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The design and construction of facilities for handling cattle

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The design and construction of facilities for handling cattle

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Abstract

The cattle handling facilities described in this paper are recommended for use with extensively raised cattle which have a large flight zone and are not completely tame. This paper contains diagrams and designs for corrals, yards, sorting (drafting), handling and loading trucks. Single-file races, crowd pens, restraint devices and truck loading ramps should have high solid sides to help keep the cattle calm. Solid fences prevent the cattle from seeing moving people and other distractions outside the fence. Cattle will move more easily through curved races because a curved race prevents the animals from seeing people up ahead. Curved races must be laid out correctly to make them work efficiently. A curved single-file race must not be bent too sharply where it joins the crowd pen. An animal standing in the crowd pen must be able to see two or three body lengths up the single-file race. Equipment for restraining (fixation) of cattle for veterinary procedures should utilize three behavioral principles: (i) blocking the animal's vision; (ii) slow steady motion of parts of the apparatus which are pressed against the animal; and (iii) optimal pressure. A restraint device must apply sufficient pressure to provide the feeling of being held, but excessive pressure that causes pain or struggling must be avoided. Shadows, sparkling reflections, high-pitch noise and objects which jiggle or move will cause cattle to balk and impede movement through the race. © 1997 Published by Elsevier Science B.V.

Keywords: Handling; Sorting; Drafting; Restraint; Race; Cattle

1. Introduction

Well-designed facilities for veterinary work, loading trucks, sorting and other procedures will make handling more efficient and help reduce stress and injuries. Reducing stress during handling is important because handling stresses can lower conception rates (Hixon et al., 1981), suppress immune function (Kelley et al., 1981; Blecha et al., 1984), and raise cortisol levels (Zavy et al., 1992). Rough handling will reduce weight gains and increase shrink (Grandin (1980a)). Cattle handled quietly in well-designed facilities had much lower heart rates compared to cattle handled roughly in poor facilities (Stermer et al., 1981). The amount of stress imposed upon an animal during handling is greatly affected by its previous experiences (Grandin, 1984a, 1987a, 1993b and Fordyce, 1987). Cattle which have been handled gently will be quieter and less agitated when they are handled in the future. Weaner calves accustomed to regular gentle handling usually have less bruises during marketing because they are accustomed to handling (Wythes and Shorthose, 1984). Animals remember aversive handling experiences for at least a year (Hutson, 1985a). Good facilities will reduce bruises and carcass damage on cattle and injuries to people. In the US, the cattle industry loses US$22

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million annually from bruises (Livestock Conservation Institute, no date). Bruise losses in New Zealand equal to 1% of the country's annual export beef earnings (Marshall, 1977). Labor efficiency is greatly improved in good facilities. One person can provide a continuous flow of cattle into the squeeze chute for vaccinations, ear tagging and other procedures (Grandin, 1983a).

2. Cattle perception

Design of efficient handling facilities will be aided by an understanding of the behavioral characteristics of livestock. Cattle have 360° wide angle vision (Prince, 1977). They can see behind themselves without turning their heads and are sensitive to harsh contrasts of light and dark in loading ramps, races and handling areas. To facilitate cattle movement, illumination should be even, and there should be no sudden changes in floor level or texture. Even though ruminant animals have depth perception (Lemmon and Patterson, 1964), their ability to perceive depth at ground level while moving with their heads up is probably poor. Hutson (1985b) suggests that there may be an extensive blind area at ground level and moving livestock may not be able to use motion parallax or retinal disparity cues to perceive depth. To see depth on the ground, the animal would have to lower its head. This would explain why cattle stop and balk at shadows. Cattle are more sensitive to high-pitch noises than people (Kilgour et al., 1983). The sound of banging metal can cause balking and agitation. Rubber stops on gates and squeeze chutes will help reduce noise. The pump and motor on a hydraulic squeeze chute (crush) should be located away from the squeeze. On pneumatically powered equipment, silencing devices must be installed. The sound of hissing air will agitate cattle.

3. How to prevent balking

A single shadow that falls across an alley or race can cause balking. The lead animal will often stop and refuse to cross the shadow. Cattle will also balk at puddles of water, drain grates and bright spots of sunlight. Drains should be placed outside of races and crowd pens. Handlers should be cautious about causing moving shadows. Cattle have a tendency to approach a more brightly illuminated area, provided the light is not glaring in their eyes. Lamps directed toward the interior of a truck will facilitate loading at night. However, squeeze chutes and loading ramps should not facing the sun because cattle will not approach blinding light.

Sometimes it is difficult to drive cattle under a roof or into a building for handling. The animals will enter more readily if they are lined up in single file in a race (Grandin, 1980a). When a squeeze chute is inside a building or under a shade, the single race should extend at least 3–5 m outside the shade. Never place the edge of the shade or a building wall at the junction between the single-file race and the crowd pen.

Cattle will also balk at moving or flapping objects. A coat flung over a fence or a shiny reflection off a truck bumper may stop the movement of cattle. If the cattle see people standing in front of the squeeze chute, they will refuse to approach. Installation of shields for handlers to stand behind may improve cattle movement. It will be easier to observe the distractions that are causing balking when the cattle are calm (Grandin, 1996). Problems with balking tend to come in bunches. When one animal balks, the tendency to balk spreads to the next animal in line. An animal must never be prodded until it has an opening to move into. Cattle can be easily moved in large pens with a piece of cloth or a plastic tied to a stick (Grandin, 1993a). The animals will move away from the rustling plastic or the flapping cloth. Dogs should only be used in open areas where there is sufficient space for the cattle to move away. When dogs bite livestock, it is highly stressful (Kilgour and DeLangen, 1970).

4. Solid fences

The sides of the single-file race, loading ramp, and crowd pen should be solid (Grandin, 1980a, 1987a). The crowd gate should also be solid to prevent cattle from attempting to turn back and rejoin their herdmates. The principle of solid fences is like putting blinkers on a harness horse. The solid fences prevent the cattle from seeing people, vehicles

and other distractions outside the fence with their wide-angle vision. Solid race sides will help prevent wild cattle from becoming highly agitated in a race (Fig. 1). Observations in a race with a solid and an open-sided portion indicated that some wild cattle are much more agitated in the portion of the race where they could see out. The cattle should see only one pathway of escape, up the single-file race. They will balk if the race entrance appears to be a dead end. Sliding or one-way gates at the junction between the single-file race and the crowd pen must be constructed from bars or mesh so that cattle can see through them. However, a gate which is used in a single-file race for stopping cattle movement during sorting or dipping should be solid to prevent excited animals from attempting to push through it. All other races and forcing pen fences should be solid.

On steel corrals, it would be too expensive to construct all the holding pens, sorting pens and alleys with completely solid fences. On fences built from pipe or rod, a 30–60 cm-wide belly rail placed at cow eye height will facilitate movement and will prevent the ramming of the fence by excited cattle. This is especially important in facilities where wild Brahman, Brahman cross and Zebu cattle are handled because Brahman-type cattle are more excitable and difficult to block at gates (Tulloh, 1961). A belly rail is also recommended for handling excitable genetic lines of European continental cattle. Corrals constructed from wide wood planks do not need an additional belly rail because the boards create a substantial visual barrier.

5. Flight zone

When a person enters an animal's flight zone it will move away. If the handler penetrates the flight zone too deeply, the animal will either bolt and run away or turn back and run past the person. When the flight zone of a group of bulls was invaded by a mechanical trolley, the bulls moved away and maintained a constant distance between themselves and the trolley (Kilgour, 1971). The best place for the person to work is on the edge of the flight zone (Grandin, 1980a). This will cause the cattle to move away in an orderly manner. The animals will stop moving when the handler retreats from the flight zone. To make an animal move forward, the handler must be positioned behind the point of balance at the shoulder (Kilgour and Dalton, 1984).

The size of the flight zone varies depending on the tameness or wildness of the cattle. The flight zone for extensively raised cows may be as much as 50 m, whereas the flight zone of feedlot cattle may be 2–8 m. The edge of the flight zone can be

Fig. 1. Well-designed curved single-file race with solid sides and a walkway along the inner radius for the handler.

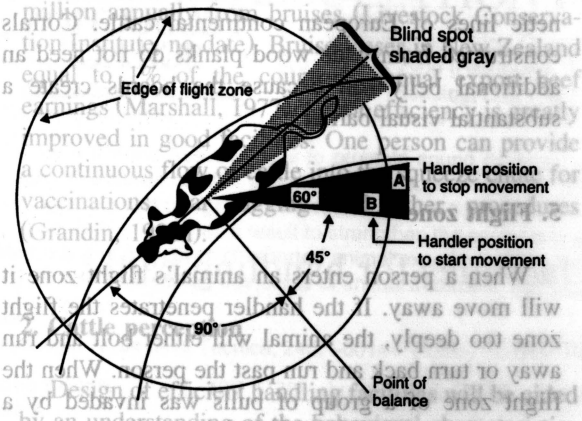

Fig. 2. Correct handler positions for driving cattle. The handler should remain on the boundary of the flight zone for most efficient cattle movement. He moves from position A to position B to make the animal move forward. From Grandin, 1980a.

determined by slowly walking up to the animals. The circle in Fig. 2 represents the edge of the flight zone. Extremely tame cattle are often difficult to drive because they no longer have a flight zone. The size of the enclosure in which the livestock are confined in may affect the size of the flight zone. Sheep experiments indicated that animals confined in a narrow alley had a smaller flight zone compared to animals confined in a wider alley (Hutson, 1982). Flight distance is also affected by previous experience. Cattle with previous experiences with gentle handling will have a smaller flight distance than cattle which have been handled roughly, and animals raised intensively in buildings in close contact with people will have a smaller flight distance than extensively raised range cattle.

Many people make the mistake of deeply invading the flight zone when cattle are being driven down an alley or into an enclosed area such as a crowd pen. If the cattle attempt to turn back, the person should back up and retreat from inside the flight zone. The cattle attempt to turn back because they are trying to escape from the person inside their flight zones. Cattle sometimes rear up and become agitated while waiting in a single-file race. A common cause of this problem is a person leaning over the race and deeply penetrating the flight zone (Grandin, 1983a). The animal will usually settle back down if the person backs up and retreats from the flight zone.

6. Curved race more efficient

A curved race is more efficient than a straight race for two reasons. First, it prevents the cattle from seeing the truck or squeeze chute until they are almost in it. A curved race also takes advantage of the animal's tendency to circle around the handler (Grandin, 1980a). Cattle will face a handler who enters their pen. As the handler moves through the pen, the animals will circle around him. A curved race takes advantage of the natural tendency to circle around a person. A curved race provides the greatest advantage when the cattle have to wait in line for vaccination or other procedures. Experiments with continuously moving livestock indicated no significant difference between straight and curved races for run-through time (Vowles et al., 1984a). However, when a curved race with a round crowd pen is used in a practical situation with the livestock lined up and waiting to enter a squeeze chute, the curved system is faster (Vowles and Hollier, 1982). Circular crowding pens and curved races can reduce the time spent in moving cattle by up to 50% (Vowles and Hollier, 1982).

Cattle can be driven most efficiently if the handler is situated at a 45–60° angle to the animal's shoulder (Fig. 2). A well-designed curved race has a walkway for the handler along the inner radius (Fig. 1). The handler is forced to stand in the correct position to facilitate animal movement. The curved lines on Fig. 2 represent the curved race. The solid fences in Fig. 1 block out all visual distractions except for the handler on the catwalk.

In Australia and South America, cattle are often given veterinary treatment in the single-file race, whereas in the US, Canada and many European countries, the animals are treated while held in a squeeze chute (crush) or head gate (stanchion) at the end of the race. In a South American or Australian operation, completely solid race sides would block access to the cattle. In this situation, the outer fence should be completely solid and the fence on the inside radius should be constructed from pipe or wood planks with spaces between them. The handler walkway is omitted. To prevent leg injuries, the inner radius fence should have a 60 cm high solid panel at the bottom. In curved race systems with completely solid sides, the handler walkway should

run alongside the race and never be placed overhead. The distance from the walkway platform to the top of the race fence should be 100 cm.

7. Curved race and crowd pen dimensions

For feedlot and range cattle handling facilities, the recommended inside radius for a curved race is 3.5–6 m (Grandin, 1980a; Vowles and Hollier, 1982). A single-file race must be long enough to take advantage of cattle following behavior. The minimum length for a race used for handling large numbers of cattle is 9 m (Grandin, 1983a). A half circle race with a 3.5–5 m inner radius is the ideal length. Excessively long races are not recommended because some cattle have a tendency to lie down and get trampled if they are held too long in a race. The longer race with the 6 m inside radius is recommended when cattle are vaccinated rapidly while held in the race. When a race is designed, care must be taken to avoid bending the race sharply at the junction between the single-file race and the crowd pen. A sharp bend at this point will make the entrance to the race appear to be a dead end. The cattle will balk and may refuse to enter. An animal standing in the crowd pen must be able to see a minimum of two body lengths up the single-file race.

Curved races can be built from wood, steel or concrete. When wood or concrete is used, the race can be built in a series of straight sections (Fig. 3). The posts should be spaced 1.2 m apart. To reduce construction costs, the race in Fig. 3 has a single board for a person to step on to prod cattle. For large numbers of cattle, a complete handler walkway should be constructed.

If space is restricted, a race with an inner radius as small as 1.5 m can be used if certain rules are followed (Grandin, 1984b). When the inner radius is shorter than 3 m, the race must have a minimum of a 3 m-long straight section joining the race to the crowd pen. This prevents the race from appearing to be a dead end. A race with a very short inner radius must be built in a continuous smooth curve. Cattle will get stuck if it is built in a series of straight sections. The recommended race width for a race with straight sides is 66–71 cm for adult cows and 51 cm for calves. These dimensions may vary depending on cow size. A V-shaped race should be 41–45 cm wide at the bottom and 81 cm wide at the 152-cm level. A common mistake is to make the race too wide. There should only be 2 cm of clearance on each side of the largest cow which will use the race. Fence height for races, crowd pens and corrals is 152 cm for English breeds and tame cattle, and 167–183

Fig. 3. Curved wood, wide curved lane with solid sides which leads to the round forcing pen.

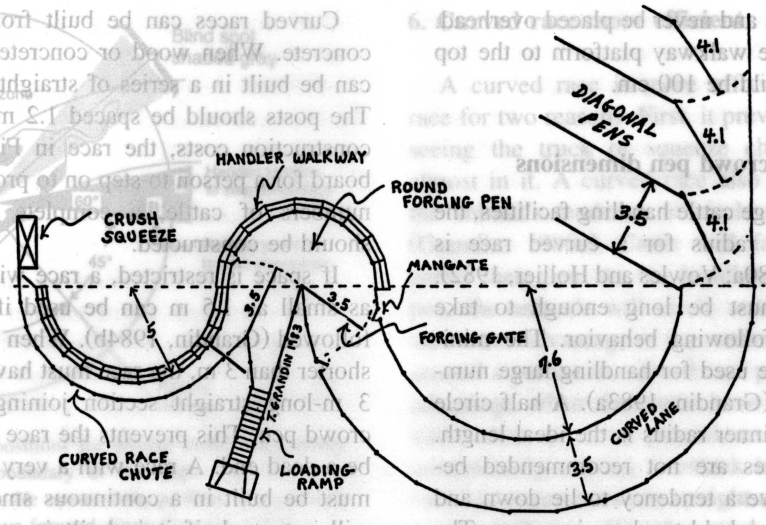

Fig. 4. Basic cattle handling system with curved race, round crowd pen and curved lane.

cm for Brahman, Brahman cross, Zebu excitable genetic lines of European continental or wild cattle.

Fig. 4 illustrates a curved race, round crowd (forcing) pen and a wide curved lane. The crowd pen has solid fences and is equipped with a crowd gate which can be advanced behind the cattle. This gate should be solid. The wide curved lane holds cattle which are waiting to go into the crowd pen. A single person can easily move them into the crowd pen by working along the inner radius of the 3.5 m wide lane. This basic layout can be used on ranches, in feedlots for the main cattle handling facility, and in slaughter plants. For small handling facilities on farms or feedlot hospitals, the wide curved lane can be deleted and the round crowd pen can be connected directly to existing alleys. Fig. 4 is designed

Fig. 5. Well-designed round crowd pen with solid fences and a solid crowd gate.

for easy layout. It consists of three half circles which are located along the dotted line on Fig. 4. If the crowd pen is constructed from wood, the fence can be built in a series of straight sections with 1.2 m post-spacing. The ideal length for the crowd gate is 3.5 m. A longer gate is unwieldy and a larger crowd pen is inefficient because it holds too many cattle. For smaller operations, the gate length can be reduced to 3 m.

Fig. 5 illustrates a well designed round crowd pen with solid fences, solid crowd gate and a walkway for the handler. The handler can advance the crowd gate as he walks along the walkway. This crowd pen can be used to direct cattle into a single-file race or into a single-file loading ramp. There is one mistake in Fig. 5; the sliding gate at the junction between the single-file race and the crowd pen should be constructed from bars so that the cattle can see through it. A solid sliding gate makes the race entrance look like a dead end. Research indicates that solid fences for crowd pens are more efficient. Cattle moved faster through a crowd pen with solid fences compared to one with a pipe fence or partially open-board fence (Vowles et al., 1984b). The inside of Fig. 5 is smooth to prevent bruises. All structural supports are on the outside.

If a straight crowd pen is used with a funnel leading to the single-file race, one side should be straight and the other side should be on a 30° angle (Meat and Livestock Commission, no date). If space permits, a round crowd pen is recommended because it is more efficient, as some types of cattle move more slowly when they walk straight through the crowd pen into the single-file race (Vowles et al., 1984b).

Mangates should be installed as indicated on Fig. 4, and they should be 45 cm wide because large cattle cannot pass through the narrow opening. A hinged solid metal or plywood flap which opens inward toward the cattle makes a good mangate. The flap is held shut with a spring and there is no latch. If a person is chased by the cattle, he can open the gate quickly because there is no latch.

8. Loading ramps

Fig. 4 has a gate which can be used to direct cattle to either the loading ramp or the single-file race to the squeeze. In the US, the most efficient loading ramps are single-file, because US trucks have a narrow 76 cm wide rear door. Therefore, the ramp should be 76 cm wide for adult cows and fattened cattle. This is narrow enough to prevent adult cattle from turning around. If the ramp is used for calves only, it should be made narrower. The efficiency of the ramp can be further improved by curving the single file ramp. The use of a ramp wider than the truck door is not recommended for loading, because it is inefficient and the cattle will become bruised when they strike the door frame. In countries where the back gate of the truck opens up to the full width of the truck, a ramp equal to the truck width can be used. In the US and other countries where trucks with narrow doors are used, a 2.5–3 m-wide ramp is recommended for unloading only.

Many animals are injured on loading ramps which are too steep. The maximum recommended angle is 20° for permanent ramps and 25° for adjustable ramps (Grandin, 1983b). The crowd pen on a single-file loading ramp must have a level floor except for a slight drainage slope. Sloping the floor of the crowd pen 10° will cause livestock to pile up against the crowd gate. On concrete ramps, stair steps are recommended. The dimensions for the stair steps are a 30-cm tread width and a 10-cm rise. The steps should be deeply grooved to provide a nonslip surface. On wooden ramps, the cleats should have 20 cm of space in between them (Mayes, 1978). To help prevent falling during unloading, permanently installed ramps should have a flat-level dock at the top (Stevens and Lyons, 1977). The minimum width for the level dock is 1.5 m. A self-aligning dock bumper will help prevent injuries caused by cattle stepping down between the truck and the loading-dock (Rider et al., 1974). Even if the truck backs up to the dock into a misaligned position, the gap is blocked by the self-aligning bumper. The bumper can be constructed from two pieces of steel welded together to form an 'L' shape. The 'L'-shaped piece of metal pivots on a heavy steel pin attached to the front of the dock. One side of the 'L' overlaps and rests on the dock floor. Loading ramps should also have telescoping side panels to prevent cattle from jumping out between the truck and the ramp. If a portable ramp is used, it should be sturdy. Ramps which sway or move when cattle walk on them are likely to cause balking.

9. Working corral for a large ranch

Figs. 6 and 7 are of a large corral system for gathering cattle for transport, sorting, working through the squeeze chute, weighing and other chores. It can be used by handlers on foot or people mounted on horses. It is especially suited for ranches where calves or yearlings are removed from the ranch annually for shipment to feedlots. The layout shown in Fig. 4 forms the left-hand side of the corral. The only difference is that the inside radius of the wide curved lane is expanded to 10.66 m. Most of the actual cattle handling and sorting is conducted in the wide curved lane labelled 'sorting reservoir', the single-file race, round crowd pen and diagonal pens. Cattle are more easily controlled in the 3.5 m-wide lanes and pens. The large gathering and post-working pens are only used to hold cattle before and after the actual handling operation. The curved lanes and diagonal pens eliminate square corners and promote cattle movement. The gates on the diagonal pens are 4.2 m long on a 3.5 m-wide lane because gates opening on an angle eliminate sharp corners. The round gathering and holding pens have no square corners for cattle to bunch up in. Fig. 6 is easy to set out by placing strings on the ground as indicated by the dotted lines. To prevent mistakes, the entire corral should be set out and the ground should be marked with lime before starting construction.

Groups of 20–40 animals are directed from the gathering pen into the curved sorting reservoir lane. This lane serves two functions. First, it holds cattle which are waiting to go to the loading ramp, or the squeeze chute, in the same manner which was described in Fig. 4. Secondly, it holds groups of cattle which are being sorted back into the diagonal pens (Fig. 6). Sorting back into the diagonal pens is efficient because the animals have a strong tendency to move back in the same direction from which they came (Grandin, 1980a). Many US ranchers prefer sorting back into the pens from an alley because it is quick, and it enables them to see the animals more easily than sorting through a single-file race. Cattle which have been sorted into the diagonal pens can

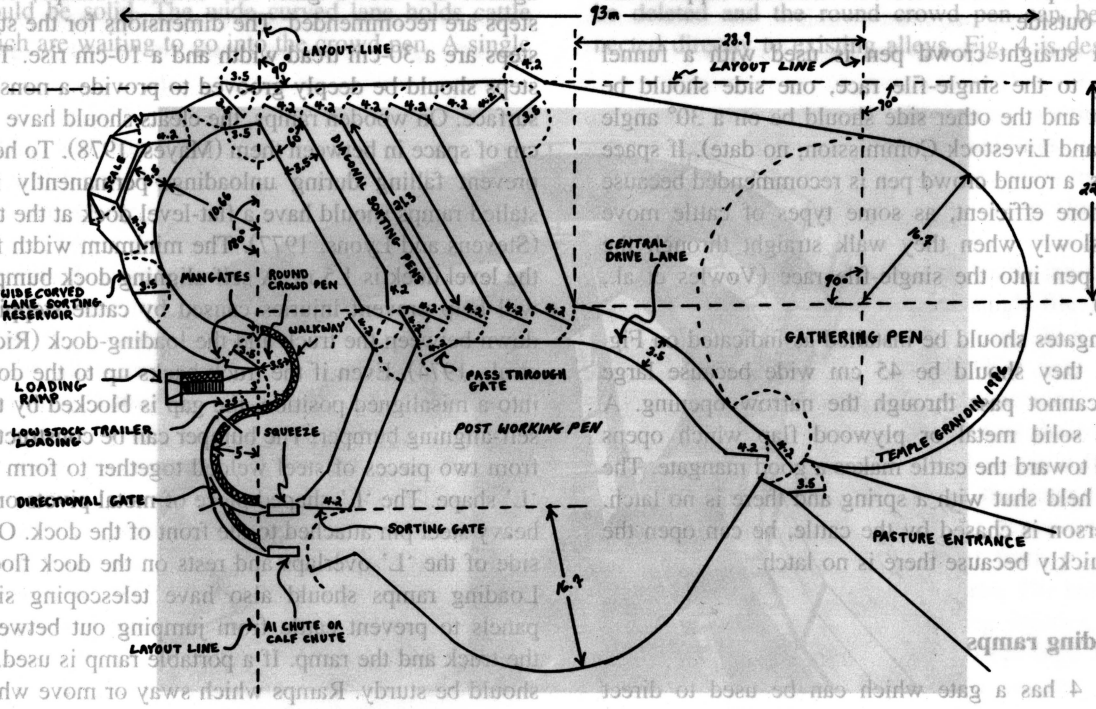

Fig. 6. Corral layout for a large ranch where calves are shipped to a feedlot.

Fig. 7. Corral similar to Fig. 6 constructed from wood planks.

either be released back to pasture or moved into the curved lane to go to the scale, loading ramp or squeeze chute.

When cows and calves are being separated, the calves are sorted into the diagonal pens. The cows are allowed to pass through one of the diagonal pens into the large post-working pen. This corral system can handle 300 cow-and-calf pairs or 400 adult cattle. To expand the systems, additional diagonal pens can be added. The length of the diagonal pens should not be increased. If they are too long, the cattle will bunch up. Increasing the size of the gathering pen is not recommended. If it is too big, driving cattle into the curved lane may be difficult. To increase the gathering area, an additional round gathering pen should be built at the pasture entrance. The corrals can be reduced for smaller herds by omitting one or two of the diagonal sorting pens and reducing the size of the gathering and post-working pens. The basic round shape of the pens should be maintained to eliminate corners for cattle to bunch up in.

Fig. 6 is equipped with a sorting gate in front of the squeeze chute. When cows are pregnancy-tested, the pregnant cows can be directed to the post-working pen, and the nonpregnant cows can be directed into one of the diagonal pens. A second sorting gate and alley can be easily added to create a three-way sort out of the squeeze chute. The sorting gate or gates in front of the squeeze chute can also be used for high-speed sorting as cattle walk through the squeeze. Any animal which needs veterinary treatment can be easily caught in the squeeze. An added advantage of sorting through the squeeze chute is that the cattle will learn to enter it readily. As an added incentive to enter the squeeze, feed can be made available in the post-working pen. Feeding palatable barley grain to sheep immediately after handling reduced the time required to drive them through a race (Hutson, 1985b).

This corral can also be used in pasture rotation systems which have centrally located handling facilities and the pastures are laid out like a wagon wheel (Savory, 1978). The gathering pen and post-working pen are eliminated and replaced with a 6 m-wide lane which encircles the corral and forms the hub of the wheel. Pasture fences radiate from the 6 m-wide lane. Switching cattle from pasture to pasture is easy when they come in for water in the 6 m-wide lane.

Fig. 6 can also be used in feedlots by eliminating the gathering and post-working pens and connecting the lanes to the alleys in the feedlot. Additional

feedlot handling system layouts are available from Paine et al. (no date). Paine's publication contains layouts of diagonal pens for shipping, receiving, weighing and loading cattle in large feedlots, and it also discusses feedlot hospital design.

The corrals in Figs. 6 and 7 are most suitable for use with British, European or British/European crosses with Brahman. These types of cattle can be readily sorted back into the diagonal pens by cutting animals out of the reservoir lane one at a time. Purebred Brahmans and Zebu tend to mill and circle more tightly. Cutting out animals and sorting them back is often more difficult.

Fig. 8 is designed for large properties (ranches) in Australia or South America which handle Brahman or Zebu cattle fattened on grass. In this type of operation, the steers remain on the ranch for several years instead of being shipped to a feedlot. More sorting is required due to the greater range of cattle ages and types. Older steers which have been sorted many times may be harder to sort back in an alley than inexperienced calves and yearlings, hence the Australians developed the pound yard (Dept. of Primary Industries, 1969). It enables the person sorting the cattle to look at each animal carefully before a sorting decision is made. However, it is slower than sorting back in the alley.

Fig. 8 provides the advantages of both high speed sorting in a single-file race and pound yard sorting. Cattle can be sorted three ways with the two sorting gates in the single-file race. During sorting, all cattle have to pass through the headgate and squeeze chute.

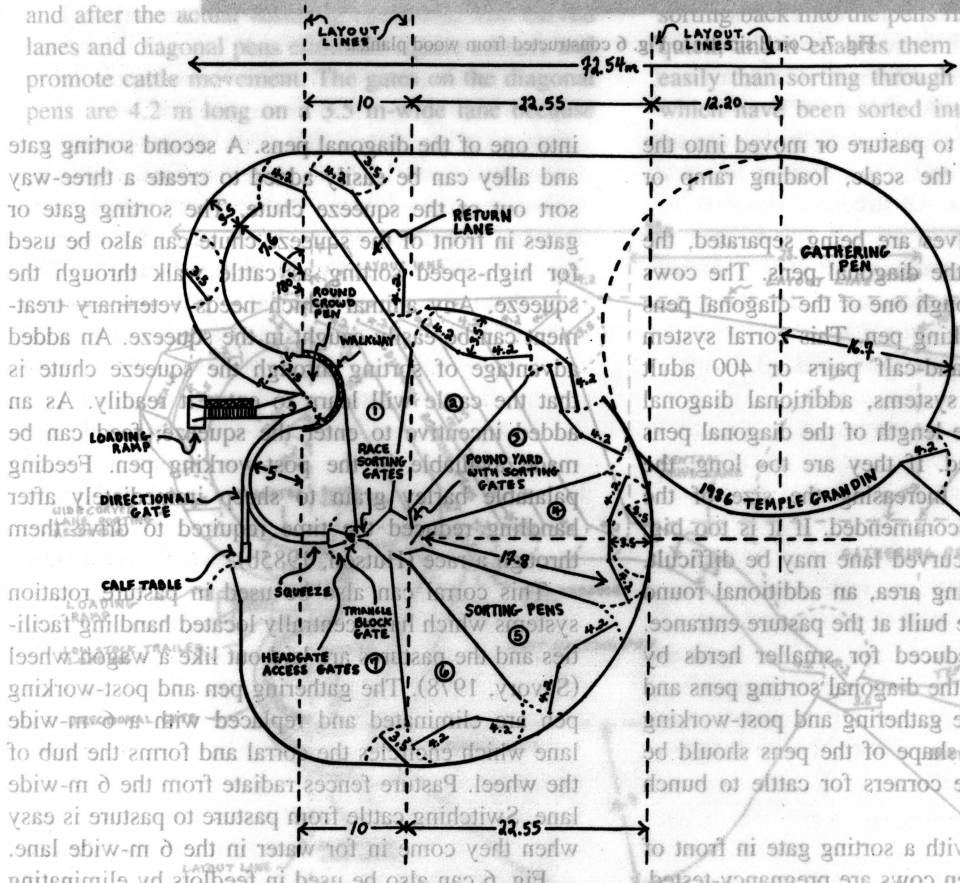

Fig. 8. Corral layout for a large Australian or South American ranch which has greater sorting requirements because steers remain on the ranch for fattening on grass. This design can also be used with electronic sorting and computerized systems, where each individual animal is evaluated and then sorted into different weight or frame size catagories.

They can be sorted five ways out of the 5-m diameter pound yard. Each animal is admitted one at a time. A person on a platform over the pound yard can easily open and shut the gates with ropes or levers. A triangular block gate is used to stop incoming cattle and control cattle flow into the pound yard. It consists of 1.52 m high solid sided triangle with 76-cm sides which is hinged at its apex. For details on building this gate, refer to Juergenson, 1979; Canada Plan Service, 1979. After sorting, the cattle in the sorting pens can be easily moved through the return lane for vaccinating, branding, truck loading, etc. If a dip vat is required, an additional directional gate and race can be added to lead to the dip vat. Fig. 8 is easy to set out and build by using the dotted lines as a guide. Fig. 4 has been incorporated into this corral. Sorting pens 2 through 6 are in a half circle with a 17.8-m radius. Fig. 8 can be easily modified for electronic sorting of cattle. Producers in the US are now doing more individual animal evaluation and there will be an increasing need for the type of layout shown in Fig. 8.

10. Squeeze chutes and headgates

A good headgate and squeeze chute will improve the care and management of cattle health because catching and restraining cattle is easy. There are many different types of commercially available headgates for restraining the animal's head. Headgates can also be built from plans available from Midwest Plan Service, 1975, Inglis and Williams, 1979 and Vowles, 1980. The four basic types are scissors stanchion, full opening stanchion, positive control and self catcher (Grandin, 1980b). A description and the advantages and disadvantages of each type are listed below.

10.1. Scissors stanchion

It consists of two biparting halves that have pivots at the bottom (Fig. 9). After release, the animal walks out through the headgate. It is available in the curved bar type shown in Fig. 9 or a straight bar. The curved bar stanchion in Fig. 9 is one of the most popular general-purpose headgates. The curved bar provides better head control because it prevents the

Fig. 9. Squeeze chute with scissors stanchion headgate with curved neck bars.

animal from sliding its head up and down. The animal may choke if it lays down in the chute. The straight bar provides poor head control because the animal can slide its head up and down. Choking in a straight bar stanchion is almost impossible because the straight bars can not press on the throat. A curved bar stanchion is recommended for general cattle handling on feedlots and ranches. A straight bar stanchion is recommended for gentle dairy cows and for veterinary clinics where an animal must remain in the headgate for a long period. It is also recommended if the primary use of the headgate is restraining cows for pregnancy checking or artificial insemination or when a headgate is used alone without a squeeze chute.

10.2. Full opening stanchion

This consists of two biparting halves which open and close like a pair of sliding doors. It is available in both straight bar and curved bar models. The advantage of this type of headgate is that large bulls can walk through it more easily. The disadvantage is that the sliding mechanism is more complicated.

10.3. Self-catching

This headgate can be set like a trap to automatically catch the animal's head when it enters. Forward movement of the animal will close the gate around its neck. Self-catching gates are recommended for gentle cattle without horns. To prevent injuries to the

cattle and damage to the gate, the cattle should walk slowly into the headgate. The mechanism is complex and needs constant adjustment. These gates work best on small ranches or dairies where a single person handles gentle cattle. They are available in both curved and straight bar stanchions.

10.4. Positive control

This headgate locks very tightly around the animal's neck like a pillory. It provides excellent control of the head, but it is more likely to choke animals than a curved bar stanchion. It is recommended for wild cattle with horns because it is easier to catch horned cattle with this type of gate. After the neck is released, the animal must back up before the gate is swung open to allow it to exit. Another advantage is that it requires less effort to operate than the other types of head gates.

Choking in a headgate is usually asphyxiation caused by excessive pressure on the carotid arteries in the neck (White, 1961) or on the wind-pipe (Fowler, 1978). Due to the pressure on the arteries, animal can die very rapidly if it starts to lose consciousness in a headgate. The headgate must be released instantly when the first signs of asphyxiation occur. Choking is most likely to occur when a headgate is used without a squeeze. A properly adjusted squeeze chute can greatly reduce choking by preventing the animal from lying down. The best squeeze chutes have two movable side panels which are hinged at the bottom and pulled together by a lever system at the top. These are superior to chutes with a single movable side because the animal remains standing in a balanced position. The 'V' shape of the squeeze sides supports the animal. Proper adjustment of the space between the squeeze sides at the floor can greatly reduce choking. For 113–180 kg calves, the squeeze sides should be 16 cm apart at the chute floor, 21 cm for 272–360 kg cattle and 30 cm apart for most cows and fed steers (Grandin, 1980b). For large bulls the spacing may need to be wider.

On commercially available squeeze chutes, the sides have bars which can be dropped down for access to the sides of the animal (Fig. 9). The solid panel at the bottom can also be opened for access to the underside of the animal. When a squeeze chute is being purchased, the position of the control levers should be considered. On some headgates and squeeze chutes, the levers are situated where they may injure the operator if a latch is accidently released. Commercially built headgates and squeeze chutes have two basic types of latches. The first type is a ratchet-latch which locks into a definite notch as the headgate or squeeze is closed. It has the disadvantage of being noisy, but it is safer because it is less likely to be released accidentally. The second type is a friction latch which consists of a steel rod which passes through a hinged metal plate. It has the advantage of being quieter than a ratchet latch, but it is more likely to come unlatched accidently. Friction latches must be well maintained to keep them safe.

A survey conducted in large feedlots by Grandin (1980b) indicated that operator carelessness and trying to handle cattle too rapidly was the primary cause of choking, escaping and legs caught in squeeze chutes. The survey results also indicated that Brahman cross cattle were more likely to escape from a squeeze chute than English/European cross cattle. Allowing cattle to run rapidly into a squeeze chute and slam against the headgate can cause serious injuries. Examination of beef carcasses revealed old, healed spinal injuries in the back and neck (Grandin, 1980b). Even animals which appeared to be normal may have had hidden spinal damage. A skillful squeeze-chute operator can slow cattle down before they reach the headgate by partially closing the squeeze. Injuries can also be reduced by handling cattle quietly in the race leading up to the squeeze chute. Excessive use of electric prods especially on Brahman, Brahman cross and Zebu cattle can increase squeeze-chute injuries because excited cattle slam into the headgate and make greater attempts to escape.

To prevent shoulder bruises, the headgate should have neck bars constructed from round pipe with a minimum diameter of 6.2 cm. A 7.6 cm diameter pipe is recommended. The larger pipe diameter is less likely to bruise the neck. Headgates can be padded with old conveyor belts or split tires. Split motorcycle tires are the ideal size for headgate stanchions.

Many large feedlots and some ranches use hydraulics instead of muscle power to operate the squeeze chute. A correctly adjusted hydraulic squeeze

chute is usually safer for both people and animals. The dangerous protruding levers are eliminated, and people are less likely to become tired and make errors which can cause an accident. Most commercially available hydraulic squeeze chutes in the US have a factory adjusted pressure relief valve which prevents excessive pressure from being applied to the animal. Cattle can be seriously injured if excessive squeeze pressure is applied. Animals which have been oversqueezed will sometimes appear to have pneumonia symptoms a few days later. Autopsies of cattle which have died from oversqueezing indicated that they had internal ruptures (Grandin, 1980b). When a hydraulic squeeze chute is designed, the force exerted on the animal should be determined. Measurements with a hydraulic load cell of the force exerted by the squeeze sides indicated that the recommended force 69 cm from the bottom pivots at a single point is 454–680 kg for cattle weighing over 272 kg and 270–362 kg for cattle weighing less than 272 kg (Grandin, 1983a). These force readings are *not* hydraulic system pressure. Oversqueezing is most likely to occur if the pump motor supplied with the squeeze chute is substituted with a larger motor or if a tractor hydraulic system is used. If an animal has difficulty breathing while held in a hydraulic squeeze chute, the pressure relief valve should be loosened.

11. Calf tables

Young calves on many US ranches are restrained for branding, castration and dehorning by roping them with a lariat. Roping calves properly so excitement is minimized is a highly skilled occupation. Many ranches now use a calf table to restrain calves. This is a miniature squeeze chute which can be tilted to the horizontal position. Commercially available calf tables are available with the four different types of headgates. Some calf tables have no headgate and the calf table is squeezed and tilted with the same lever. A well-designed calf table requires little physical effort to bring it to the horizontal position. Tables are available which will handle up to 200 kg calves. For tilting adult cattle to the horizontal position for foot trimming, two basic types of equipment are commercially available: a tilting table on which the animal is secured by two wide belly straps, or a tilting squeeze chute. The tilting squeeze chute is safer for both the operator and the animal.

12. Artificial insemination chute

For improved conception rates, cows should be handled gently during artificial insemination. They should not be allowed to become agitated and overheated (Stott et al., 1975). The chute used for artificial insemination should not be used for painful procedures such as dehorning, branding or having her head pulled around and restrained with nose tongs. Nose tongs are very aversive to cattle and they will attempt to avoid them after having experienced them once. A less aversive form of head restraint is a rope halter.

Cows can be easily restrained for artificial insemination or pregnancy testing in a dark-box chute (Parsons and Helphinstine, 1969; Swan, 1975; Canada Plan Service, 1984) Fig. 10. It has no headgate or squeeze sides and it will hold the wildest cow with minimum excitement. The dark box is 66–71 cm wide depending on cow size, and consists of completely solid sides, solid front, and a solid top. A piece of cloth is hung over the cow's rump to make it completely dark. When the cow is inside the box, she is in a snug dark enclosure. If the cows refuse to enter the dark box, a small window can be cut in the front gate. Cow entry is usually not a problem if a good single-file race leads up to the

Fig. 10. Dark box chute for artificial insemination and pregnancy testing.

dark box. The dark box works on the same principle as the dark room which is used for handling deer in New Zealand. Groups of deer brought into the dark room will allow people to touch them and remain clam. Outside the dark room, the deer would become agitated and attempt to jump high fences. The dark box and the dark room may reduce physiological arousal levels (Hale et al., 1987; Lay et al., 1992). Experiments with poultry indicated that blind-folded birds had lower heartrates and respiration rates during shackling and slaughter (Douglas et al., 1984). Preliminary experiments with cattle are yielding a similar result (Kinsman, 1986, personal communication). A new novel dark box can cause stress (Lay et al., 1992). Prior to breeding cattle should be handled in the box so that they can become familiar with it.

If wild cows are to be handled, an extra-long dark box can be constructed. A tame cow which is not displaying estrus is placed in front of the cow which will be inseminated. A wild cow will usually stand quietly and place her head on the 'pacifier' cow's rump. Cattle will often remain calmer when they are in bodily contact with other cattle (Ewbank, 1968). After insemination the cow is released through a side gate. The 'pacifier' cow remains in the dark box. If large numbers of cows are going to be pregnancy checked or inseminated, 2–6 dark-box chutes can be built side by side in a herringbone pattern on a 60° angle (McFarlane, 1976). They are built like regular dark-box chutes and the cows exit through the front of each chute. On some herringbone systems a single, large front gate is used to release all the cows at once. The outer fences, front gates, and tops are solid. The fences in between the cows are constructed from bars so the cows can see and feel each other. This will help keep them calmer.

13. New restraint ideas

There is a need to improve restraint devices for handling cattle, especially for extensively raised animals that are often wild. When untamed semi-wild cattle are handled in a squeeze chute, 1.6–7.8% are bruised (Brown et al., 1981; Grandin, 1987b). Most of these bruises are caused by hitting the headgate too hard. From a behavioral standpoint, existing squeeze chutes are poorly designed. The open barred sides permit cattle to see the operator who is deep inside the animal's flight zone. This may cause the animals to become agitated. The installation of solid sides and a solid barrier in front of the headgate to block the animal's vision will keep a semi-wild animal calmer (Grandin, 1993b). The behavioral principles of restraint are: blocking the animal's vision; slow, steady motion of the equipment and optimal pressure. The device must apply sufficient pressure to provide the feeling of being held, but excessive pressure that causes pain and struggling should be avoided. Semi-wild cattle will remain calmer if restraint in a headgate is accompanied with body restraint. Slow steady motions of people and equipment are calming and sudden jerky motion excites and agitates cattle.

Design ideas from equipment used in slaughter plants should be adopted for ranch and feedlot use (Marshall et al., 1963; Grandin, 1992, 1993b). A double rail conveyor restrainer used for beef cattle in slaughter plants outfitted with a head restraint device would almost eliminate injuries to cattle caused by lunging against the headgate. The animals straddle a moving conveyor. The system is described by Giger et al. (1977), Grandin (1987b, 1988, 1991, 1993c).

14. Dipping vats

Pharmaceuticals are reducing the need for dipping cattle to eradicate external parasites. Ivermectin has replaced dipping on many cattle ranches and feedlots in the US. There is still a need for dip vats in areas where livestock have to be dipped frequently due to the high cost of ivermectin. Dipping is still required in some quarantine areas because Ivermectin does not kill all the parasites immediately (Campbell et al., 1983). The eventual replacement of dip vats with injectable or pour-on products is beneficial because dipping is stressful and the disposal of used dip chemicals may create pollution.

Injuries, stress and chemicals splashing on people can be reduced by a well designed entrance to the dip vat (Fig. 11, Grandin, 1980a). Many injuries and

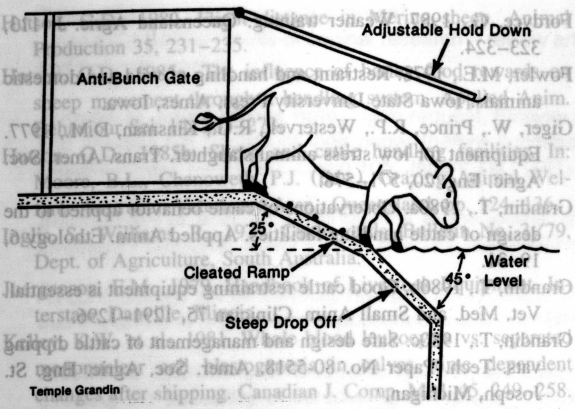

Fig. 11. Dip vat entrance design which will reduce injuries and chemical splashing. From Grandin, 1980a.

drownings occur because too many cattle enter the dip vat at once or they jump on top of each other. The two anti-bunch gates in Fig. 11 can be adjusted to allow only one animal to pass through at a time. The pair of gates is located on each side of the single-file race. The opening between the ends of the two gates is adjusted for animal size. To prevent wild cattle leaping into the vat, an overhead rack directs the animal head first into the water. Over 95% of the cattle will fully submerge their heads and will not have to be pushed under with a stick. The hold-down rack also reduces chemical splashing. To further reduce splashing, an 8 cm-diameter pipe should be installed on both sides of the vat wall approximately 1 m above the water. Splashing water will hit the pipe and fall back into the vat.

Each animal enters the vat by walking down a ramp which is deeply grooved to prevent the animal from slipping. The ramp is on a 20–25° angle. The animal can stand on the ramp without slipping. When it steps out over the steep drop off, its center of gravity will change and it will fall into the water. The animal will seldom attempt to back out because it does not start slipping. Many vat builders make the mistake of building a slide. A slide is a bad design because the cattle sometimes flip over backwards while going down the slide. More detailed information on vat design and construction can be found in Grandin (1980a,c, 1983a). For specific information on chemical use and disposal contact, it should be made with the local agricultural officials in each country. Universities and pharmaceutical companies can also provide information on dip vat management and chemical usage.

15. Bruise and injury prevention

Careful, quiet handling will greatly reduce bruises. Fifty percent of all bruises are caused by rough handling (Grandin, 1983b). Surfaces which contact cattle should be smooth (Stevens and Lyons, 1977). Sharp corners should be padded with old conveyor belts or split tires. A smooth, flat surface such as the inside of a race does not need padding. Bruises are most likely to occur when animals hit an object with a small diameter such as the edge of a steel bar or a nail sticking out of a fence. An animal striking the corner of a square 10 cm diameter post is more likely to bruise than an animal striking a round 10 cm diameter pipe post. Gates should be equipped with tie-backs to hold them back against the fence. A gate swinging out into an alley can seriously bruise an animal if it becomes jammed between the end of the gate and the fence. The use of sticks, metal pipes and sharp objects for driving cattle should be forbidden. Guillotine gates which slide up and down should be counterweighted to prevent them from injuring an animal's back. The bottom of the guillotine gate should be constructed from a 7.5 cm diameter pipe to prevent bruises. If an air cylinder is used to actuate the gate it should be connected to the gate with a cable. This will prevent back injuries because gravity will close the counter balanced gate. Back injuries caused by a powerful cylinder forcing the gate down on an animal are prevented.

Animals can become crippled and injured if they slip and fall on slippery concrete floors. Cattle handling facilities should have nonslip floors (Stevens and Lyons, 1977; Grandin, 1983b). In races, crowd pens, scales and other cattle-handling areas, concrete floors should be deeply grooved. The grooves should be made in both directions in a 20 cm square or diamond pattern. The grooves should be 2.5–5 cm deep. In existing facilities, concrete floors can be roughened with a pneumatic hammer or a grooving machine. These recommendations are for handling facilities where cattle are handled intermittently such as auctions, feedlots and ranches. The deep grooves

described above should not be used in the animal's living quarters or in milking parlors where dairy cows walk twice a day. The deep grooves will cause excessive hoof wear in these locations.

16. Washable facilities

In large feedlots, veterinary clinics and dairies, handling facilities should be designed so the squeeze chute, single-file race and the concrete slab around the squeeze chute can be easily washed. Drains should be located outside of the areas where cattle will walk. Concrete floors should be sloped 0.63–0.30 cm every 30 cm towards a drain. Curbs should be installed to contain the wash water and direct it to a drain. The best type of drains are open concrete ditches. Square concrete ditches should be constructed slightly wider than the width of a shovel for easy cleaning. One good drain design is to locate a large drain directly under the squeeze chute and slope the floor towards it from all sides. Cattle can not see the drain under the squeeze-chute floor.

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16. Washable facilities

handling facilities should be designed in such a way that they can be washed down with a hose. Chute, single-file and crush should be constructed of solid materials. Concrete is the best material for floors and should be installed to contain the wash water and direct it to a drain. The best type of drains are open concrete ditches. Square concrete ditches should be constructed with the bottom of the ditch level with the floor. Round ditches are easily cleaned and are designed to drain directly under the squeeze chute and slope the floor towards it from all sides. Cattle can be washed down with a hose. Water can be supplied by a large, high pressure unit or by a hose connected to the mains water supply. Water should be heated to 60–70°C to be effective in removing fat and grease. Detergents should be used to help remove dirt and grease. Disinfectants should be used to kill bacteria and viruses. Cleaning and disinfecting should be carried out every day.

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