CUIMR-T-80-012 C3

A SYSTEM TO SINGULATE AND ALIGN SQUID FOR PACKAGING AND PROCESSING

D. E. Brown

R. Paul Singh
Associate Member
ASAE

R. J. Coffelt

ABSTRACT

To reduce packaging time of whole California Market Squid (Loligo opalescens) and facilitate automatic feeding of a newly developed squid cleaning machine, a system to align and singulate squid has been developed. Squid are circulated in a holding tank by water jets which also singulate and direct the squid through ducts to an alignment slide. The squid slide down the alignment ramp and are oriented mantle first. As the squid slides down the ramp, the tentacles drag causing the body to rotate clockwise or counterclockwise and orient itself. Data are presented relating machine performance to processing rates for the squid cleaning machine and the packing industry.

INTRODUCTION

Squid is an important and inexpensive source of protein in much of the world, particularly the Orient. The current annual world catch is estimated at 4.5×10^8 kg (5.0×10^5 tons), and a sustainable fishery may reach 9.1×10^{10} kg (1.0×10^8 tons)(Kato, 1975).

The appearance of whole squid in the local supermarket, where it is sold in small amounts, is considered unpleasant and unappetizing. This is despite the low retail price for whole squid, $1.52 to 2.18/kg ($0.69 to $0.99/lb). Hand cleaning of squid adds $4.41 to $6.61/kg ($2.00 to $3.00/lb) to the price for the restaurateur or retail consumer.

(Singh; R/F-33)

One species, Loligo opalescens, commonly referred to as California Market Squid, abounds off the western coast of the United States. It is currently packed by hand and frozen for foreign and domestic markets in 0.4, 1.3, 2.2, and 4.5 kg boxes (1, 3, 5, and 10 lb boxes). Squid is also canned, by hand packing of squid in cans, for foreign markets. Automatic weighing machines are used in the packing of frozen, boxed squid.

Most squid packed by hand in boxes and frozen is left randomly oriented in the box. The boxes are then weighed and adjusted to the desired weight by adding or removing an individual squid. Random packing of squid in a 0.4 kg (1 lb) box generally takes 1 worker 5-10 seconds (DeLuca, 1980). The California Market Squid average 13.0 squid/kg (5.9 squid/lb).

Certain processors, in an effort to make the whole frozen squid more visually appealing to the consumer, orient the top layer of squid in the box so that the squid bodies are parallel and in a uniform direction. A clear plastic window in the cover of the box allows the consumer to inspect the squid in this top layer. This orientation of individual squid is done by hand before or after the boxes are weighed. One processor is currently operating a hand packing line, employing 12-15 workers, at 56.7 kg/min (125 lb/min), using 2.2 kg (5 lb) boxes (Nobusada, 1980). A machine to automatically feed squid, in a uniformly oriented condition, to the workers packaging or canning whole squid would greatly reduce packing time.

A machine to skin and eviscerate Loligo opalescens squid was recently developed (Brown and Singh, 1979). It automatically mounts an individual squid on a holding device. Using water jets, it skins, eviscerates, and removes the inksac and backbone in 8 seconds. In an initial staging area the tentacles are severed and saved for consumption. The head and eyes are also removed. Squid are fed into this machine one by one in a uniform orientation, mantle first. An orientation device was developed by Brooks and Singh (1979) and was utilized to feed squid in the desired orientation into this machine. The individual squid were deposited by hand on this orientation slide as needed by the cleaning machine. It is estimated that a multihead machine (60-70 cleaning stations) using the principles of this prototype could process 2,300 kg/hr (2.5 tons/hr). An automatic feeding device, providing oriented, individual squid to each cleaning station would greatly aid in the utilization of this machine by the seafood processing industry.

OPERATION

The singulation technique reported in this study was developed to provide aligned, individual squid for processing, either packaging or cleaning. This technique is pictured in Figures 1 and 2. Squid were batch loaded in a circulating water tank, from a bucket or bin. Continuous loading was also tried using a metered belt conveyor. The density of squid in fresh tap water is 1.10 g/cc (Brooks, 1979) and the squid sink to the bottom of the tank. The tank is 0.91 m in diameter and 0.25 m deep. The capacity of the tank is 210 L.

Squid are kept circulating in the tank by the action of water jets C, D, E, and F, as shown in Figure 1. Water jets C and D issue streams of water and the squid suspended in the water are directed toward the entrance of a duct located at the periphery of the tank. This duct leaves the tank at a tangent at section A-A (Figure 1). It is also pictured in Figure 3. The flow of water in this duct is accelerated by the action of water jet B, Figure 1 and Figure 3. The accelerated column of water in the duct draws water from the main tank and the squid suspended in the water, which have been directed to the duct's entrance. The squid then leave the tank in the

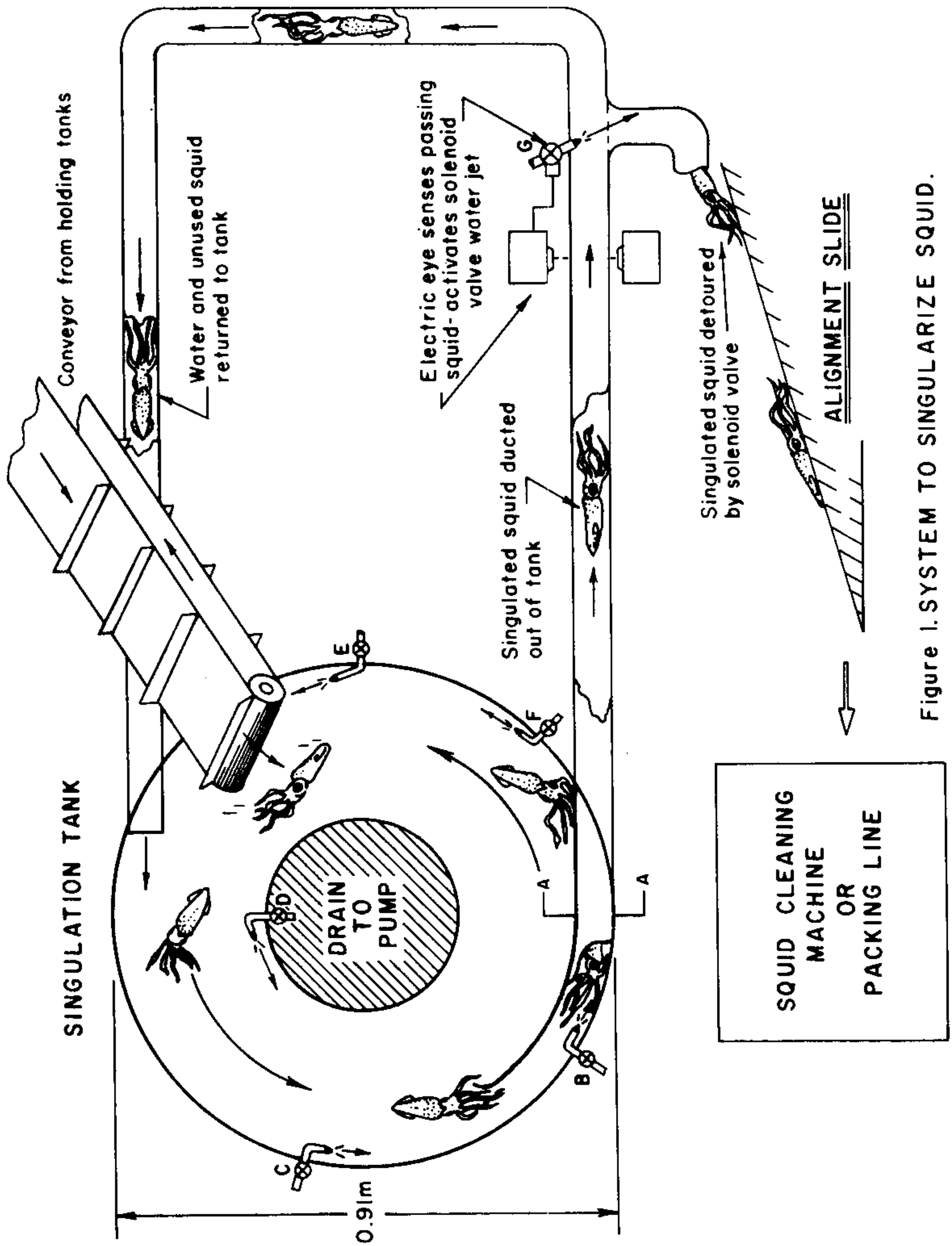

Figure 1. SYSTEM TO SINGULARIZE SQUID.

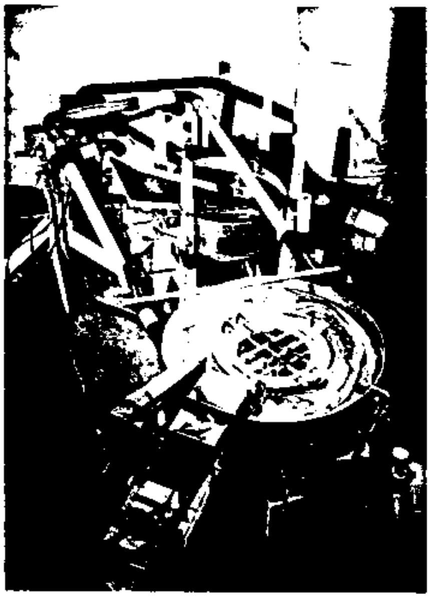

Figure 2. Tank and duct of system to singulate squid.

Figure 3. Exit duct from tank and water jet B (Figure 1).

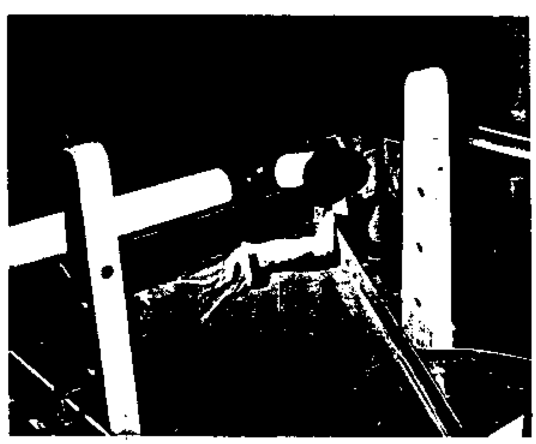

Figure 4. Squid diverted from ducting and onto alignment slide.

duct flowing single file with the water in the duct. The major axis of their bodies remain parallel with the duct (51 mm in diameter) as the squid flow through it. They are seen to enter and flow through the duct in either an anterior first or posterior first orientation. Their average velocity in the ducting is 0.45 m/s. The water flow rate through jet B was maintained at 0.3 kg/s by a centrifugal water pump. Water jet B consists of a copper tube with an inside diameter of 11 mm.

Squid are removed from their single file condition in the duct by the action of water jet G controlled by a solenoid water valve, Figure 1. An electric eye senses a passing squid in the duct. It activates a solenoid valve which produces a powerful water jet to divert the squid through a duct at a right angle to the direction of flow. The flow rate through this removal duct is normally very low due to the elevated height of its exit. The squid travels a short distance in this duct and is then deposited on an alignment slide. Brooks and Singh (1979) developed this orientation technique, Figure 4. The squid are oriented in a mantle first condition, tentacle mass following (Figure 1), as they travel down the slide. The coefficient of sliding friction of the squid tentacles is higher than that of the body. This allows the squid to rotate into the desired alignment as it slides down the ramp. Brown and Singh (1979) used this alignment slide to orient squid for a skinning and evisceration machine. The squid that have been ducted from the singulation tank and aligned are then ready to enter this cleaning machine or a weighing and packaging line. The squid that are not removed from the duct by the water jet are returned to the tank and enter the system again.

As the density of squid in the tank rises, the likelihood of two squid entering the singulation duct, at A-A, simultaneously, increases. These squid are separated in the duct by the action of water jet B. Water jet B is offset to one side of the duct and as two squid enter the duct, they are subject to the velocity profile difference of Figure 5, at section A-A. The squid in this region of higher velocity accelerates past the squid occupying the duct with it, Figure 6. They proceed through the remaining ducting single file.

PERFORMANCE INVESTIGATION

It was observed that the singulation rate, for removal of squid from the tank, was dependent on the density of squid in the tank. Three tests were performed to gauge the effect of tank density on removal rate. Frozen, whole squid (Loligo opalescens) were purchased from Merideth Fish Company, Sacramento, California, and thawed just prior to use. Their overall length, from mantle tip to tentacle end, ranged from 0.23-0.33 m. For the first test the number of squid in the tank was maintained at 10 for a 10 minute test period. The number of squid removed and ducted from the tank to the water jet removal station, G, Figure 1, were counted. The density of the squid in the tank was then changed to 30 and 60 squid for 10 minute periods.

The 10 minute test period was chosen because the condition of the squid deteriorates if exposed to fresh water and repeated action of the water jets for a greater period. The mucous-like layer covering the squid disintegrates and floats free. In actual practice this would not be a problem as the squid would be continuously removed from the system and skinned or packaged. In the above tests the squid were recycled many times.

A second series of tests were performed to test the effectiveness of the water jet removal device and alignment system. Two modes of operation were tested. Continuous operation would simulate the singulation of squid for a packing operation of whole squid. Removal of squid from the ducting system on demand would provide singulated squid for a cleaning machine.

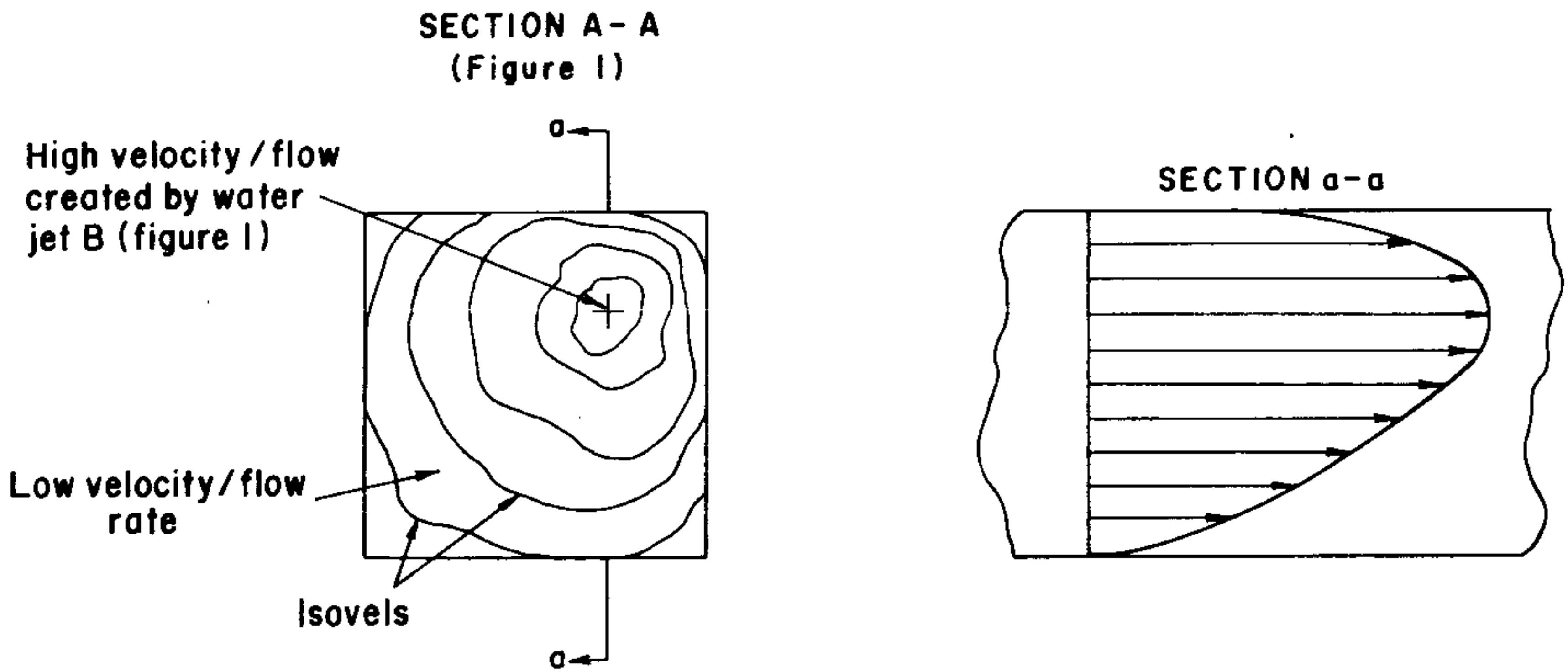

Figure 5. VELOCITY PROFILE IN SINGULATION DUCT AT ENTRANCE.

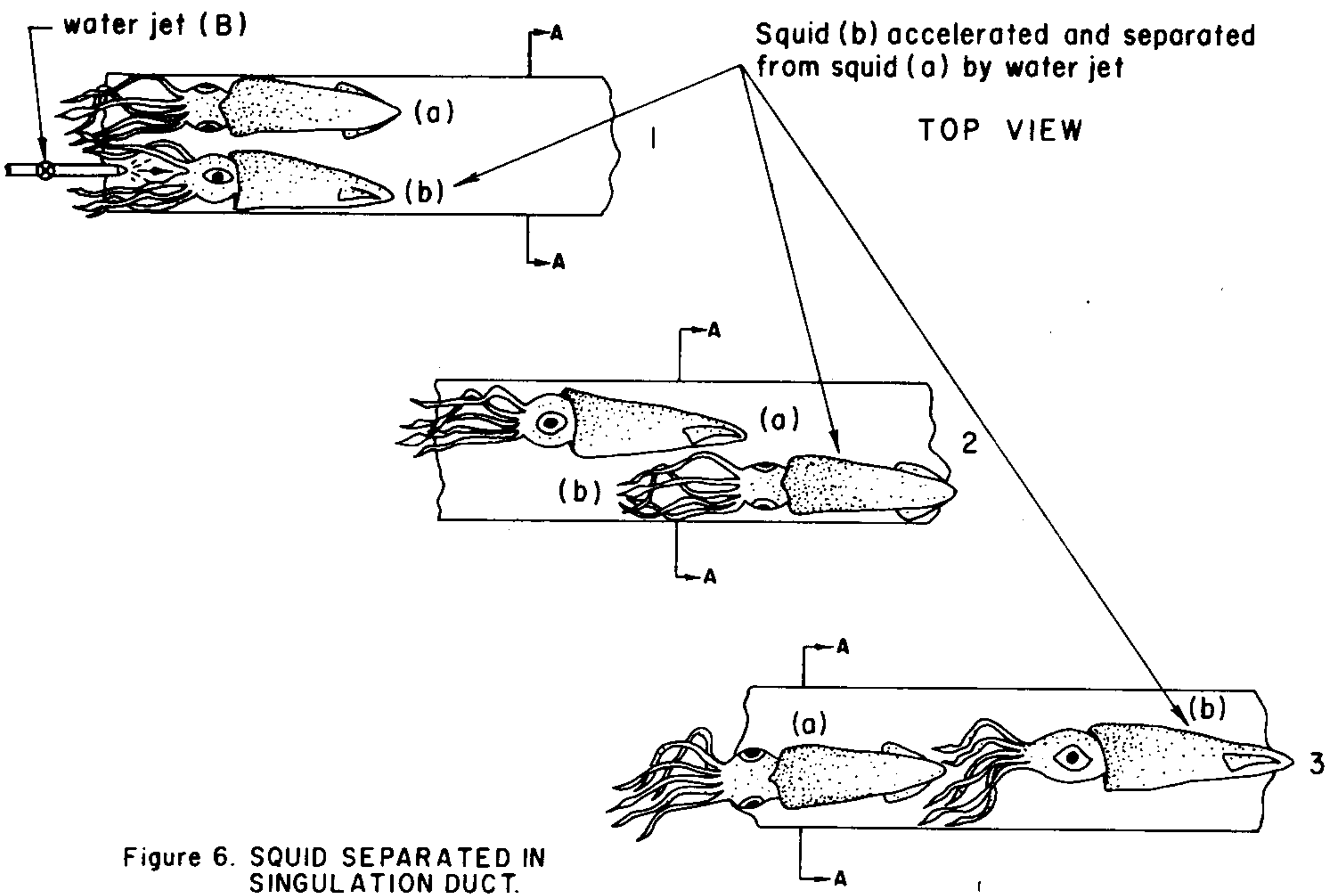

Figure 6. SQUID SEPARATED IN SINGULATION DUCT.

In a continuous operation mode, the water jet at G, Figure 1, was fixed in the open position. All squid were to be diverted out of the ducting system onto the alignment slide. The number of squid in the tank was maintained at 60 and the duration of the test was again 10 min. The squid arriving at the bottom of the slide in the desired condition for packaging in uniform alignment were counted. All squid were returned to the circulating tank for maintenance of 60 squid in the tank. The water that is deposited on the slide with the squid was also recycled by pumping it back into the circulation tank continuously.

In tests simulating the demands for aligned squid of the skinning and gutting machine described earlier, squid were removed from the ducting system every 8 seconds. The electric eye controlling water jet G was equipped with a reset circuit which prevented its operation until a simulated signal from the squid cleaning machine was received. The next squid in the duct then activated the electric eye and the water jet diverted that squid to the alignment slide. The number of squid in the tank was maintained at 60 and duration of the test was 10 minutes. Squid removed from the ducting system and aligned properly were recorded and the squid were returned to the circulation tank.

RESULTS AND DISCUSSION

The results of tests performed to determine the average removal rate over the 10 minute test period for the ducting of squid from the circulation tank is shown in Figure 7. The average removal rates ranged from 0.4 squid/sec. with a tank density of 10 squid, to 0.8 squid/sec. for 30 squid, and 2.1 squid/sec. for 60 squid. For the 60-squid test, the spacing of the squid in the duct dropped to an average of only 0.23 m. This is about the minimum spacing required for effective removal of squid from the duct by water jet G,

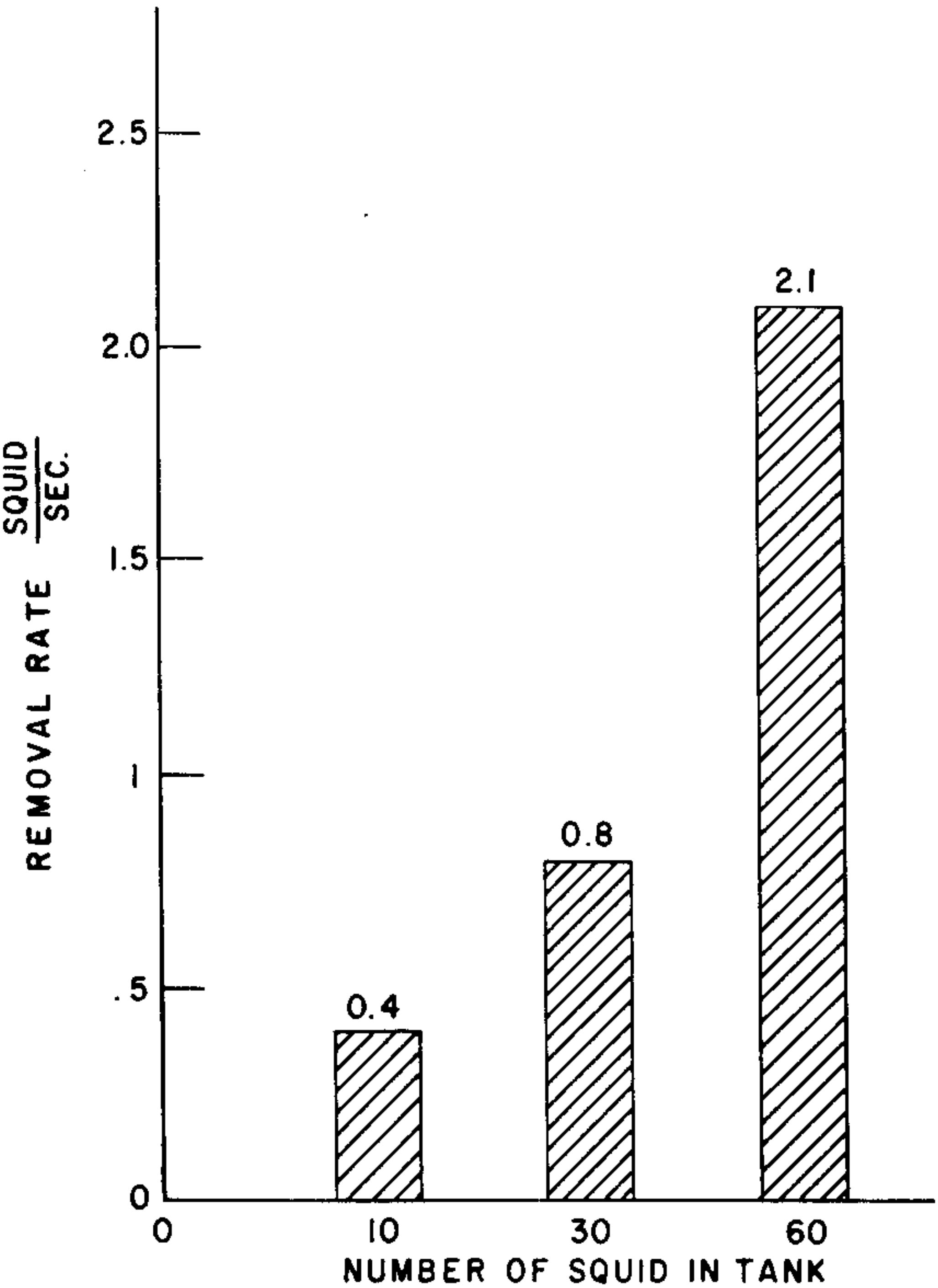

Figure 7. Average singulation rate, squid ducted out of holding tank.

Figure 1.

The percentage of squid removed from the ducting by water jet G under continuous operating conditions was at the 92% level. With a tank density of 60 squid, 1.9 squid/sec. on the average were successfully diverted to the alignment slide under continuous operation. These squid were aligned at a 71% level. This is lower than the 81% level reported by Brown and Singh (1979), and the 100% figure reported by Brooks and Singh (1979). The reasons for this low alignment rate will be discussed later in this section.

As was stated earlier, 12-15 workers currently pack squid in 2.2 kg boxes, with the top layer aligned, at the rate of 56.7 kg/min. Using an average of 13.0 squid/kg, 12 workers could pack 740 squid/min. Each worker packs on the average 1 squid/sec. The singulation/alignment technique described in this report could supply a worker with 1.9 squid/sec if the 100% alignment rate can be achieved.

The second test for removal of squid from the ducting on simulated demand from the squid cleaning machine resulted in an 89% removal rate. Every 8 seconds the electric eye was reset with a simulated signal from the skinning/cleaning machine. The first squid passing the electric eye activated the water jet removal system at G, Figure 1. The squid not removed by this system remained in the duct and returned to the circulation tank. Those squid that were deposited on the alignment slide were aligned at a rate of 76%.

Because the skinning machine developed has an operation time of 8 seconds/squid, the singulation machine could provide squid to a large number of skinning machines. Multiple solenoid-controlled water jets diverting squid would be required. With a maximum removal rate from the singulation tank of 2.1 squid/second, this singulation device could automatically feed 15-17 squid skinning machines.

These squid removed from the ducting system and deposited on the alignment slide were aligned at a lower than expected rate. Figure 8 compares these results with previous research. Brown and Singh (1979) reported an alignment rate of 81% for squid deposited on the alignment slide of the squid cleaning machine described. On April 19, 1980, in a public demonstration, a near 100% alignment rate was observed. Brooks and Singh (1979) found a 100% alignment rate for squid dropped on an alignment ramp. Operated continuously the alignment slide in this report aligned squid at a 71% rate. On simulated demand, a 76% rate was achieved, Figure 8. The two most likely reasons for the difference in performance are: the quantity of water dropped on the slide with the squid; and the material that the slide is made of. Brooks and Singh (1979) observed squid orientation on a galvanized sheet metal ramp with a constant fine spray of water to facilitate the sliding motion. The squid cleaning machine developed by Brown and Singh (1979) used a plexiglas slide and fine water spray to orient squid. Large amounts of water are deposited along with the squid by the system described in this report. PVC plastic was used in the construction of the slide.

A mechanical device to drain the squid of excess water and then drop the squid on the slide is needed to improve the alignment rate. An investigation of the slide material and its effect on the friction coefficient of squid tentacles and body would be necessary to select the optimum material for this component of the system.

During the 10 minute test periods, the skin of squid exposed to circulating fresh water does tend to separate from the body. Understanding this phenomenon and its effect on the alignment rate must await further study.

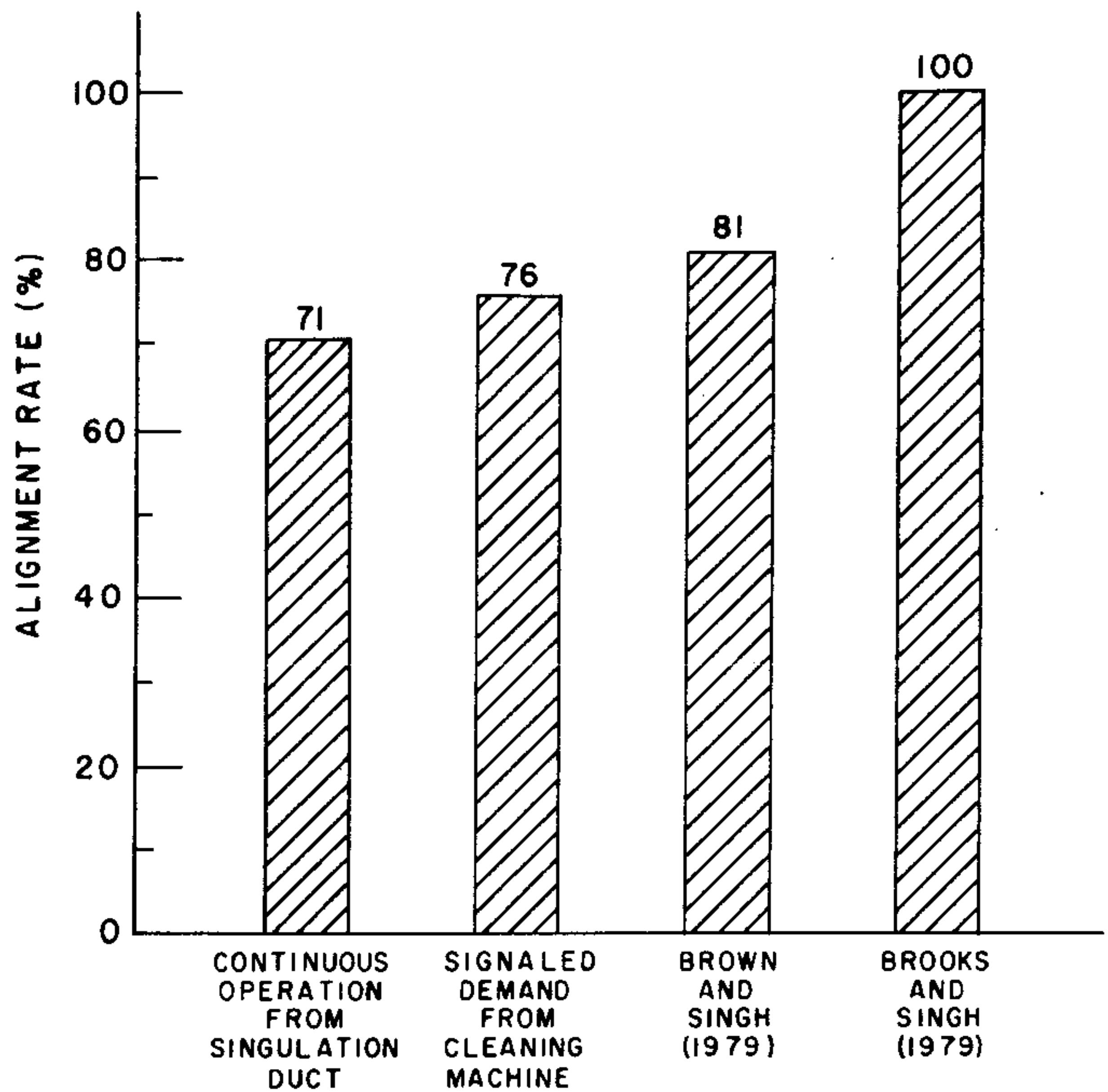

Figure 8 Alignment rate for squid sliding on inclined ramp.

REFERENCES

1. Brooks, L. A. and R. P. Singh. 1979. Properties of squid useful in designing of cleaning and handling systems. TRANSACTIONS OF THE ASAE 22(3):658-663.

2. Brown, D. E. and R. P. Singh. 1979. A machine to eviscerate and skin squid. ASAE Paper No. 79-6525, ASAE, St. Joseph, MI. 49085.

3. DeLuca, A. Personal communication, 1980. State Fish Co., San Pedro, CA., May 13.

4. Kato, S., and J. E. Hardwick. 1975. The California squid fishery, from expert consultation of fishery for squid and other cephalopods. FAO Fishery Report (170, suppl. 1).

5. Nobusada, K. Personal communication, 1980. Sea Products Co., Moss Landing, CA., May 16.

ACKNOWLEDGEMENT

This research was supported by Sea Grant, Project No. R/F-33, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.