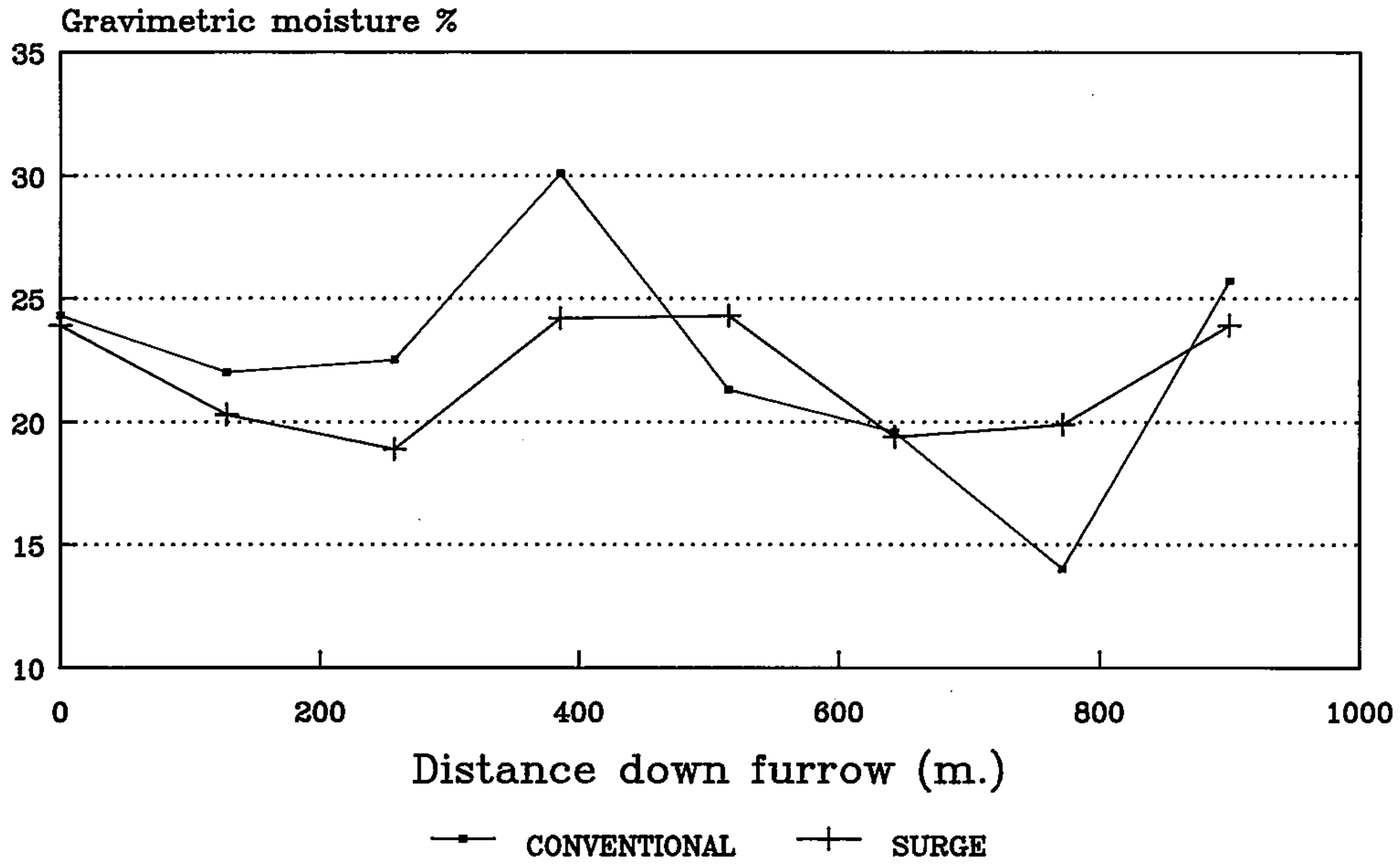


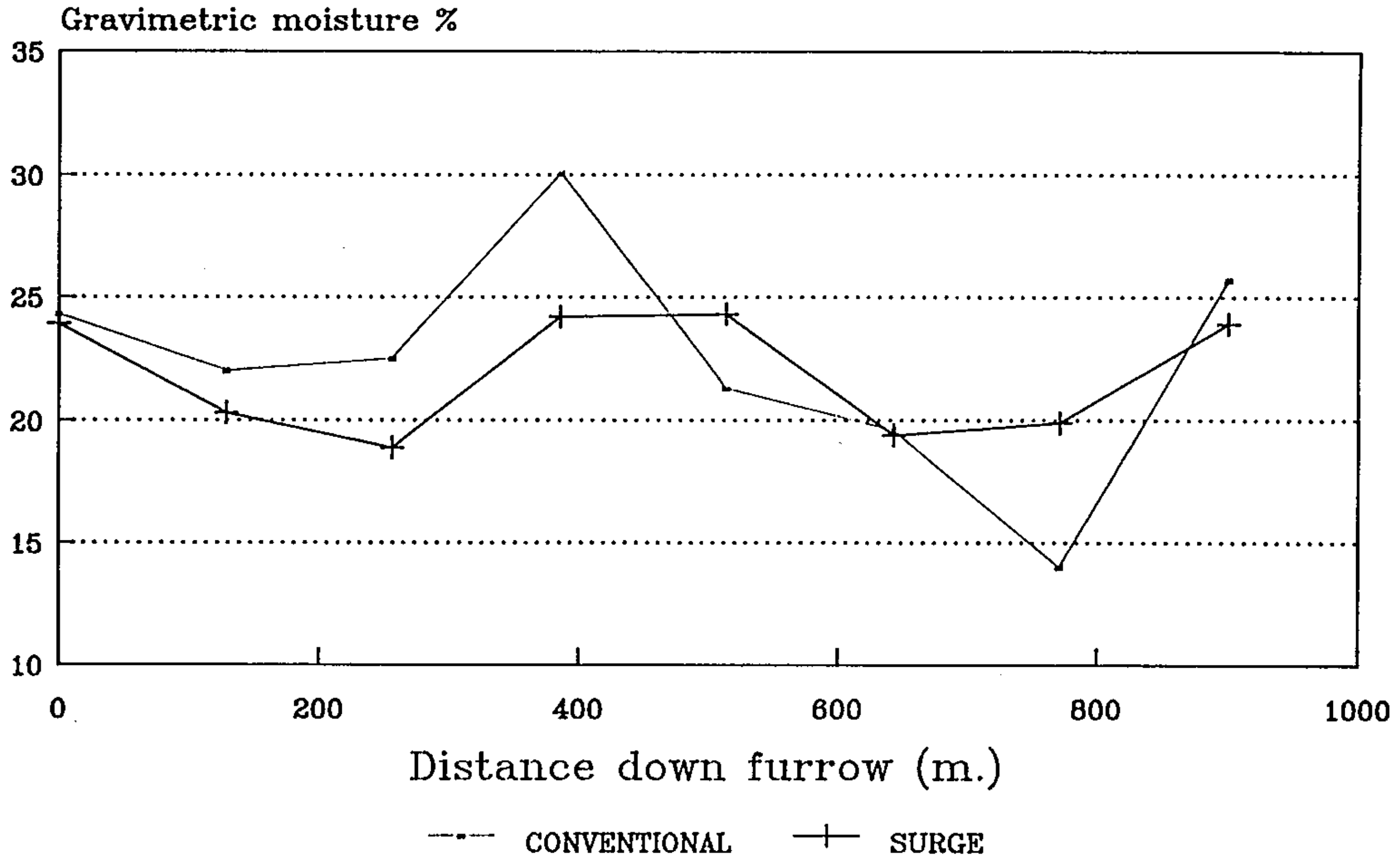
Fig.6 — MOISTURE DISTRIBUTION
DOWN FURROW



mean moisture to 80cm.

Fig.6 – MOISTURE DISTRIBUTION

DOWN FURROW



mean moisture to 80cm.

Because the co-operator wanted to maintain this system, no meaningful measurements of run-off as a proportion of total input were possible. It was necessary to place a second bank at the end of the measured furrows to ensure any such tail water did not interfere with water advance in furrows chosen for measurement.

Surge-irrigated furrows were more uniform in reaching the end of the field than those conventionally irrigated. This implies a reduced tail water/run-off component from surge irrigation.

3.6 Unit reliability

It is essential that surge valves be reliable since they are required to operate without attention for long periods, including overnight.

This investigation was hampered by failures of the unit's power supply and electronics caused by water entry. Some redesign or modification to overcome these problems for this particular unit will be required.

Corrosion of the cast aluminium-alloy body of the unit (Plate 3) may be a problem for surge irrigation valves used with some of the irrigation waters of the Burdekin district which are aggressively corrosive. As a result of this corrosion, rubber seals (Plate 4) for the flow switching vane in the unit required refastening after only one year's use of the unit.

4. SUMMARY OF VISIT : DAWSON-CALLIDE AREA

The growers interviewed who had used surge irrigation agreed that water savings of varying degrees were achieved. All these growers have limited underground supplies and were using or had used P & R surge valves (Plate 5).

All indicated that furrow advance was quicker and more uniform, and this was a distinct advantage where a range of soil types was present in the one field. The surge system was being used almost exclusively for cotton production. Savings in water and power costs for these growers varied from less than 10% to 30%.

Only two growers have persisted with the surge system. Both indicated they could not adequately manage their current cotton production without this system. Both had permeable alluvial soils merging to black cracking clays on the lower end of the fields and surge irrigation provided the means to move water across the alluvial soils to the cracking clays in a reasonable time. Manageable irrigation sets were then possible with the limited pumping capacity to allow the 10-12 day irrigation cycle required for cotton.

Various reasons were given for not continuing to use surge irrigation. One grower had returned to lucerne production. Another had tried the system for two seasons but, given the initial cost of the valves, considered the water and power savings (<10%) were insufficient to warrant the capital outlay to set up his enterprise completely. Another large enterprise cited (i) the escalating cost of the valves (more than doubled between purchases) (ii) increased capital in ancillary equipment, and (iii) additional work to operate the system adequately as the reasons to quit the surge system.

The local cotton industry consultant suggested that some of the initial users of surge irrigation, who had since abandoned its use, had tried to set 'too fine a line' in their operations. Rather than match their pumping capacity and the extension of the previously irrigable area through use of the surge system, growers planted larger areas than could be managed. They then tried to use the surge system to stretch their available irrigation capacity to cover this increased area. When the 10-12 day irrigation cycle requirement for cotton could not be met, then they ceased use of surge irrigation, convinced that it had failed.

The local QDPI Extension Agronomist indicated that there had been no been irrigation research on the use of surge irrigation in cotton or other crops in the area. Consequently, there was no basis on which growers could calculate the manageable increase in irrigable area through the use of the surge system.

In the Burdekin, surge irrigation would be used to give more efficient use of available irrigation supplies leading to reduced production costs, rather than to extend the irrigable area from a limited water supply to increase total production. Adoption of surge irrigation in the Burdekin will be influenced by extent of change necessary to existing capital works on farms in the Delta area and the suitability of farm design/layout for its adoption on the new Burdekin River Irrigation Area farms.

5. RECOMMENDATIONS

The following recommendations arise from the results of this evaluation:

1. Extension programs should encourage canegrowers to adopt this technology to increase their irrigation efficiency and reduce irrigation costs.

2. Information on the latest equipment developments/methods in surge irrigation should be distributed to the industry.

3. Further evaluation of the benefits of the surge system is warranted for soils with low infiltration and/or percolation rates.

4. Evaluation of the benefits of the surge system is warranted for heavy clay soils where long irrigation runs are used; for example, in the Burdekin River Irrigation Area where field lengths are often one kilometre or more.

5. The capacity of the surge system to be used with fertigation to provide uniform fertiliser distribution and increased fertiliser use efficiency in irrigated fields should be evaluated.

6. The applicability of the surge system in the sugar industry where green cane harvest and trash blanketing are used.

6. DISSEMINATION OF INFORMATION

In the Burdekin sugar industry, the surge irrigation system has been displayed at Field Days, discussed at pre-season shed meetings of growers, and will be included as a demonstration on district field tours later this year.

The results will be circulated to all canegrowers through sugar industry publications.

7. REFERENCES

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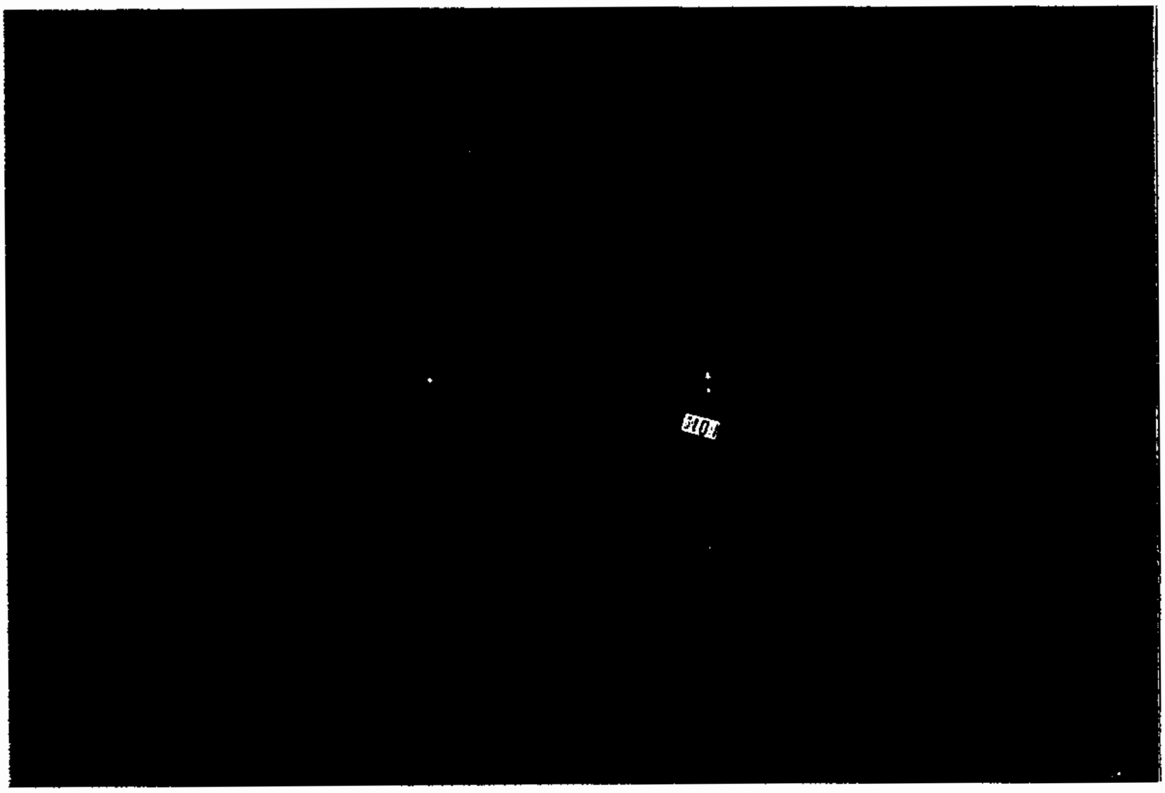

Plate 1 - Timer unit after Humphreys *et al*

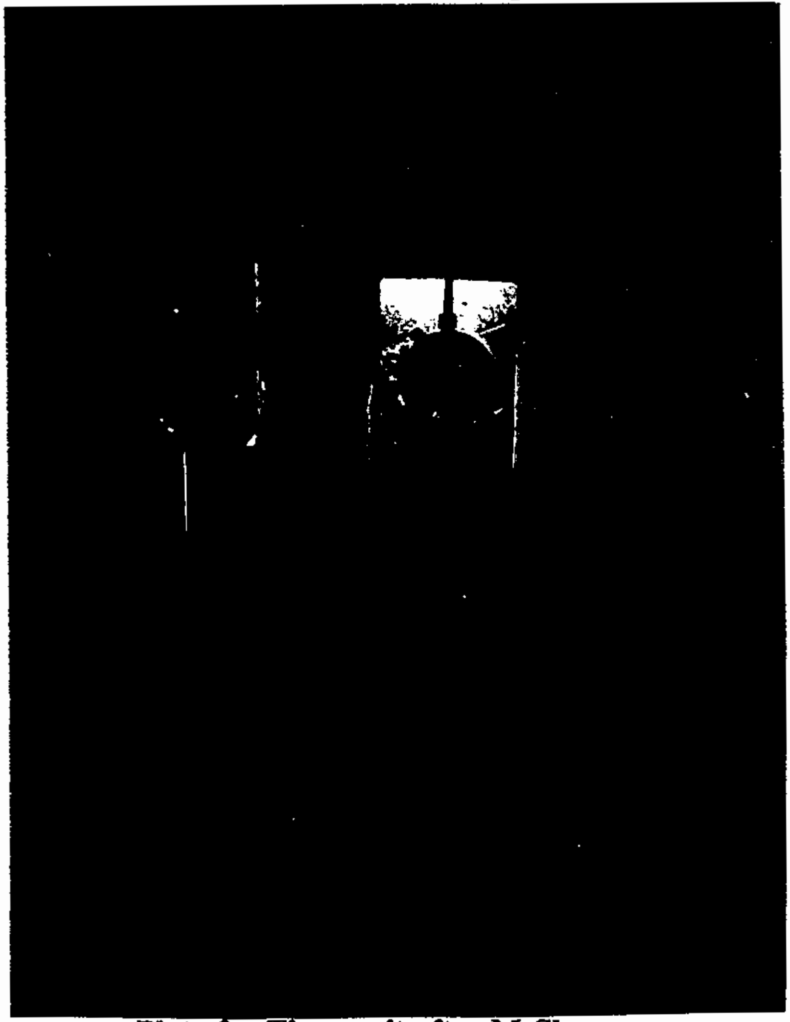

Plate 2 - Time unit after McShane

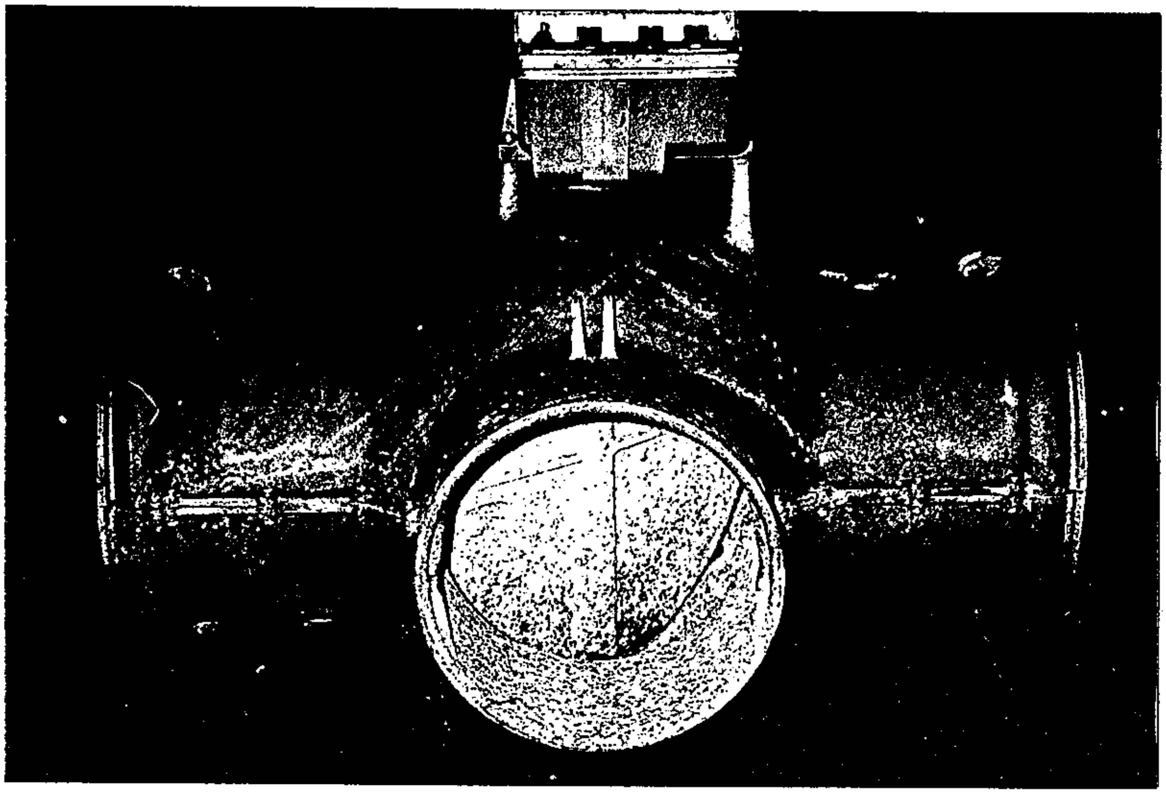

Plate 3 - Corrosion of P & R valves

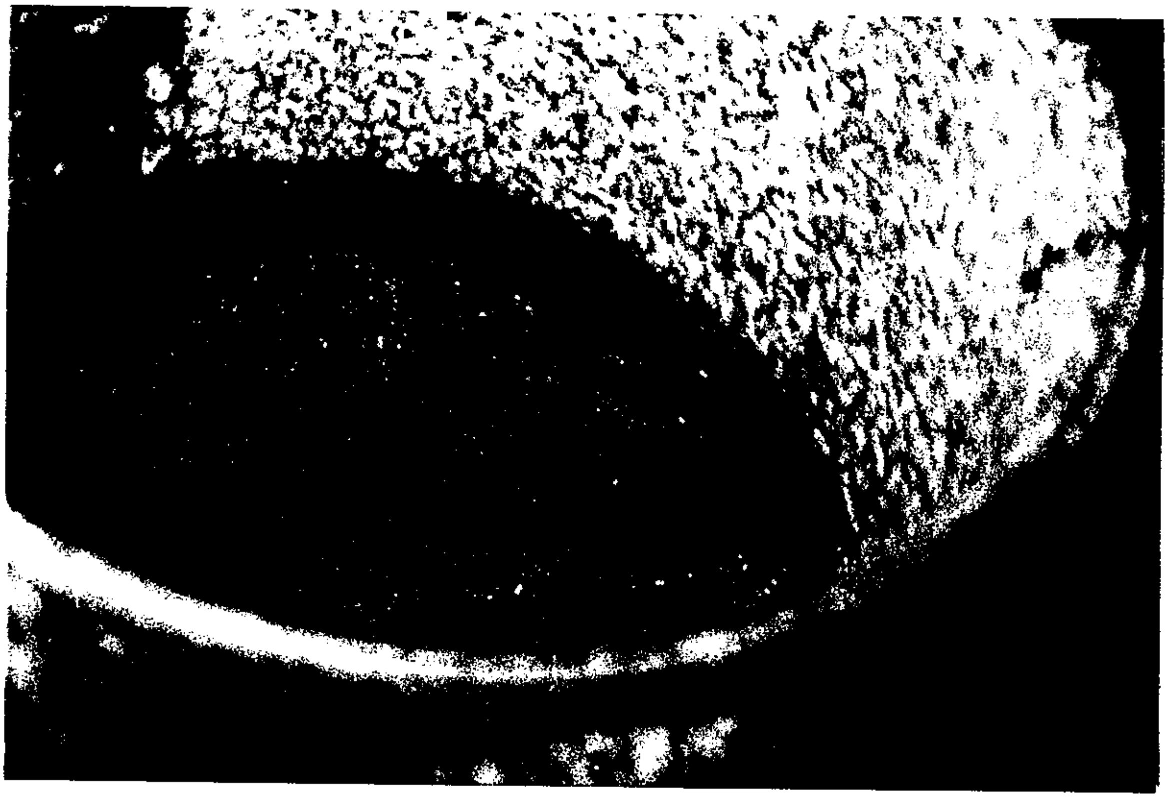

Plate 4 - Rubber seals loosened by corrosion

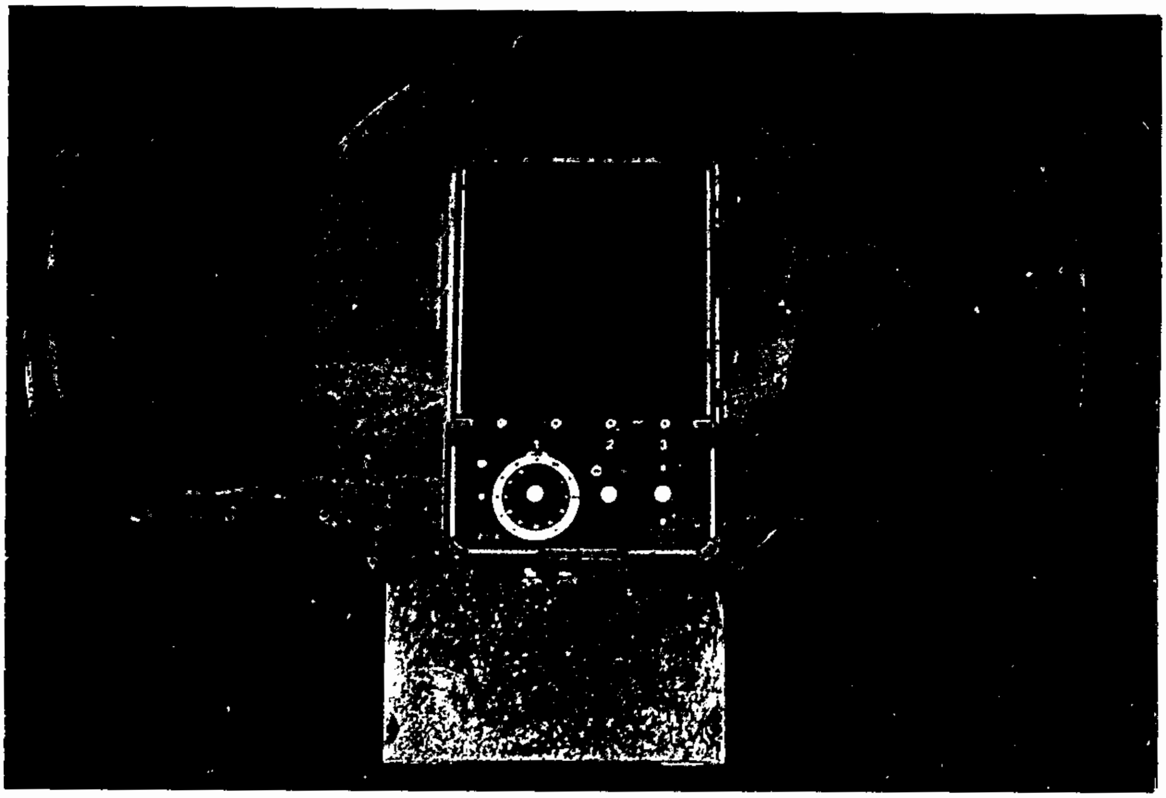

Plate 5 - P & R valves used in this evaluation