A Review of Control Systems in Australian Grain Terminals

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Kontroll- und Steuersysteme in australischen Getreidehäfen
Systèmes de contrôle dans les terminaux céréaliers d'Australie
Sistemas de mando y control en puertos australianos para cereales

オーストラリアにおけるPWH

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Summary

The four important centres of operation and control in grain terminals, i.e., receival hoppers, shipping weighers, shipping control room and main control room, are discussed and control systems in some of the more recent terminals and terminal extensions in Australia are described.

1. Introduction

Grain terminals for the shipment of Australian grain are located in all Australian states, other than Northern Territory, extending from Gladstone in Queensland around the eastern, southern and western seaboards, to Geraldton in Western Australia.

The receival, storage, land transport, handling and delivery to shiploading facilities is the responsibility of State organisations which may be either growers co-operatives or government controlled Boards or Authorities.

The grains handled include wheat, oats, barley, sorghum and various oilseeds. Wheat is the largest grain export item, amounting to 15.2 million tonnes in the 1979—80 financial year.

Some details of the control systems installed in grain terminals in recent years are given in the following paragraphs.

2. Typical Terminal Operation

A typical simplified flow diagram for the handling and storage of grain within a terminal is shown in Fig. 1. It will be noted that this diagram excludes any accurate weighment of grain into storage, this being the current situation in a majority of the States.

After discharge into rail or road receival hoppers the grain is transported by belt conveyor to bucket elevators and thence lifted to a height above the storage for distribution. The grain flow path may include pre-cleaners and automatic sampling and, in order to provide flexibility in handling, radial distributors may be included, thus allowing transfer to a number of possible locations. Storage may comprise vertical cells or horizontal storage sheds, the grain being delivered into storage by belt conveyor and discharged by belt tripper. Discharge valves under cells and storages allow grain to be extracted from storage and transported again by conveyors and elevators to either grain cleaners and ultimate return into storage or direct to shipping weighers.

The weighment of grain for export is carried out by the use of hopper type batch weigher systems comprising garner (surge) bin, weigh hopper and discharge hopper, the rate of batch weighing being designed to suit the shipping conveyor handling rate.

Belt conveyors transport the grain from the shipping weighers to the shiploaders.

In addition to the radial distributors mentioned previously the grain flow paths include various diverter valves for the transfer of flow direction.

Australian grain terminals also include comprehensive dust control systems which extract and transport grain dust to storage hoppers for later disposal.

3. Typical Control Features

Grain terminals have four important centres of operation and control, these being:

1. Receival Hoppers,
2. Shipping Weighers,
3. Shipping Control Room,
4. Main Control Room.

3.1 Receival Hoppers

At this location, rail or road trucks dump grain into hoppers. Rail deliveries provide a majority of the receivals at most terminals, the unloading operations involving manpower for truck positioning, discharging and cleaning up.

An important operating function at this location is to adjust the flow from the hoppers so as to ensure that grain is discharged at a rate and sequence which will allow the most rapid discharge and movement of the trucks.

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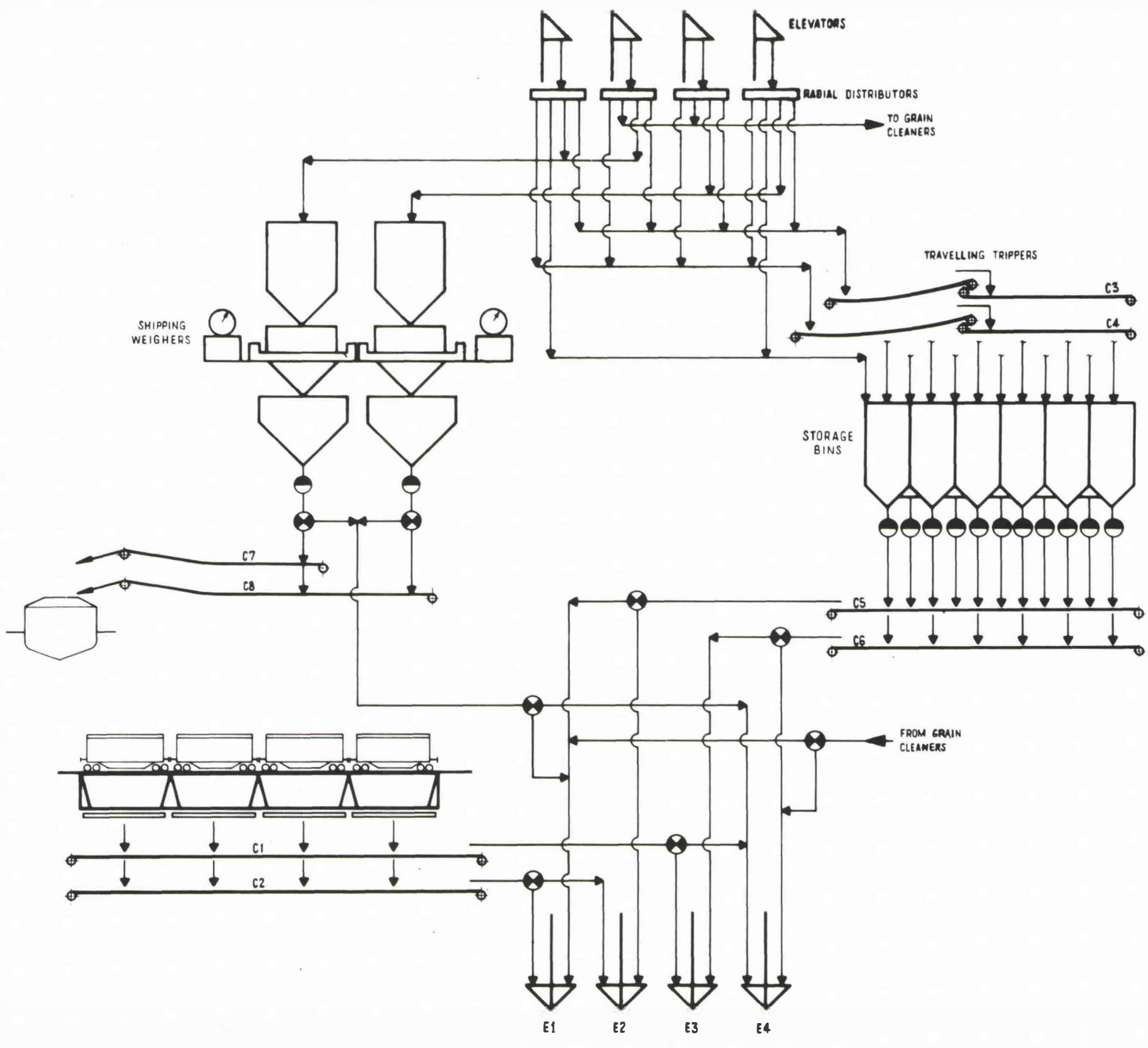

Fig. 1: Simplified flow diagram of typical grain shipping terminal

Belt weighers are provided in the grain receival flow path to give an indication of belt loadings and maintain a record of the quantity of grain delivered into storage. A weight totalising instrument associated with the belt weigher is installed within the remote main control room so as to allow grain stocks in storage to be recorded for inventory control.

The arrangement of a rail receival system designed for high handling rates may include more than one rail track and each track may feed several receival hoppers so as to provide a means of rapid unloading and handling, in addition to allowing segregation of incoming grains. Automation of such a system becomes essential if a high unloading rate is to be maintained. This involves a control system which will continuously control the opening and closing of the receival hopper valves, in a sequence and time programme such that rail trucks may be moved at maximum rate.

In the case of rail receivals it is normal for no marshalling of rail trucks to be carried out prior to their arrival at the terminal. Hence adjacent trucks in the same train load may contain different grain types or varieties. This situation requires constant alteration to the grain flow path or destination each time there is a different grain type received, and all such alterations to the flow path are carried out from the main control room. Reliable communication between the receival hoppers and the main control room is essential.

3.2 Shipping Weighers

All outgoing grain must be accurately weighed and the weight certified by a print out.

The weighers are placed in the flow lines from the shipping elevators and have the same handling capacity as the elevators. These weighers are usually located in a position remote from the main control room and existing machines incorporate a control console and scale head directly connected by mechanical linkages to the weight hopper. The operation of the machine and print out device is subject to the control and certification of the Weights and Measures Department in each State. Load cell type weighers are also available but have not been used extensively, to date, in Australian terminals.

The weighing machines are batch type, bulk weighers, which operate on an automatic weigh cycle, the total quantity of grain to be weighed being preselected by an operator at the weigh console. The grain hoppers above and below the weigh hopper incorporate level sensors which provide monitoring and alarm features in the case of the upper hopper, and an inhibit function to the weigh cycle for the lower hopper.

The main control room remote from the weighers is provided with an indication of the level of grain in the two hoppers associated with each weigher and is also provided with an alarm indication of any overflow from the upper hopper.

A remote weight totaliser for each weigher may also be located in the main control room.

3.3 Shipping Control Room

The shipping control room is located on galleries above the wharf and this is remote from the main area of the terminal. This control room is placed in a position which will allow general viewing of the shiploading operations.

A grain shipping system comprises a number of parallel flow paths of belt conveyors which collect the grain from the shipping weighers and deliver it via trippers to fixed loading spouts or travelling shiploaders and thence to the ship's holds.

Typical terminals in Australia, have four grain flow paths to shipping and any one of these flow paths may be directed to one of twenty or more tripper positions along the shipping gallery, thus allowing the grain to be fed into any one of the four shiploaders. Each shiploader is fitted with collecting belt conveyors which deliver the grain to the ship through a loading spout on the shiploader boom.

The operator in the shipping control room directs the positioning of trippers feeding to spouts then controls the flow of grain into the hatches.

The feed shoe under each shipping weigher hopper is fitted with a motorised valve and position transmitter to allow remote control and indication of the valve opening, these valves being operated from the shipping control room. Each grain flow path from the shipping weighers is provided with a loading rate indicator which is calibrated in tonnes per hour. This may be obtained by measurement of power on a conveyor drive motor, or by a belt weigher.

Each travelling shiploader (or fixed loading spout) has an operator whose function is to move the shiploader and adjust the spout position as the ship is being filled. The conveyors on the shiploader and hence the flow of grain from the terminal, are controlled from the shipping control room.

Each complete flow path must be fully interlocked and all tripper positions indicated so as to allow thorough checking and verification of correct operation and final destination.

The operational procedures for the loading of ships vary with different terminal operators but, essentially, the stevedore orders the quantity of grain required in each hatch and this information is made available in the shipping room, and to the shipping weigher operator as well as to the main control room. As the shiploading operation proceeds, the stevedore continually requests details of the loading progress on a "per hatch" basis, and this information must be computed and updated from the shipping weigher readings.

The shipping control room operator maintains contact via a communications link either directly with the shipping weigher or through the main control room, and the reliability of this link is vital to the shiploading operation.

3.4 Main Control Room

The main control room is situated within or adjacent to the workinghouse attached to the storage cells and from this location the flow of grain throughout the whole complex is controlled and monitored.

It is important that this control room operator has full knowledge of the workings of all plant items, and facilities should be provided to give indications of plant operation under the control of other operators, e.g. grain receival, shipping weighers and ship deliveries.

Information relating to grain receivals is gathered from incoming road or rail trucks and is passed on to the terminal superintendent and main control room so that the storage locations within the complex may be determined.

The flow of grain from the receival hoppers is controlled from the main control room and the grain flow path may comprise belt conveyors, elevators, spouting and chutes, to deliver grain into the top of the storage cells.

Belt trippers on the oversilo conveyors discharge the grain into the selected storage cells and the position of these trippers is indicated on the main control room mimic panel.

In order to increase the flexibility of the handling system radial distributors are fitted in the grain flow paths and are normally associated with an elevator. The distributors comprise a rotating spout which can direct the grain flow to any one of a number of different spouts and thence by chutes and feed shoes to the storage or shipping system.

The radial distributors, are controlled remotely from the main control room, giving an indication of their position and providing facilities for interlocking associated flow paths. The correct and precise positioning of the rotating spout opposite the selected outlet is important so as to avoid admixtures or blockages.

There is an obvious need for comprehensive interlocking to be established in the overall control scheme and this must be backed up by indications, discrepancy alarms and path selection switches to ensure correct handling, with careful monitoring, so as to avoid spillages or admixtures of different varieties.

The transfer of grain within the storage complex and between storage locations is initiated and monitored from the main control room. Other operations such as grain cleaning or fumigation may also be carried out.

Delivery of grain from the storage cells to the shipping weighers and thence to the ship, is a most important function and hence there is a need for strict control of all flow paths to ensure that the correct grains are being handled and directed to the required hatch destination within the ship.

The grain is transported along flow paths to the shipping weighers in a similar manner to the inloading system and the feed onto the understorage conveyors is controlled, under each bin, by a rack and pinion valve. Normally, only one valve will be opened to feed a single flow path but provision must be made to allow more than one feed for possible blending requirements.

The main control room mimic panel is provided with indications and discrepancy alarms in the case of the tripper position and individual indicators in the case of undersilo valves, and this allows all destinations and sources of grain within the storage to be checked and verified during the handling operation.

Each dust control system and the central collection and storage system is fully automatic in operation and all systems are controlled and monitored from the main control room. Interlocks are provided to ensure that the dust collection plant is in operation before the associated handling plant may be started.

It is essential that all belt conveyors and elevators be provided with speed responsive switches to verify actual operation of plant, thus avoiding overheating of drive pulleys or spillages of grain. Also, it is essential that choked elevator boot detectors and choked chute detectors, at all important change of direction points in the handling system, be provided.

4. Extent of Automation in Australian Terminals

The design of control systems in new terminals and terminal extensions in Australia over the past decade has been strongly influenced by:

a) Terminal operator requirements,
b) economics,
c) industrial relations.

Australian terminal operators pay a great deal of attention to housekeeping, ensuring not only a minimum of problems from pest infestation but also reducing the risk of explosion hazards. This regular housekeeping establishes a workforce which can also be utilised for operational work, e.g. moving trippers, operating manual valves etc. This has been used as one of the arguments against automation.

The high degree of automation which has been achieved in overseas terminals, particularly in the USA, can be economically justified by the savings in manpower. There is difficulty in arguing the same justification in Australia because of the precedents in manpower usage already established. There are, however, many intangible benefits from automation, not the least of which are a greater reliability and a more rapid execution of operations. These benefits are becoming more obvious as industrial relation difficulties increase.

5. Recent Grain Terminal Installations

Control systems in some of the more recent terminals and terminal extensions completed in Australia in recent years are described in the following paragraphs:

5.1 Kwinana Grain Terminal

This terminal is located on the shores of Cockburn Sound, Western Australia near Perth and is the largest and most modern grain terminal in Australia. The terminal is operated by Co-operative Bulk Handling Limited (Fig. 2).

The facility has rated handling capacities of 4,000 t/h for receivals and 5,000 t/h for shipping. The total storage capacity is 950,000 tonnes, spread over an area, on-shore, of 21 hectares and connected to a shipping jetty by a 730 m long conveyor gallery.

The design of the control system for this facility was completed in 1974 and this new terminal was commissioned in mid-1977.

The main control room located on-shore within the storage complex, controls the flow of grain from rail hoppers to storage and from storage to shipping weighers. This control room incorporates a curved mimic panel in a 20 m arc which, with associated control desks, allows complete monitoring and control of all on-shore operations (Fig. 3). Belt weighers are installed on all belt conveyors into and out of storage, the outputs of these weighers being connected to a computerised stock inventory control and reporting systems.

The shipping control room, located in an elevated position on the shipping gallery, controls and monitors the flow of grain from automatic batch weighers to the ship's hold via four belt conveyor systems discharging through four travelling shiploaders.

The complete control system incorporates relay logic and an on-line mini-computer provides operator guidance, also operational and stock reporting by means of visual displays and printers.

All plant operations such as movement of oversilo trippers, shipping gallery trippers and undersilo valves are carried out manually by local operating personnel.

The electrical and control installation in this terminal won the 1978 Engineering Award for Electrical Engineering, as presented by the Association of Consulting Engineers, Australia.

5.2 Newcastle Grain Terminal

This terminal is located in the port of Newcastle, N.S.W., and is controlled and operated by the Grain Handling Authority of N.S.W.

The original terminal was built in the late 1930s and was extended and modernised in 1970 and again in 1978, increasing the storage capacity to 92,000 tonnes. The maximum grain receival rate is 2,000 t/h and the maximum shiploading rate is 4,000 t/h.

The design of the control system for the 1970 modernisation is basically similar to the Kwinana Terminal installation described above, but excluding the computer installation. When the further modernisation work was carried out in 1978 a decision was made to completely automate the new storage extensions. This automation work involved the installation of remote controlled trippers on the oversilo belt conveyors and motorised valves undersilo (Fig. 4).

The movement and positioning of the oversilo trippers is controlled and monitored from the central control room, the system incorporating slow-down controls for precise positioning. Each storage cell is provided with a high level detector and a level measuring device is mounted on each tripper to allow remote measurement of grain level in the storage cells, when no grain is flowing.

The discharge of grain from each cell is remotely controlled from the central control room, each cell being fitted with a motorised valve incorporating a position transmitter. The control system provides a valve selection mode for each undersilo conveyor and, in conjunction with a load detector on the belt conveyer, the operator is able to monitor both the degree of valve opening and the loading on the belt to ensure optimum control of handling rates.

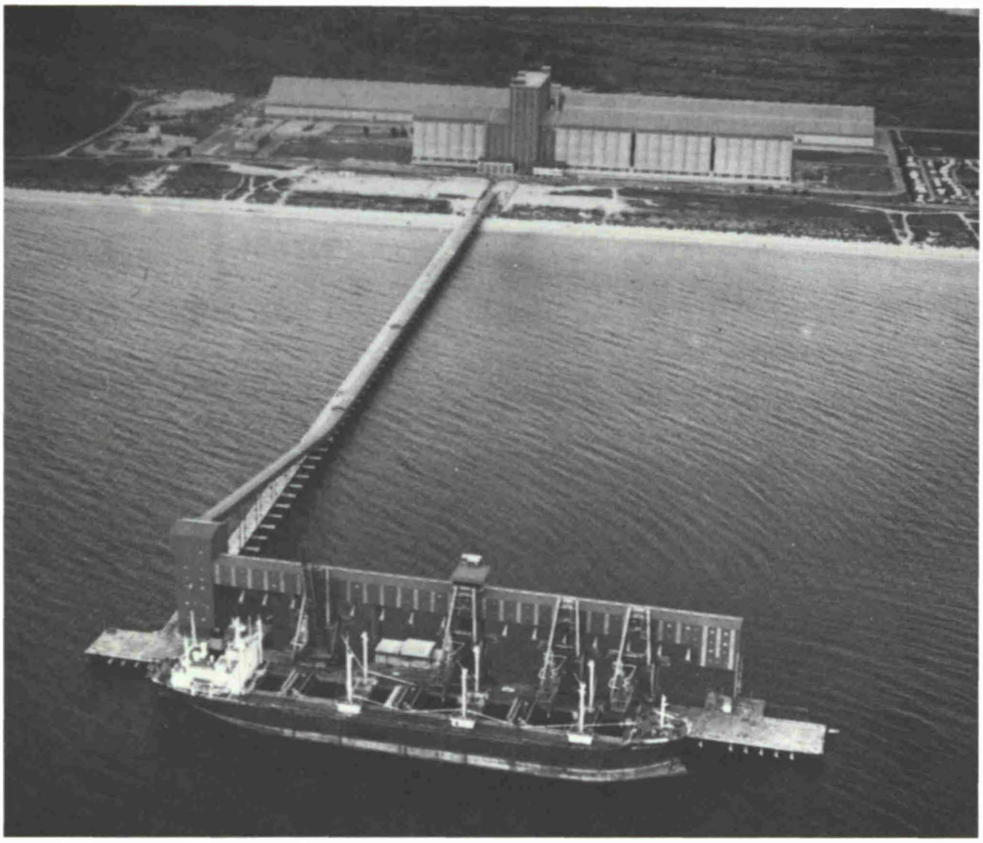

Fig. 2: Kwinana Grain Terminal operated by Co-operative Bulk Handling Limited. Located south of Perth, Western Australia and capable of loading ships in excess of 100,000 tonnes at 5,000 tonnes per hour

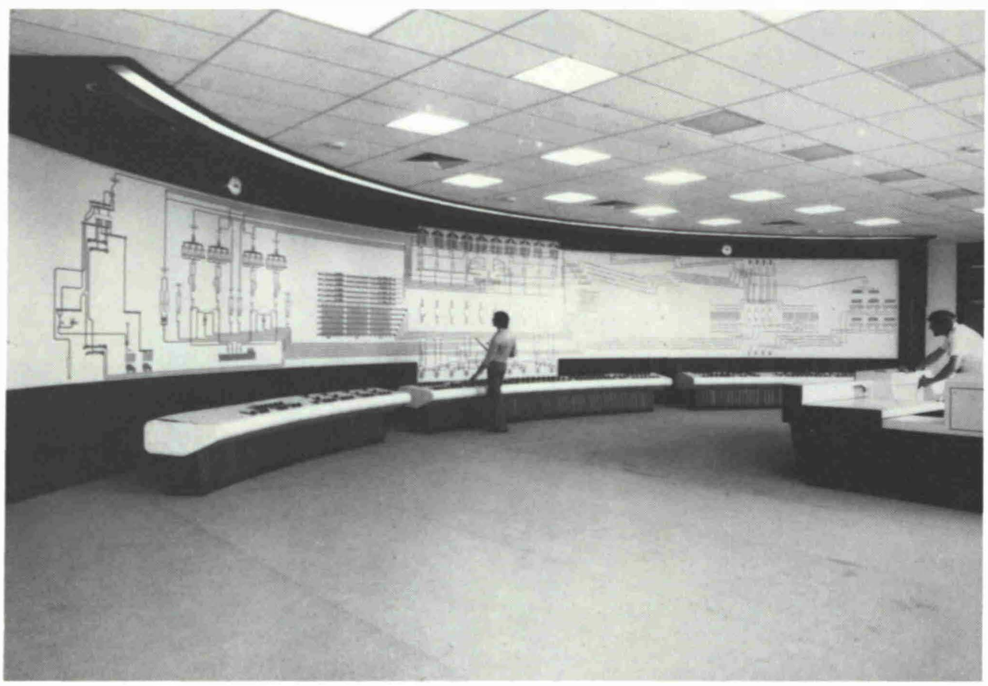

Fig. 3: Kwinana Grain Terminal Main Control Room. Includes 20 m long mimic panel and a computerised operator guidance and stock inventory control system

This control system has relay logic being an extension of an existing and well established terminal installation.

5.3 Albany Grain Terminal

This terminal is located at Albany on the south coast of Western Australia and is operated by Co-operative Bulk Handling Limited.

The original terminal was built in 1956 and has been extended on a number of occasions.

In 1980 the shipping system was modernised providing for a loading rate of 1,600 t/h via three fixed type shiploaders. These loaders include a boom conveyor and telescoping spout with rotational movement, the boom being capable of luffing and slewing movements (Fig. 5).

This new shipping gallery system incorporates a control room which allows control and monitoring of the flow of grain from the shipping batch weighers to the ship. An existing control room within the main storage complex has been

Fig. 4: Oversilo conveyors at Newcastle Terminal, N.S.W. Shows manually operated belt tripper and inlets to storage cells.

retained, and the control system has been modified to accommodate additional weighers, conveyors and elevator.

The control system for the extensions incorporates programmable logic controllers (PLCs) as follows:

1 — Located within the existing control room
1 — Located in the shipping control room
1 — Located on each of the three shiploaders

Interfaces are provided between PLCs to provide an overall integrated system.

The new shipping control system allows complete control of grain flow from the shipping weighers to the shiploader, the final positioning and control of the shiploader spout in the ship's hatches being the responsibility of the stevedores.

The rope winches for luffing of the boom and telescoping of the spout each incorporate strain gauges in sheave pins to detect slack rope conditions.

6. Control Concepts for Future Installations

The design of control systems in future Australian grain terminals is very much dependent on the operational philosophies determined by terminal operators. Economics will, no doubt, remain an important consideration but the benefits of automation, providing independence from manual labour, must become more attractive as industrial difficulties increase.

The control systems designer now has many useful tools available to him which are both reliable and efficient. Further, control systems can now be readily designed to capture and store plant status data, also provide rapid diagnostic and fault finding capabilities thus greatly simplifying the maintenance task and minimising shut-down times.

A number of new Australian grain terminals are being planned and the features enumerated above will, no doubt, be incorporated.

Fig. 5: Fixed position shiploaders at Albany Terminal, Western Australia, each capable of loading ships at 1,000 t/h.