final report

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Sheep Hindquarter Boning Leg Boning Module

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Purpose of Development:

This development was undertaken as one of two modules to automate the boning of mutton hindquarters. The first module was to remove the legs from the pelvis at the femur/os coxae. This module addressed the removal of the femur and tibia from the leg tissue.

The objective was to remove the long bones from the leg with minimal prior preparation, high yield, minimal damage to the leg tissue and at a reasonable production rate, in a machine that is robust, reliable, safe and cost effective.

Development History:

The development process is recorded in detail in milestone reports elsewhere.

M.731 Milestone One: Methods developed 18.7.95
Concepts were developed in a horizontal, hydraulically driven test rig.

M.731 Milestone Three: Proof Machine designed 20.10.95
The concepts were incorporated into a proof of concept machine which was again horizontal, hydraulically powered, but simply automated.

M.731 Milestone Four: Proof Machine built 4.12.95

M.731 Milestone Five: TTAG Assessment 20.12.95
The development was put on hold pending results of other work on the shoulder boning machine.

M.731 Milestone Seven: Concepts proven
The proof of concept machine was tested and operated automatically with good results.

M.731 Milestone Nine: Production Prototype designed.
An upright, cleanable, electrically powered prototype was designed, incorporating the features proven in the prior prototypes.

M.731 Milestone Ten: Production Prototype costed.
The cost of manufacture of the prototype was calculated.

M.731 Milestone Eleven: Go ahead to manufacture.
In February 1997 the go-ahead was given to manufacture the prototype for display at Impro Expo and subsequent trial at a site to be determined.

M.731 Milestone Fourteen: Production Prototype built.
The prototype was completed and shipped to a local boning room for preliminary trials.

M.731 Milestone Seventeen: Production trials approved.
After a brief trial the machine was accepted for trials and air freighted to the AMC conference.

M.731 Milestone Eighteen: Production Prototype installed.
The machine was installed at Southern Meats, Goulburn in October 1997 for trials.

M.731 Milestone Nineteen: Trials completed.
The production trial was completed in December 1997 following an industry open day.

Machine Description:

The machine developed is described in detail in working drawings reported in milestone reports, and is shown in Figures 1 and 2.

The main working parts consist of a pair of boning dies which bone the leg from both ends simultaneously, meeting about the joint of femur and tibia, where the tendon and connective tissue connections to the meat are severed and the bone is ejected through the inside of one of the hollow boning dies.

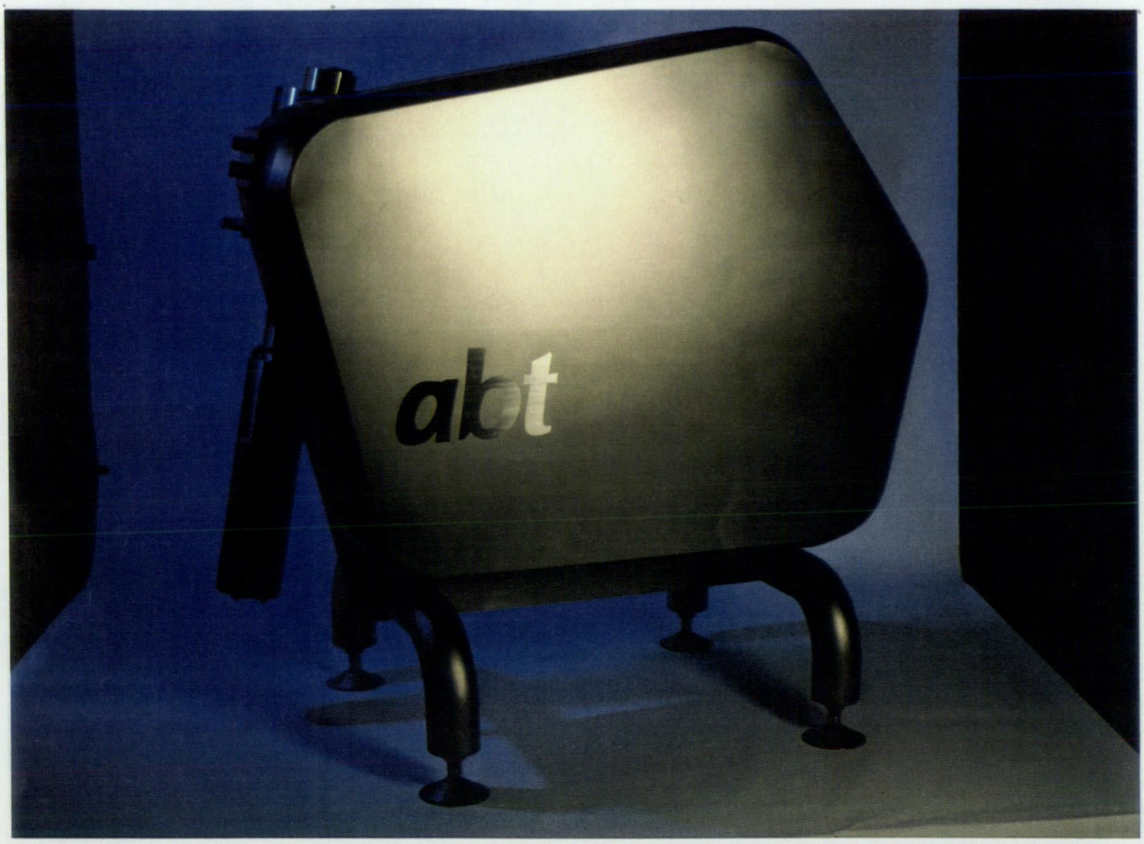
Each die set consists of an annular cutting ring which contains flexible scraping elements and means to compress the flexible scraping elements to force their scraping edges against the bone.

The bottom die set is completely hollow entirely through the flexible scraper and out the bottom of the die set. The top die set contains the addition of a pusher mechanism to push the bone set down through the femur side.

Other components of the working mechanism comprise the mechanism for driving the die sets together and providing the high compressive forces necessary to sever the final tendon connections, and a bone guiding system. The bone guiding system comprises a guide to ensure that the tibia end engages correctly in the aperture of the flexible scraper as the process begins, and a second guide which restrains the bone set about the joint of femur and tibia both laterally and in the medial plane until the die sets are partially closed and the bones are well contained in their respective scraping elements.

In operation the leg is first prepared by the removal of the tarsal bones by a saw cut and by severing the major tendons about the proximal end of the femur. The leg is then manually loaded into the machine with the femur end engaged in its corresponding bottom die and the tibia end located against the top guide. The other guide is then swung into position to restrain the cut and the press cycle initiated, by push button.

As the die sets are driven together the bones pass through their respective scraper elements until the die sets come completely together, when the bone is ejected. The die sets are then retracted leaving the meat, tunnel boned on the outside of the femur die set.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Trial Results:

The production trial involved a significant period of tuning and adjustment of the machine, followed by a number of runs of several hundred legs, up to the stage where confidence in the consistency of performance could be expressed.

Production Rate:

A continuous production rate of 5.5 legs per minute was achieved with the machine running using an A.C inverter drive and squirrel cage motor, and the operator removing the meat prior to loading the next leg.

Yield:

Yield tests were conducted under two sets of conditions, both times comparing yield to manual boning, by trimming a number of randomly selected bones (from both manually and machine boned legs) to an even, clean standard and comparing the amount of tissue trimmed.
Using plain conical-faced scrapers, mechanically boned yields were within a few grams per leg of manual standards.
Using improved scrapers with yield enhancing lugs, mechanically boned legs yielded 20gm more per leg than manually boned legs.
Opportunity to increase this improvement in yield exists with further refinement.

Reliability:

a) Machine reliability:
The operating mechanism of the machine was tested with a workshop simulation running automatically over the period of a week to complete 120,000 cycles. At the end of that period no detectable faults were apparent and the device still performed its boning function.

b) Process reliability:
During the production trial no machine-caused boning faults (leading to broken bones or other major process breakdown) were recorded. Some broken bones did result when lack of operator care in loading the machine resulted in the guides not guiding the bones as they should.
The life of the flexible scraping elements was proven to be at least 800 legs.

Cost Benefit:

Assume machine operation increased to 9 legs per minute:

Labour reduction:	3 @ $70,000
Yield gain:	40gm / ccs @ $3 / kg
Annual production:	380,000 ecs / shift
Machine cost:	$225,000
Interest, depreciation, R & M	31%

Labour	+ $210,000	
Yield	+ $45,600	
Machine Costs	- $69,750	
Net Gain	+ $185,850 pa.	per machine for a single shift operation.

For a two shift operation (2nd shift 150 days / year)

Labour	+ $368,000	
Yield	+ $79,800	
Machine	- $78,750	
Net Gain	+ $369,050 pa.	per machine for a double shift operation.

Recommendations:

The prototype leg boning machine has proven the concept and process reliability of boning legs by machine.

The machine does need to be upgraded by:

- -increasing operational speed
- -automatically ejecting meat
- -refining flexible scrapers
- -overall design upgrade
- -further development to remove patella

It is recommended that a programme is undertaken to redesign and speed up the machine and that a commercialization programme is commenced.