AN AUTOMATIC FEEDGATE SYSTEM TO ASSIST COW MOVEMENT IN HERRINGBONE MILKING PARLORS

Thesis for the Degree of M. S.

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ABSTRACT

AN
AUTOMATIC FEEDGATE SYSTEM
TO
ASSIST COW MOVEMENT
IN
HERRINGBONE MILKING PARLORS

by

Gerald Edgar Danner

A working prototype automatic feedgate system was designed, constructed, and tested. The system was installed on one side of a double-8 herringbone milking parlor at the Dairy Research and Teaching Center, Michigan State University.

Time and motion studies included data on operator interruption time due to cow movement and traffic within the parlor. The feedgate system in combination with the existing crowdgate produced a decrease in average operator interruption time per cycle of 66 per cent.

Approved William [signature]
Major Professor

Approved B A Stout
Department Chairman

AN AUTOMATIC FEEDGATE SYSTEM TO ASSIST COW MOVEMENT IN HERRINGBONE MILKING PARLORS

by

Gerald Edgar Danner

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Finally, I am grateful to everyone who has assisted me in this work.

Gerald E. Danner

I dedicate this work to the memory of my deceased mother and father. The memory of my father, George, a small dairy farmer and my mother, Edna, a housewife, has been an inspiration to me to complete my college education — an opportunity they never had.

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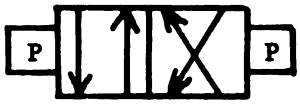

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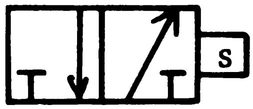

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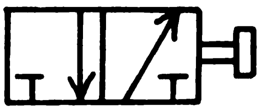

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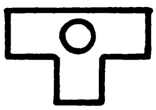

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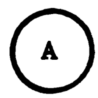

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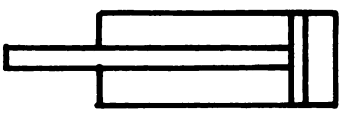

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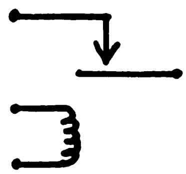

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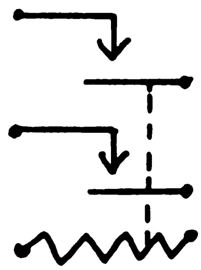

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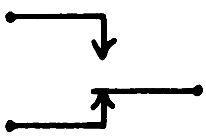
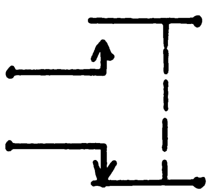


Single Pole Double Throw Switch



Single Pole Double Throw, Double Break Switch

F.G. Feedgate   C.S. Cow Switch   Cyl. Cylinder

N.O. Normally Open   N.C. Normally Closed   N neutral

I. INTRODUCTION

The modern dairy farmer, just as any other businessman, must use labor efficiently in order to help assure a profitable return on his investment dollars. Since the milking operation itself has the highest single labor requirement of the dairy farm, increased mechanization must be considered as an alternative to manual labor. This labor is increasingly difficult to procure — partly because of the need for highly competent and responsible personnel to take charge of the milking operation during long and sometimes unusual hours.

The need for increased mechanization has already been demonstrated and several companies have responded by offering the dairyman many new kinds of labor saving devices to make the milking operation more efficient.

Bickert, et. al., (1970), in a simulation, determined the approachable limit to the capability of various herringbone milking parlors with different degrees of mechanization. One new scheme, the semi-automated polygon parlor equipped with automatic machine detachment, automatic cow udder stimulation, automatic feedbowl covers, and a crowdgate was shown to have the capability of about 120 cows per manhour. The normal average parlor efficiency over the last decade has been in the neighborhood of one-third of this figure or less.

In order to attain the simulated labor efficiency, a very high degree of mechanization would be needed. The working hardware for an automatic machine detaching unit and a crowdgate has already been built and tested (see Bickert, _et_. _al_., 1970 and Gerrish, _et_. _al_., 1970). However, an acceptable system of working automatic feedbowl covers and gates has not been set forth.

1.1 Background on Recent Milking System Mechanization

Until the last two or three years, there were few dramatic changes in milking systems and parlors since the introduction of the herringbone milking parlor, a configuration which had numerous advantages over other parlors (see Hoglund, et. al., 1969). Recent developments in milking systems and parlors will increase the present day labor efficiency of the milking operation from around 40 cows per manhour to well over a hundred cows per manhour.

Some of these newer developments include different parlor configurations such as the polygon and rotary parlors. Other ideas have taken form in automatic milking machine detachment, dual pulsation systems, automatic udder stimulation, crowdgates, better milk metering devices, and feedbowl covers. All of these would potentially reduce the amount of labor involved in the milking operation, leaving the man to do only the tasks that are too costly to mechanize or are not conducive to mechanization at this time.

The idea of feedbowl covers is just now becoming a reality. As the milking routine becomes more and more mechanized, the time it takes a man to operate the gates and to move a batch of cows into the (herringbone) parlor and move them out again becomes a considerable part of the operator's allotted time per cow.

Especially in parlors where grain is fed, cows, when entering the parlor, may stop at one or more successive feedbowls and eat grain left by the previous batch of cows. This slows down the loading of the batch and more importantly, causes the operator to interrupt ths work routine to chase cows. Likewise, on the exit cycle, the batch of cows may leave slowly because of one or more cows who stop and munch on leftovers.

Feedbowl covers (described by Reisgies, 1967) or a similar idea could be used to help solve this cow traffic problem. At least two companies (Ag Pro and Blue Diamond Dairy Service) now have a parlor option that covers the feed prior to cow exit and exposes the feed upon entrance. These systems, however, are not as ambitious as the one proposed by Reisgies.

1.2 Background and Logic of System to Accomplish the Desired Cow Traffic and Movement in the Parlor

Reisgies probably developed the first feedbowl covers in 1967. His work showed that a substantial improvement in labor efficiency could be realized with such a system.

Figure 1.2 shows the logic and interconnections of the desired system adapted from Reisgies and applied to what will be called the Automatic Feedgate System hereafter.

The sequence starts with a signal that the cows are ready to be released. In a highly mechanized system this signal may be that all milking machines have been detached from a batch of cows. The exit gate would automatically open and all feedgates would close. The cows, no longer having access to feed, would be encouraged to leave the parlor. When the parlor is empty the exit gate would close, the entrance gate would open and only the first feedgate would open. Only when cow number 1 is in position would feedgate number 2 open. Feedgate number 3 would open only if feedgate number 2 were open <u>and</u> cow number 2 were in position. This interconnected sequencing would continue until the last cow moving into position would close the entrance gate. The flow diagram in figure 1.2 could be applied to any number of stalls.

Reisgies' feedbowl covers were tested in a double-4 herringbone parlor. However, the particular design was experimental and not conducive to manufacture. Also no attempt was made to interconnect the feedbowl covers with the automatic operation of the entrance and exit gates. Test data taken indicated that such a system could potentially increase labor efficiency enough to offset the additional expense of the system. Moreover, such a system would indeed be necessary to complement a highly mechanized milking operation since the operator would have time only to do more necessary operations.

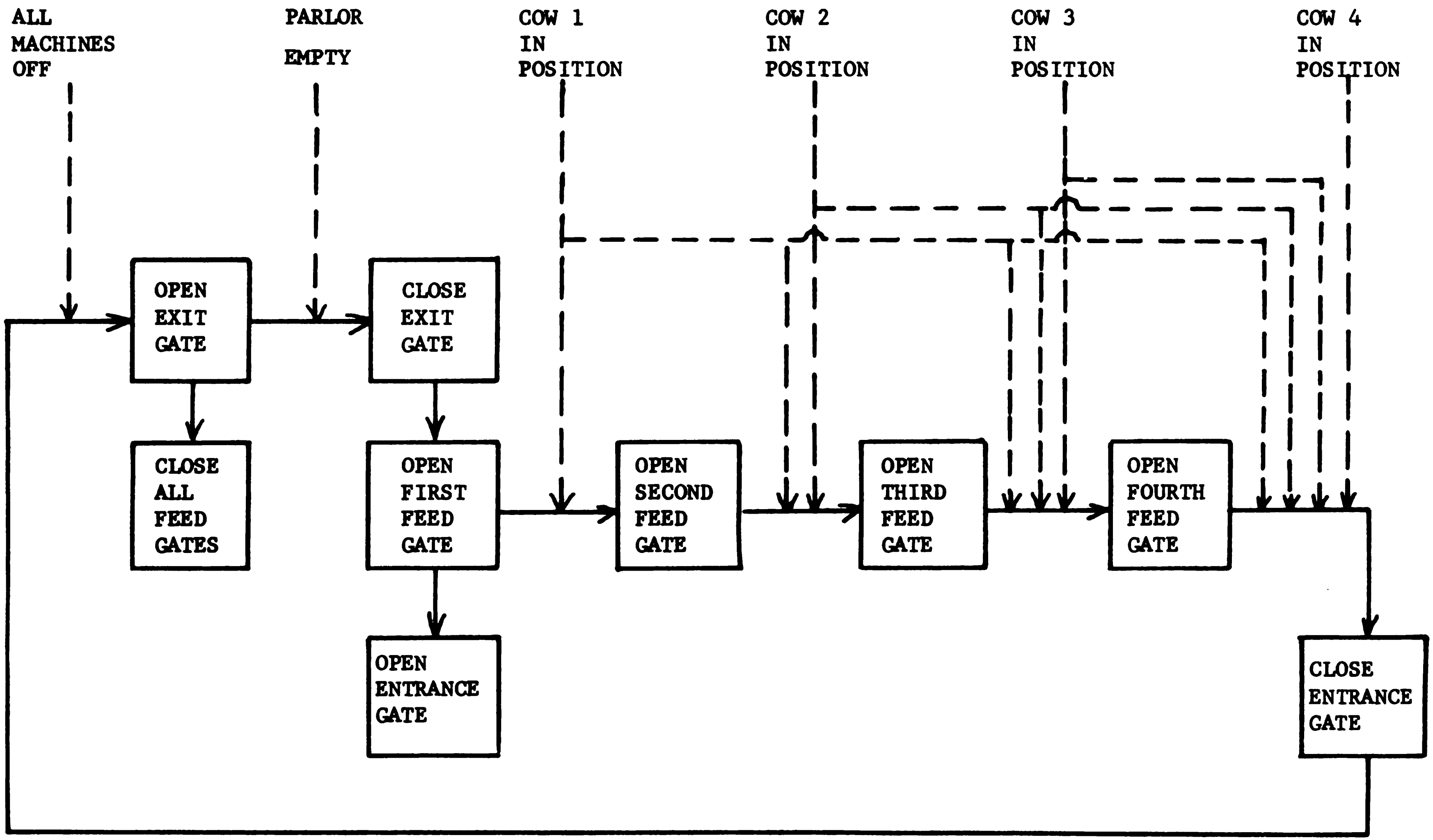


Figure 1.2 Flow Diagram and Logic of Desired Cow Traffic and Interconnected Gate Motion (adapted from Reisgies, 1967)

1.3 Statement of Objectives

The overall objective of this study, then, is to design, develop, and construct a system that will:

1. Aid in cow traffic in order to reduce or eliminate man interruption due to cow movement within the milking parlor.
2. Be readily adaptable to existing herringbone parlors.
3. Be economically compatible with a highly mechanized parlor operation.

Finally, the system will be tested, time and motion data analyzed, and recommendations made as to possible design changes.

II. EXPERIMENTAL

2.1 Design Criteria and Initial Prototype

2.11 Criteria of system design

The following general design criteria were established in order to make the system most flexible, convenient, and efficient from the operator's standpoint.

A. Simple controls requiring minimum use by the operator.

B. Feedgate sequencing and interlocking as shown in figure 1.2.

C. Provision for feedgates to operate as an independent system or to be interconnected with the automatic operation of the entrance and exit gates.

D. Provision for manual operation of the entrance and exit gates, even when the system is in the automatic mode.

E. System switch in the off position to totally de-energize the system such that all feedgates will assume an open position.

2.12 Criteria of component design

Other specific criteria apply to key components of the system which should function according to the following principles. These apply to any type of design — electric, pneumatic, hydraulic, mechanical, etc.

A. Use of minimum force by the feedgate to move the cow out.

B. Gate must be fast opening at appropriate time indicated in sequence.

C. Positive residual force on all gates not already open.

D. Cow switch rods for opening gates to contact cow on an in-sensitive area.

E. Sensitive cow switch which only needs to be momentarily actuated in any direction.

F. Continuous force on a closing gate to move cow out, but using non-positive drive so as not to injure cow.

G. Cow switches and actuators must not be dangerous or a hindrance to cow movement.

H. System components must be tolerant of environment and abuse.

2.13 First working prototype feedgate

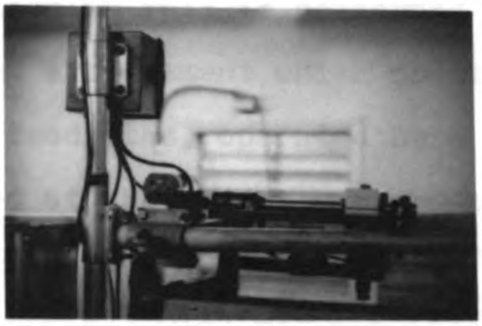
In order to accomplish all of the design criteria and facilitate testing the initial prototype, a mechanical/electrical model was designed. The prototype was installed at the first stall of a double-8 herringbone milking parlor.

Figure 2.13A shows the gate in a closed position. Figure 2.13B shows a cow's eye view of the gate opened, exposing the feedpan. The feedgate, which opened and closed through a 30 degree arc, was operated by a reversible electric gearmotor and a rotary to linear actuator (see figure 2.13C, D, E). The actuator, which was moved back and forth by the rotation of a stainless steel shaft, was linked to a one foot lever arm on the feedgate and produced up to 50 pounds of force on the gate. This force on the gate was produced by the friction drive of the actuator on its shaft. Actuator slippage on the shaft could occur at a pre-set value so as not to injure the cow.

This model, even though completely workable and extremely reliable, was probably not the most economical unit that could be built.

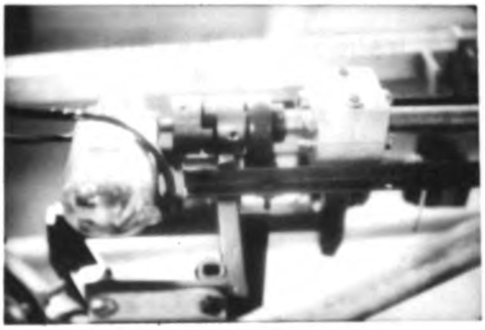
A. Closed Feedgate

B. Open Feedgate and Feedpan



C. Feedgate Mechanism

D. Mechanism- Gate Closed Position



E. Mechanism- Gate Open Position

Figure 2.13A through Figure 2.13E Initial Prototype

2.2 Description of Apparatus

2.21 Feedgate system installation in milking parlor

The feedgate system used for testing was installed on one side of a double-8 herringbone parlor. Even though the design differed from the first prototype, all design criteria remained the same. The conventional feedbowls were replaced by a positioning rail and a continuous feed trough (see figure 2.21).

The front positioning rail is patterned after the rump rail and splash panel arrangement which positions the rear of the animal. The feedgates, operated by a pneumatic cylinder, are vertically hinged at the convex outward points of the rails (see figure 2.22E) and swing through a working angle of about 30 degrees. Switches with rod actuators which control the opening of each individual feedgate are suspended above each cow. The cow actuates the switch by moving the rod as she walks by it into the stall. When actuated in proper sequence, the rearmost switch closes the entrance gate relieving the operator of the necessity of manually closing it.

2.22 Description of operation

Figures 2.22A through 2.22H show the operation of the feedgate system in an eight stall herringbone parlor. Figure 2.22A shows the normal system off mode in which the entrance

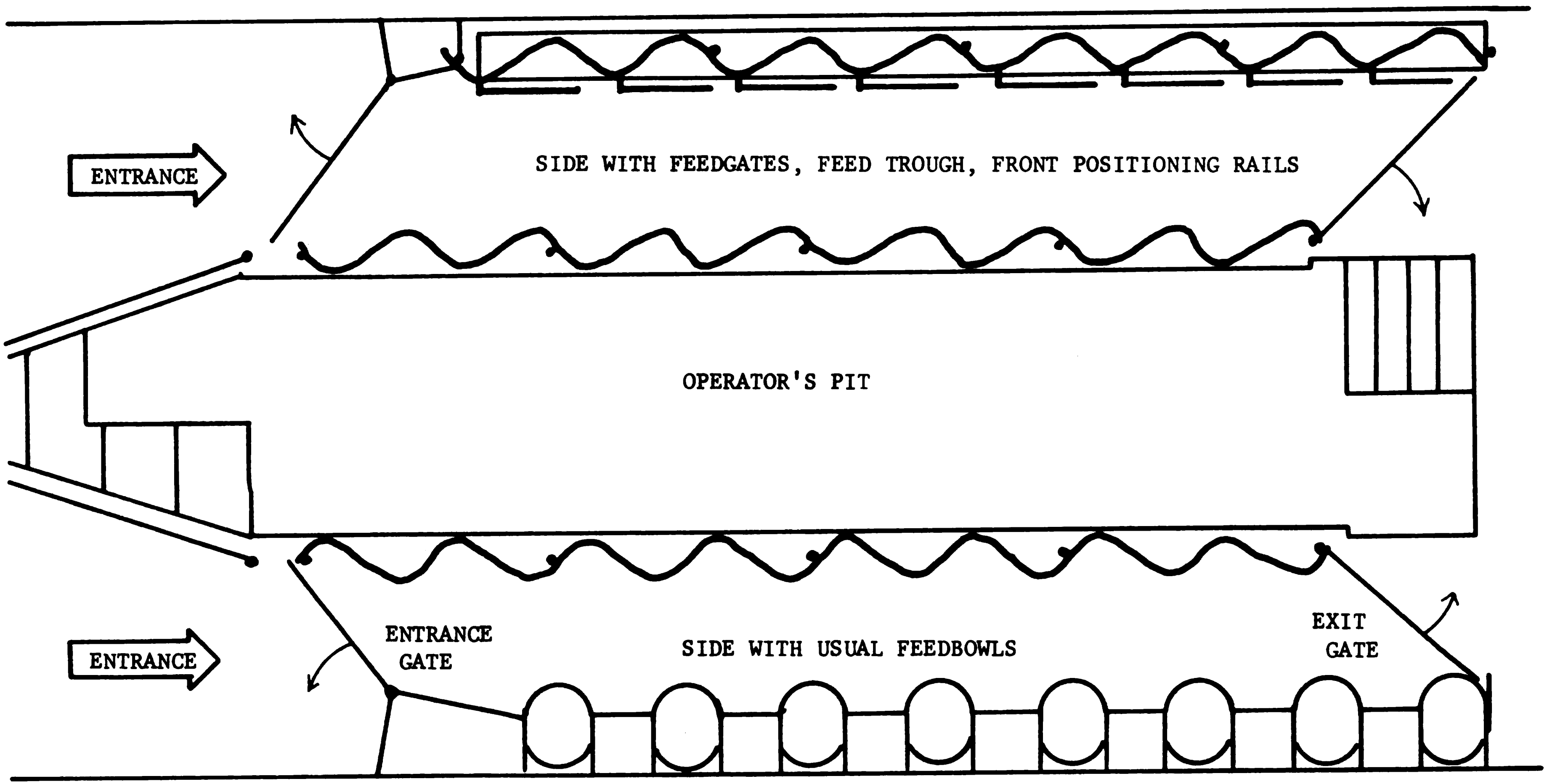


Figure 2.21 Double-8 Herringbone Milking Parlor, showing Positioning Rails and Feedgate Installation on One Side (not drawn to scale)

and exit gates are open as are all of the feedgates to facilitate easy access for parlor cleaning. Figure 2.22B shows a cow's eye view of the cow alley from the rear after the system has been turned on and is ready to accept cows. Note the feedgates are all closed except feedgate number 1 which opens automatically with the closing of the exit gate.

The sequencing action of the system during parlor loading can be seen in figures 2.22C and 2.22D. Figure 2.22C shows the front two stalls occupied, each cow actuating her own switch. Notice that cow number 2, after reaching her correct position, actuates a switch which opens only feedgate number 3. Feedgate number 4 and all subsequent feedgates remain closed. Figure 2.22D shows cow number 3 who has just come into the stall whose feedgate was opened by cow number 2 and actuates a switch opening feedgate number 4. Gates 5, 6, 7 and 8 are still closed.

Completed parlor loading can be seen in figure 2.22E which also gives a good view of the stall arrangement as well as the suspended rail to which the cow switches are attached. Figure 2.22F shows the rear two stalls of the parlor (stalls number 7 and 8) with and without cows. Notice that the rod actuator on switch number 7 contacts the cow on the back, behind the right shoulder, while on cow number 8, the rod contacts the rump of the cow. The reason for this will be explained later.

Figure 2.22A System "OFF"- All Gates Open

Figure 2.22B System "ON"- All Feedgates Closed Except #1

Figure 2.22C Cows in First Two Stalls- Feedgate #3 Open

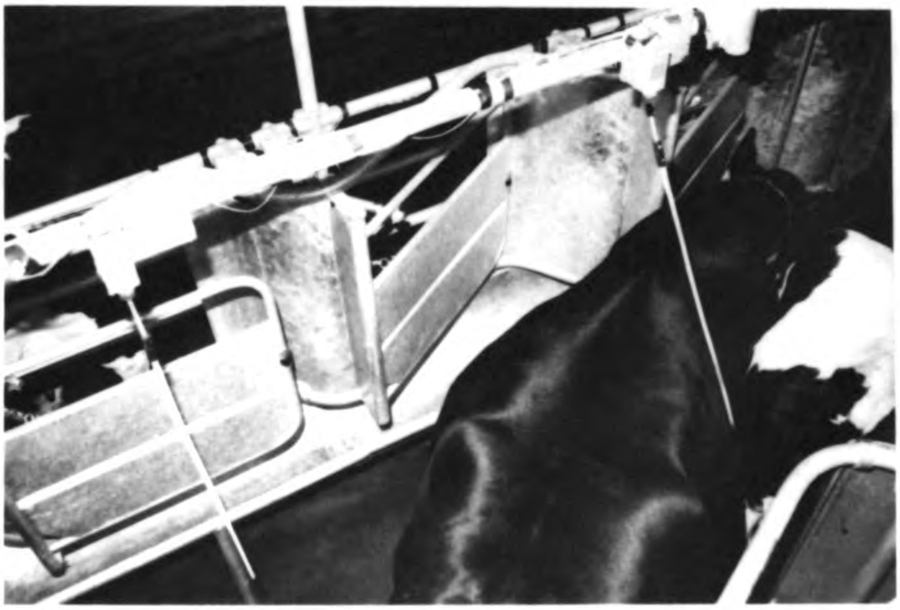


Figure 2.22D Cow#3 in Position, Feedgate #4 Open, Feedgate #5 Still Closed

Switch number 7 opens feedgate 8, the last one, and switch number 8, when actuated by cow number 8 in her correct position, closes the entrance gate. The entrance cycle is completed.

Figure 2.22G shows a view of the rear of the parlor including the group of cows in the holding pen being encouraged toward the front of the holding pen by the crowdgate. This crowding action aids in moving the cows into the parlor once the entrance gate is opened.

After the cows are milked, the exit gate opens and the feedgates sequentially close from the front, moving the cows' heads out of the feed trough depriving them of food and room. This enhances cow exit from the parlor with no encouragement or chasing by the operator (see figure 2.22H). When the last cow is out, the cow switches all assume their normal vertical position automatically closing the exit gate and opening the entrance gate as well as feedgate number 1. Enter, a new batch of cows.


Figure 2.22E Parlor Loaded- All Cows in Position

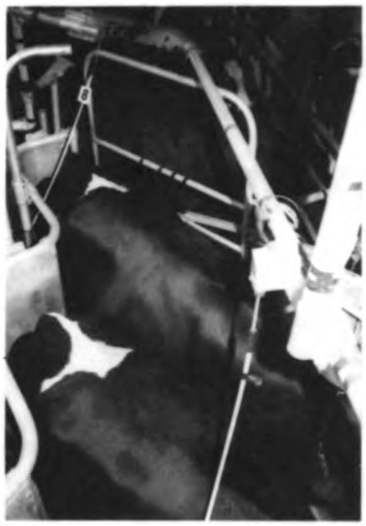



Figure 2.22F Stalls #7 and #8 Occupied (left) and Empty (right)

Figure 2.22G **Rear** of **Parlor** Including Holding Pen

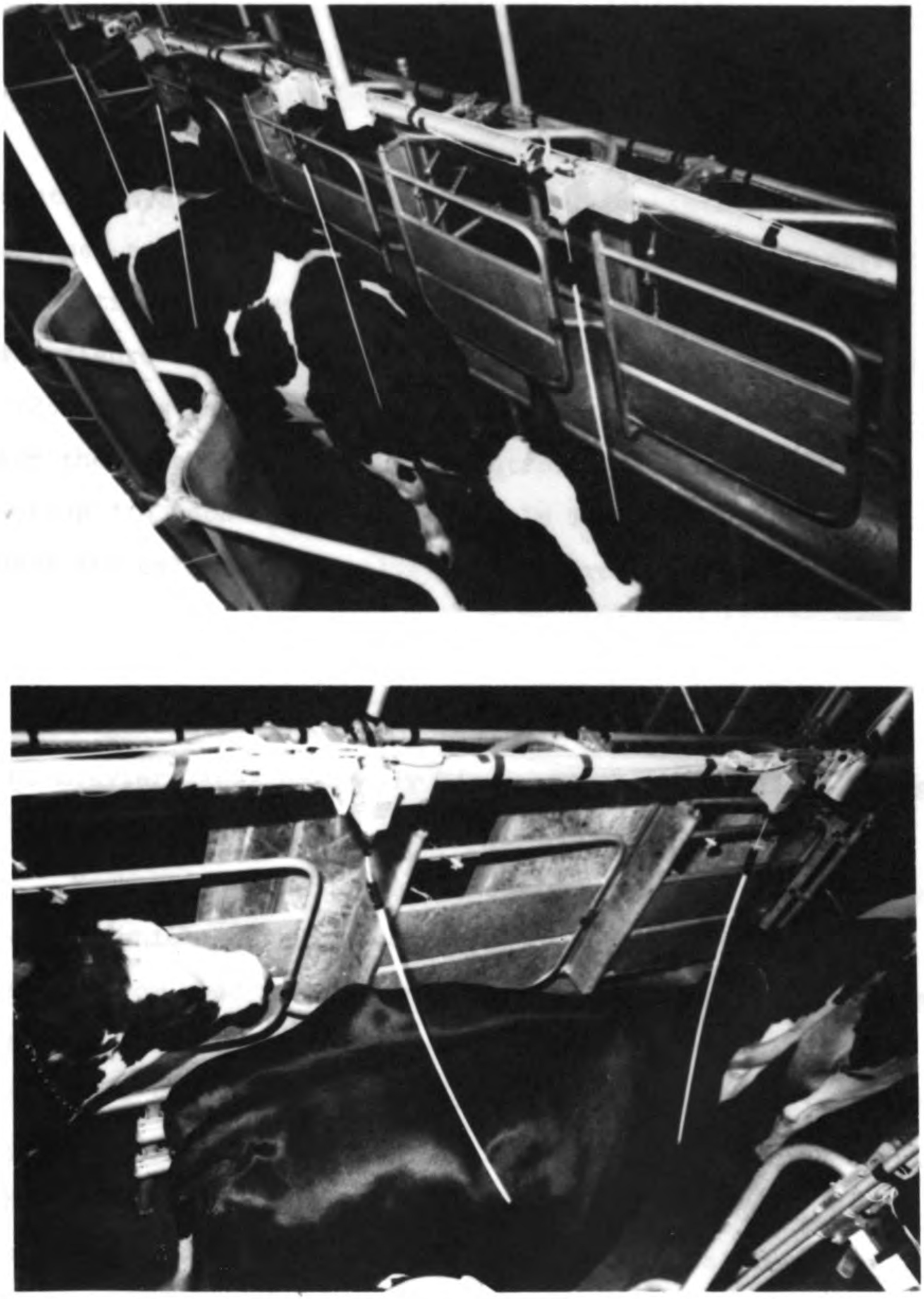


Figure 2.22H Feedgates Closed- Cows Exiting

2.23 <u>Operating mechanism and control circuit</u>

The feedgates are operated by an electric/pneumatic control system. Pneumatic cylinders, connected to a compressed air supply already present in the parlor to operate the entrance and exit gates (from manual push buttons — see figure 2.23A), are used to operate the feedgates. Figure 2.23B shows the cylinder, attached to a pin on the feedgate, and the solenoid valve which controls air flow to the single acting 3/4 inch cylinder. A simple T-clamp and bracket support the cylinder and valve — both protected behind the gate. Air lines are 1/16 inch I.D. tubing with a working pressure of 60 p.s.i.

Figure 2.23C shows the control circuit for the system — the heavier lines being air lines and the finer lines being electrical wires.

Each cow switch is connected to a relay with a holding contact which keeps the solenoid valve energized. In this way the cow need not continually actuate her switch to keep the next gate open. The normally open solenoid valves are connected in parallel to a common air supply which is controlled by the system valve. The manual/auto switch operates a relay which connects normally closed solenoid valves A, B, and C to the system in the automatic mode by means of thermal delay relays. These 2 second delay relays provide for a short duration air flow through valves A, B, and C at appropriate

Figure 2.23A Manual Control of Entrance and Exit Gates

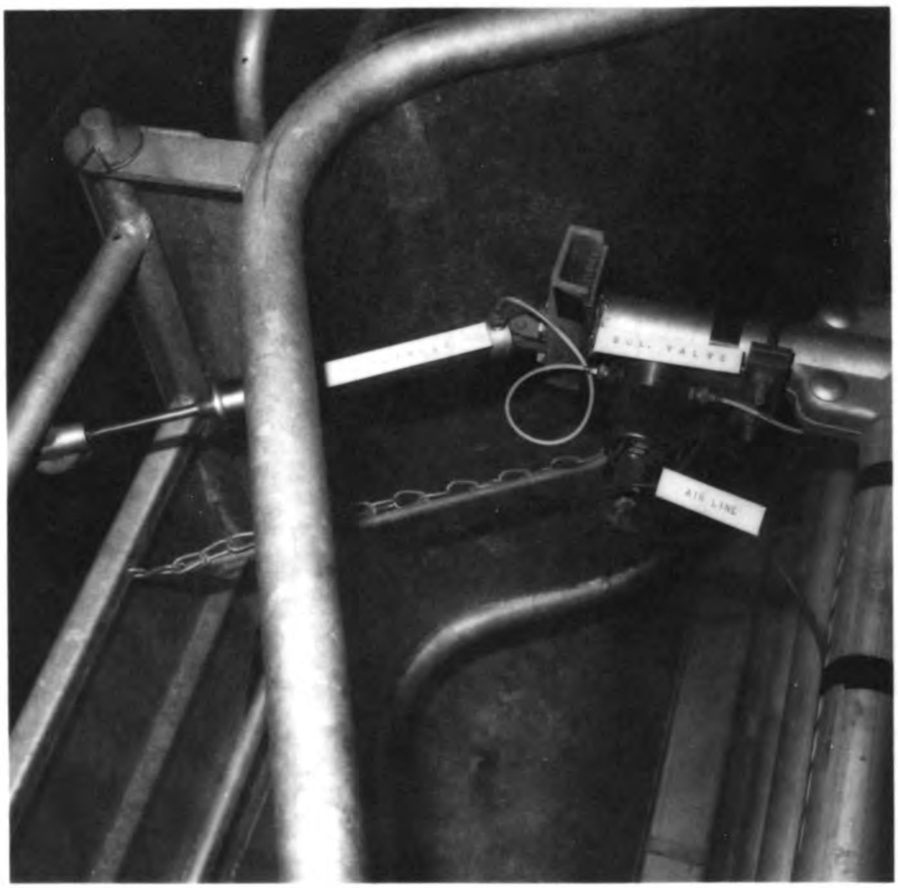


Figure 2.23B Solenoid Valve and Pneumatic Cylinder Attached to Feedgate

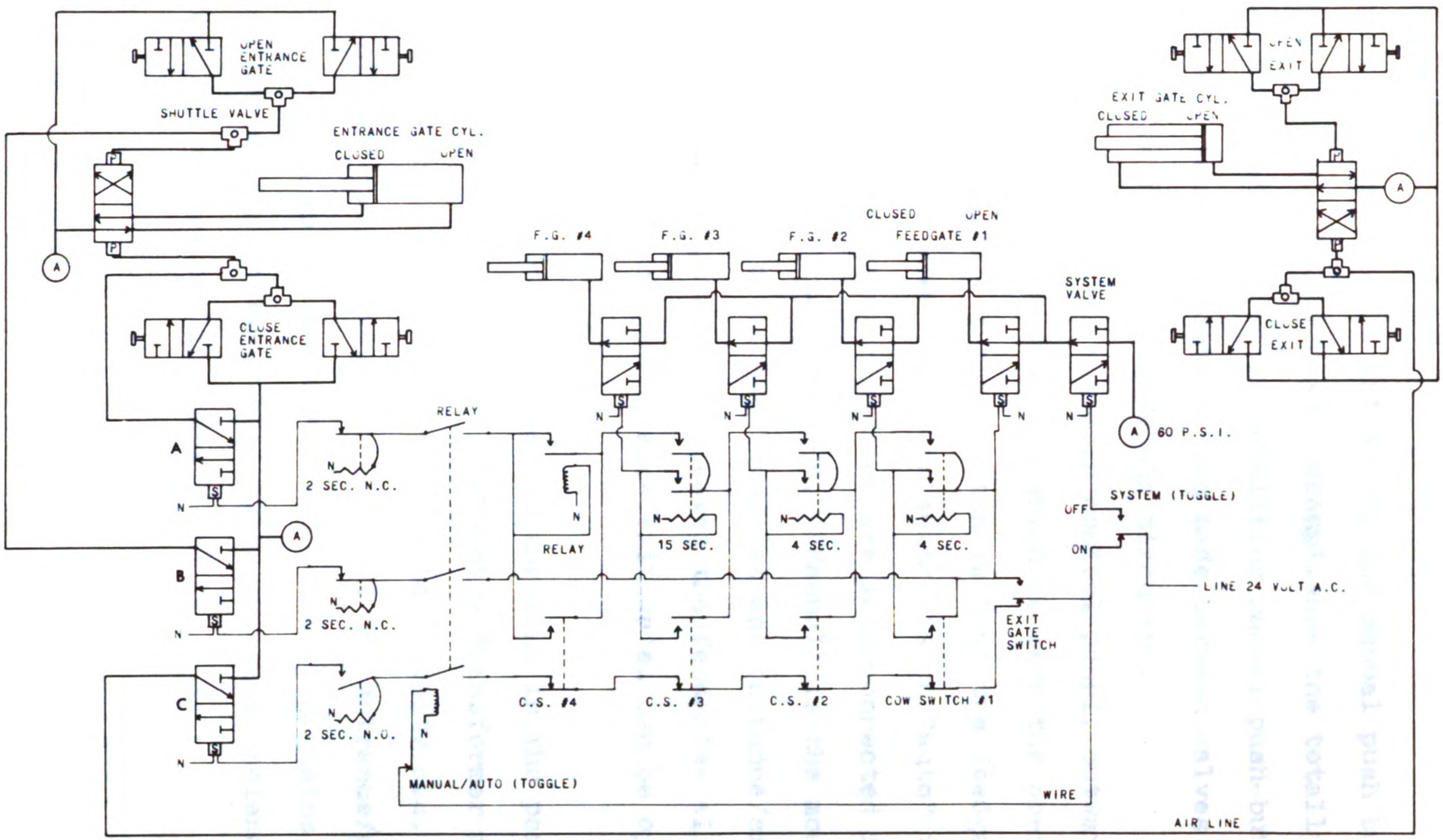


Figure 2.23C Control Circuit Diagram

times which simulate the action of the manual push buttons (figure 2.23A). This process accomplishes the totally automatic gate operation, while permitting manual push-button override. Simple connections are made between valves A, B, and C, and entrance/exit gate air circuitry.

Figure 2.23D shows the main control panel, outwardly consisting of only two switches which concern the operator. Whenever the feedgate system switch is "on" the feedgates are operational. When the lower switch is on "auto" the feedgates and entrance/exit gates are interconnected for totally automatic gate operation. "Manual" is the mode for independent operation of the feedgates and entrance/exit gates. Feedgate system "off" leaves the feedgates all in an open position. Then the entrance/exit gates can be operated manually.

Experimental control panel arrangement in the parlor is shown in figure 2.23E. Box 1 contains a transformer to step the voltage from 115 volts a.c. down to 24 volts a.c. A, B, and C are solenoid valves which control the entrance/exit gate operation in the automatic mode. Box 2 contains all of the connections between the system switches, solenoid valves, and the relays in Boxes 3 and 4.

Figure 2.23D Main Control Panel

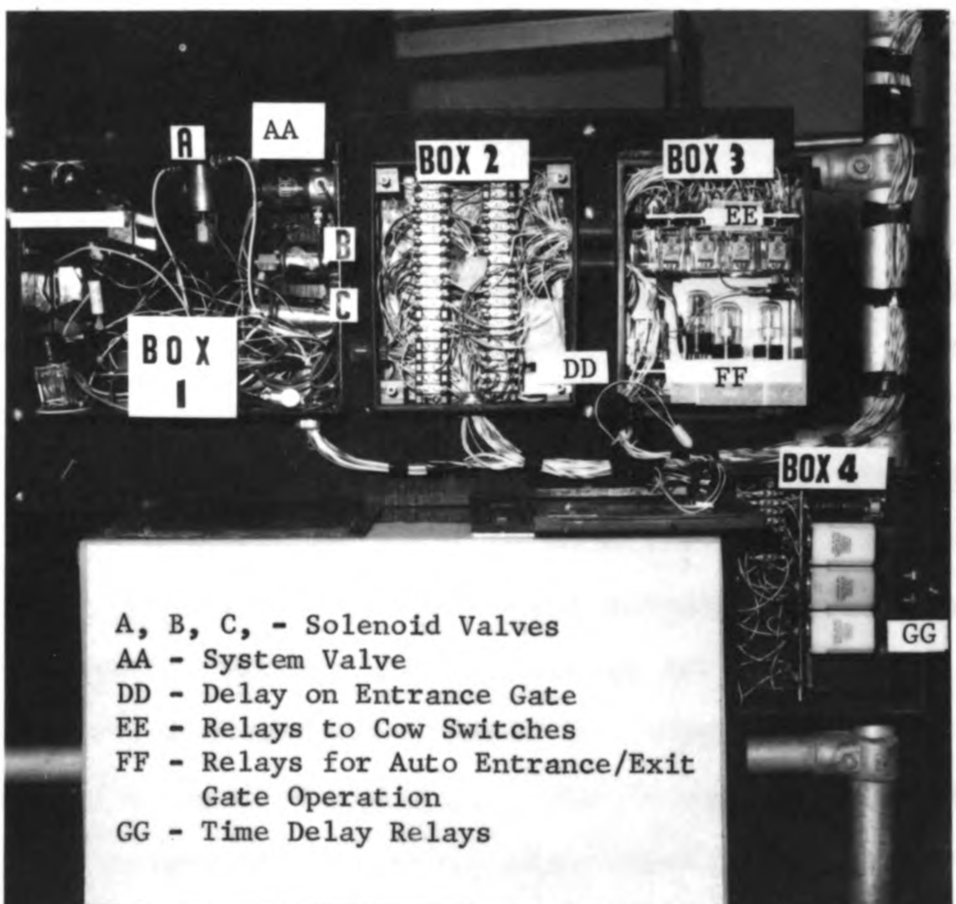


Figure 2.23E Exposed Control Circuitry Components

2.3 Feedgate System and Component Testing

2.31 Cow switch placement and design

Placement of cow switches is critical since the switches must perform two separate functions. During the entrance cycle each cow must positively actuate her switch in order that the succeeding feedgate will open and allow the next cow to enter. During the exit cycle the switches must be situated in such a way that there can be no way that a cow can be in any stall and not actuate at least one switch. If this did happen and all switches were in their normal vertical position, the exit gate would close, locking that cow in. This cannot be permitted. Figure 2.31 shows a 4-stall herring-bone with 38 inch stalls with what was found to be an optimum switch location relative to the positioning rails. Notice that switch number 4 is not in the same relative place as the others. This is because in a 38 inch stall the distance between two adjacent switches is much less than the length of a cow. Therefore, one cow could actuate two switches. Switch number 4 was put to the rear as far as possible to maximize its distance from number 3. Also number 4 is situated off center to require the signal for "close entrance" to come from the cow who has correctly positioned herself in stall number 4 — moving her rump over to contact that switch.

In locating the switches in a parlor with other than

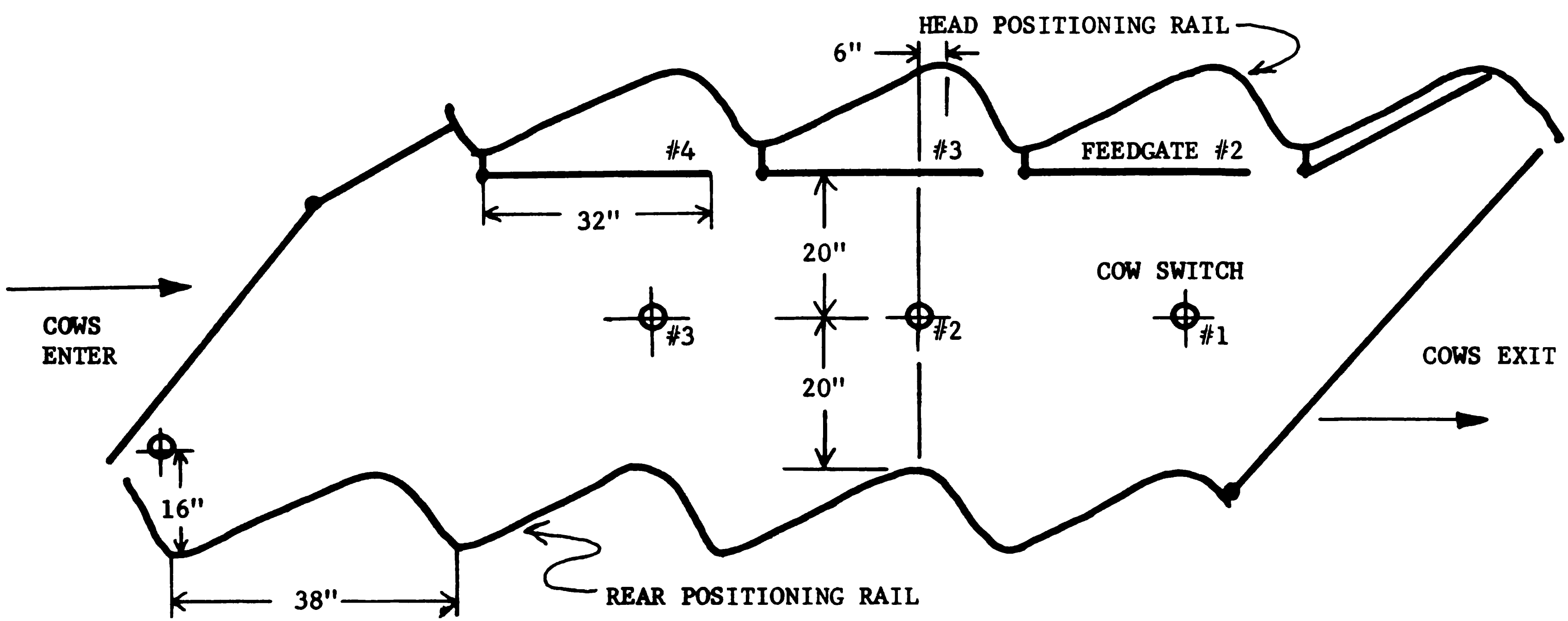


Figure 2.31 Placement of Cow Switches Relative to Stall Positioning Rails and Feedgates in a 4-Stall Herringbone Parlor with 38" Stalls

38 inch stalls it is recommended that all switches except the rearmost one, be located along the centerline of the cow alley as shown in figure 2.31. The switches should be suspended from a horizontal pipe or rail which may be adjusted longitudinally in either direction in order to correctly position the switches for best actuation.

The switch itself is a heavy duty enclosed type limit switch with a flexible spring rod actuator requiring 5 degrees deflection with a force of one ounce. Coupled to this is an extension rod actuator made of semi-rigid polyethylene plastic. This rod is very well suited for this application since it is light and flexible enough not to injure the cow. Also the rod can absorb much of the force in deformation instead of rigidly transmitting it to the switch actuator or the cow. Periodically the rod may be hand straightened.

Another important consideration is cow switch height. The switches were suspended from a rail, 7 feet above the floor with the rod actuators extending to within 44 inches of the floor. At this height, switch actuation was successful and consistent by cows ranging from 50 inches to 57 inches from the floor to the pin bone. Our average cow height agreed with that reported for Holsteins in the Agricultural Engineers Yearbook (1969).

Observations were made as to cow reaction to the switch rods. After becoming used to them, the cows were not bothered at all. One rod at the front of the parlor was painted black (the rest white) and there was less cow reaction to the black rod. Matthews et. al., (1963), and Smythe, et. al., (1961), report that cows are essentially color blind and their sense of smell is more acute than their sight. This suggests that once the switch rods assume a "parlor smell" the cows accept them better. A neutral color which blends in with the background is recommended, though.

2.32 Gate sequencing on entrance cycle

Entrance cycle feedgate sequencing is accomplished by the individual cow switches. Since the distance between two switch rods was 38 inches, a cow, being much longer than this could actuate two switches at a time as she walked by — potentially opening two feedgates simultaneously. To correct this problem the signal between switches was delayed. The most satisfactory delay under the parlor conditions during observations was about 4 seconds. This corresponded closely with the average cow travel time of .8 feet per second reported by Bickert et. al., (1970). In other words —

$$\frac{\text{stall length}}{\text{cow walk rate}} = \frac{3.1 \text{ feet}}{.8 \text{ ft./sec.}} = 3.9 \text{ seconds.}$$

However, on the rear stall a different situation was encountered. In order to assure that cow number 6 or 7 would not close the entrance gate, a time delay of 15 seconds was included so that the gate would not close until 15 seconds after feedgate number 8 opened. This time delay was determined directly from observations on cow movement and then tested, but it may vary from parlor to parlor, depending on particular cow traffic conditions.

2.33 Gate sequencing on exit cycle

Sequenced feedgate closing (from front to rear) was not a primary objective. However, a semblance of this kind of desirable action is accomplished merely by locating the common main air supply line near the first feedgate. When the exit gate opens, the front feedgate cylinders are pressurized first. Figure 2.33 shows force buildup on the feedgate versus time, comparing feedgate number 1 to feedgate number 8. Pressure starts to appreciably increase in the cylinder of feedgate number 8 about 10 seconds after feedgate number 1 begins to move. Eight to ten pounds is the maximum force on any gate; this seems quite adequate to get the cow moving — at least in a parlor without feed.

2.4 Procedure for Data Taking

The installation in which the feedgate system was tested was one side of a double-8 herringbone with automatic udder stimulation and a holding pen equipped with a crowdgate.

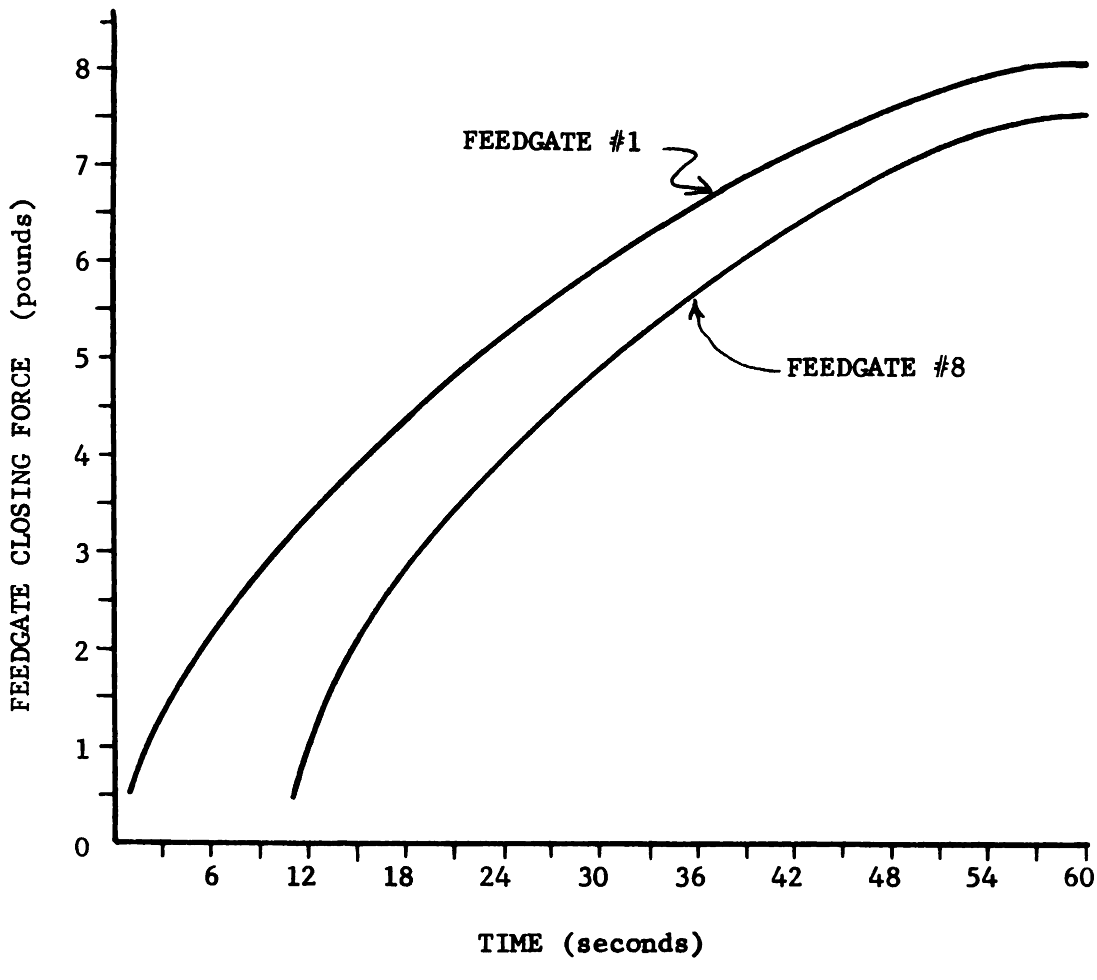


Figure 2.33 Force Buildup on Feedgate vs. Time, Showing Gate Closing Delay from Front to Rear

Individual cow feed trials prevented grain feeding in this particular parlor. Cows, milked twice a day, were brought to the holding area from the main barn in groups sometimes smaller than the capacity of the holding area. Also the entire group of cows was let in to the milk stalls before the next group was accepted in front of the crowdgate. Crowding less than a batch of cows (in this case 8) was not effective. Sometimes the crowdgate was turned off.

Data were separated as to feedgate side of the parlor and non-feedgate side and note was taken whether or not the crowdgate was effective. The operators were instructed to go through their normal milking routine, but to chase cows only when and if necessary. Normally two men working in the pit carried out the milking.

Time and motion studies consisted of observing man interruption time and cow batch travel time on each side of the parlor. Man interruption time is defined as any time either operator was interrupted from his normal milking routine to chase cows or to operate the entrance/exit gates. Cow batch travel time is the time for a batch of cows to either load or leave the parlor (milk stalls).

III. RESULTS AND DISCUSSION

3.1 Results of Time and Motion Studies

The results of the time and motion studies which consisted of data taken on over 1,300 cows (herd size about 100) are summarized in Table 3.1. In these data feedgates are considered along with the use of the crowdgate because it was found that in a parlor in which grain is not fed, the crowdgate has a significant effect on the movement of the cows into the parlor. This fact can be verified from the entrance cycle (batch loading) average man interruption time (AMIT). Without the use of the feedgates or crowdgate the AMIT was 36.6 seconds, but use of the crowdgate (but still no feedgates) reduced the AMIT to 27.2 seconds. Using the feedgate system without the crowdgate gave a slightly lower AMIT of 24.0 seconds.

The crowdgate is nearly as effective as the feedgate system for moving cows into the parlor. However, it must be remembered that this is only on the entrance cycle and that no grain is being fed in the parlor to encourage the cows to move into the stall. Therefore, encouragement by the crowdgate from the rear is quite effective in aiding cow movement. The fact that the feedgate system alone gave a slightly lower AMIT than the crowdgate alone can be partially explained by the observation that cows headed for the stall

TABLE 3.1 Mean Man Interruption Time and Mean Cow Batch Change Time for Four Situations in the Double-8 Herringbone Parlor

	WITHOUT FEEDGATE WITHOUT CROWDGATE	WITHOUT FEEDGATE WITH CROWDGATE	WITH FEEDGATE WITHOUT CROWDGATE	WITH FEEDGATE WITH CROWDGATE
	Operator Interruption Time			
Entrance Cycle	36.60 sec	27.20 sec	24.00 sec	14.90 sec
Exit Cycle	11.00 sec	10.30 sec	1.40 sec	1.25 sec
TOTAL CYCLE	47.60 sec	37.50 sec	25.40 sec	16.15 sec
	Cow Batch Change Time			
Entrance Cycle	1.19 min	.95 min	1.26 min	1.06 min
Exit Cycle	.70 min	.60 min	.64 min	.62 min
TOTAL CYCLE	1.89 min	1.55 min	1.90 min	1.68 min

with the open feedgate even though there was no grain there. This facilitated parlor loading sequentially from the front and lessened the cow movement problems for the operator. Also, AMIT includes interruption time for cow chasing and interruption time for operation of gates, the latter being essentially eliminated with the feedgate system in the automatic mode. Naturally, then, AMIT was much less with use of the feedgates and crowdgate in combination — 14.9 seconds.

The effect on AMIT of the use of the feedgates on the exit cycle (batch unloading) was more pronounced since the crowdgate has no direct effect on cow movement out of the parlor. Exit cycle AMIT was 10.3 seconds and 11 seconds without the feedgates while only 1.25 seconds and 1.4 seconds with feedgates. This 1.25 seconds is the actual observed AMIT for the exit cycle which on the feedgate side includes the time for pressing the manual open exit button, (which starts the automatic cycle) and very infrequent, short duration interruptions for chasing. This 1.25 seconds would essentially be eliminated if an exit signal was obtained automatically from somewhere within the system, say, from "all machines off."

A very impressive reduction in average man interruption time for total cycle from 47.6 seconds without feedgates or crowdgate to 16.15 seconds with feedgates and crowdgate is indicated in Table 3.1. This is a significant reduction in

AMIT from about 6 seconds per cow per cycle down to about 2 seconds per cow per cycle.

The bottom half of Table 3.1 gives the average cow batch change times (ACBCT) for the same four situations mentioned above. Here there is no real significant difference in the ACBCT's for the exit cycle. It appears that the exit times are about as short on one side as on the other. More man-interruption is associated with the non-feedgate side which implies that more chasing was done there to get the cows out as fast as on the feedgate side.

On the entrance cycle it may be noted that the ACBCT without feedgates (1.19 minutes and .95 minutes) is slightly, but not much lower than the ACBCT with feedgates (1.26 minutes and 1.06 minutes). The reason for this is reflected in the fact that the operator was interrupted more frequently without the feedgates than with them. In other words, more cow-chasing was observed on the non-feedgate side of the parlor which resulted in a somewhat faster cow movement. However, small changes in ACBCT in a highly mechanized parlor would be of no real consequence one way or the other unless the difference somehow affected the operator's routine. The entrance cycle data indicated that use of the crowdgate decreases ACBCT by 12 to 14.4 seconds per cycle.

Figure 3.1 graphically shows the relative distributions of the interruption time data of Table 3.1. From this figure

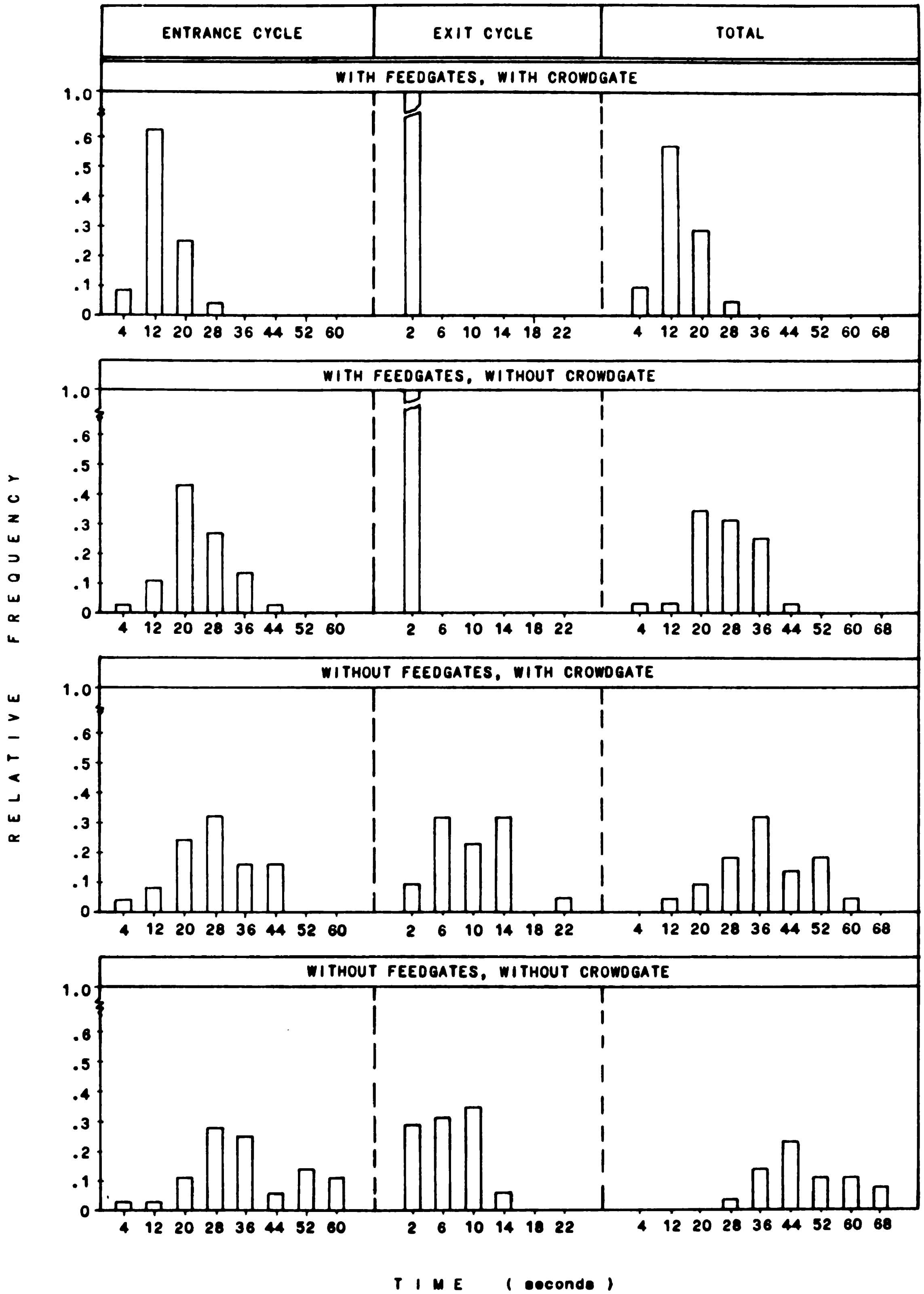


Figure 3.1 Frequency Distributions of Operator Interruption Times

can be seen the ranges of the interruption times, the relative frequencies at which they occurred, and which specific time intervals are significant with respect to different degrees and combinations of mechanization. For instance, the man-interruptions occur with a much greater frequency at the shorter durations with the use of the feedgate system. Also, all of the exit cycle man-interruptions on the feedgate side occur in the interval 0 to 4 seconds. Other comparisons may easily be made.

3.2 Economic Considerations

The Automatic Feedgate System must be economically justifiable in order to warrant further consideration. Based on the experimental installation, additional cost per stall in a herringbone parlor is estimated at $100. As stated before, this system was designed primarily as a necessary component of a highly mechanized parlor, not just as a convenience item — a component needed in order to realize a labor efficiency of over 100 cows per manhour.

The cost of a semi-automated parlor, including crowdgate, automatic detaching units, udder stimulation, etc., would be roughly $1,200 to $1,400 per stall more than a conventional parlor. Therefore, adding another $100 for feedgates to this would not be a very large percentage increase of the total. Figured as a percentage of the total initial milking parlor installation investment or figured on a "per-cow" basis, additional cost for the feedgate system would be a small part indeed.

However, in a parlor with a relatively low degree of mechanization, small herd size, or one in which excessive manual labor is available, the feedgate system is probably not economically feasible, although the system is easily added-on or built-in to any size herringbone parlor. No economic analysis has been made to determine a break-even point for this particular system.

IV. SUMMARY AND CONCLUSIONS

The Automatic Feedgate System was designed, built, and tested with all design criteria and objectives adequately met. The system proved workable and reliable in performing gate operations. A significant decrease in average operator interruption time was observed — a decrease of about 66 per cent in this study.

Further studies are necessary to test its effectiveness in a parlor in which grain is fed, although it is expected to be even more effective in such a parlor.

Advantages of the feedgate system are better realized when used in combination with a crowdgate.

Such a system is necessary in a parlor with a high degree of mechanization and where high labor efficiency is desired.

V. RECOMMENDATIONS

The following recommendations are made with respect to convenience and ease of installation of the feedgate system:

1. Wires and air lines should be enclosed in conduit.
2. A central location for control circuitry components which should be adequately protected from the harsh parlor environment is desirable.
3. Larger herringbone stalls (42 or 44 inches) would better separate cow switches which might facilitate better sequencing on the entrance cycle. Larger stalls would also leave more room for the operator to work in a parlor with more mechanization, such as automatic detachers.
4. Larger pneumatic cylinders and air lines would probably be needed to operate the feedgates in a parlor in which grain is fed.

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APPENDIX

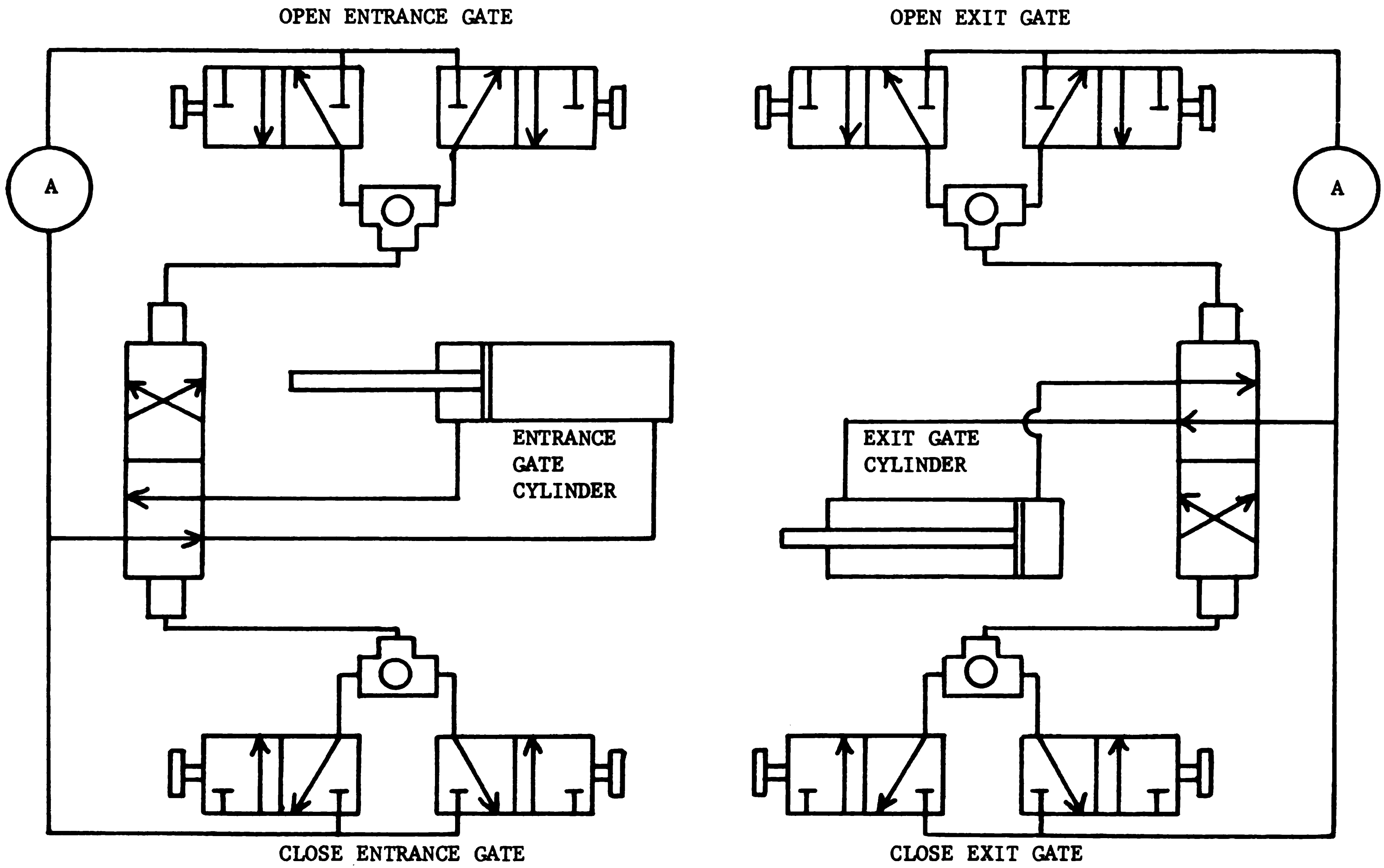

Figure 6.1 Pneumatic Circuit for Manual Operation of Entrance/Exit Gates (source: CLAY EQUIP. CO.)