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Improved Force Detection and Recording Method for the Press of the Texture Test System

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Contents

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SUMMARY

A simple means of replacing the existing force transducer of the Texture Test System (TTS) press is described. A commercial strain gage force transducer replaces the proving ring and deformation transducer that normally detects force for recording force-deformation curves in food texture tests. The strain gage transducer is connected to an independent recording system to plot force against time. Calibration is achieved by a lever and weight.

The change is simple to execute and improves the precision, resolution and operational flexibility of the TTS particularly the early models which were not as accurate as those presently in production.

Improved Force Detection and Recording Method for the Press of the Texture Test System

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1. Introduction

The Texture Test System (Food Technology Corp., Rockville, Maryland) previously known as the Kramer Shear Press (Fig. 1) has been widely adopted for measuring food texture. It comprises an hydraulically activated press to operate different texture test cells. Force is detected by a transducer that consists of a steel ring with a linear-velocity-displacement transducer to sense deflection of the ring which is proportional to force. The transducer is connected to an electronic recording system (Fig. 1). Sample deformation during testing is detected by a mechanical drive mechanism activated by the ram of the press that moves the recorder strip chart. Thus, the system records force against deformation during testing.

Early models of the system have a number of problems including poor control of sample deformation rate and inaccurate force recording. These were reduced by modifications to the hydraulic control circuit and replacing the force transducer with a "home made" strain gage unit (Fig. 2). These changes (Voisey, 1972) improved the performance of an old TTS and used an independent recording system to plot force Vs time giving greater operational flexibility (Appendix 1).

The purpose here is to describe a further minor modification where a commercial force transducer is used in place of the "home made" unit previously described. This gives added advantages such as simplified construction and an increase in the available space in the working area of the press.

2. Description of Modifications

The force transducer used is a compact flat unit (Fig. 3) that can measure tensile or compressive forces. Two load capacities are available and the one selected depends on the range of forces required: Model *FLIU35PWT with a capacity of 454 kg or Model *FL2.5U3SPWT with a capacity of 1135 kg. These are manufactured by Strainsert*, 24 Summit Grove Ave., Bryn Mawr, Pennsylvania 19010 and distributed in Canada by Intertechnology Ltd.,* P.O. Box 219, Don Mills, Ontario M3C 2S4. Other capacities such as 2270 and 4540 kg are also available. In making the selection the maximum and minimum full-scale forces to be recorded should be considered. As the transducer capacity increases, the maximum sensitivity decreases.

The components required for the modification are shown in figure 3. A shaft with a flange at one end is mounted on the hydraulic ram to hold the force transducer (Fig. 4). The shaft is pinned to the ram in the same way as the original TTS force transducer. The length of shaft is required to take up the space normally occupied by the ring type force transducer. The shaft length can be reduced if required to increase the working space for different texture test cell installations. However, the shaft is normally of such a length that the hydraulic ram operates over its normal stroke and the existing test cells fit into the machine in the original manner.

A chuck is bolted to the load cell and holds an adaptor on which the upper moving components of the TTS test cells slide and lock in place. This completes the modification, and the press can now operate in the original manner (Fig. 4).

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*The use of trade and suppliers' names does not imply an official endorsement by Agriculture Canada.

3. Calibration procedures

Calibration of the force transducer is accomplished in two ways:

1. A lever (A, Fig. 3) is suspended on pivots bolted to the right hand side of the press frame (Fig. 5). Rollers at the inner end push up on the test cell adaptor to apply compressive force to the transducer. Appropriate weights are suspended on the outer end of the lever to apply selected forces. The weight has a mechanical advantage of 5 to 1. Thus, the applied force is 5 times the weight used. For accuracy the lever must be absolutely level. This is indicated by a sensitive spirit level on top of the lever. Levelling is accomplished by lowering the ram slowly and noting the chart reading only when the lever is level. During calibration at zero force the effect of the lever's weight must be tared from the reading by adjusting the controls. When the lever is removed, the system must again be tared to re-establish zero.
2. When the level of calibration forces required makes the lever-weight combination inconvenient to operate, a proving ring is used as the calibration standard (Fig. 6).

4. Performance

Typical performance was demonstrated with the system using a 454 kg capacity transducer. A Model *300D-93 amplifier (Daytronic Inc.,* Dayton, Ohio) connected to a potentiometric type strip-chart recorder with a maximum sensitivity of 5 mV was used to record the transducer output. Calibration with the lever and weight was performed so that the full-scale chart reading was achieved at a) maximum transducer sensitivity; b) maximum transducer capacity and c) an intermediate force.

The results (Figs. 7, 8) showed that the transducer could be arranged to operate with the full-scale chart readings indicating forces ranging from 2 to 500 kg. The relationship between chart reading and force was linear within ± 0.7% under all the conditions tested (Table 1).

The modification thus serves to improve the accuracy of force recording for old models of the TTS. The advantages of an independent recording system (variable chart speed; 250 mm wide chart with greater resolution of measurement) and the potential to install larger texture test cells in the working space of the press is also gained through the change. It must, however, be recognized that for some tests, to interpret the force-time curves obtained correctly, the speed of the press ram during the test must be carefully verified.

Table 1

Non-linearity of transducer calibration curves

Full-scale recorder reading kg	Non-linearity %
2	0.6
200	1.4
500	0.6

5. References

Voisey, P.W. 1971. Modernization of texture instrumentation. J. Texture Studies 2, 129.

Voisey, P.W. 1972. Updating the shear press. J. Can. Inst. Food Sci. Technol. 5, 6.

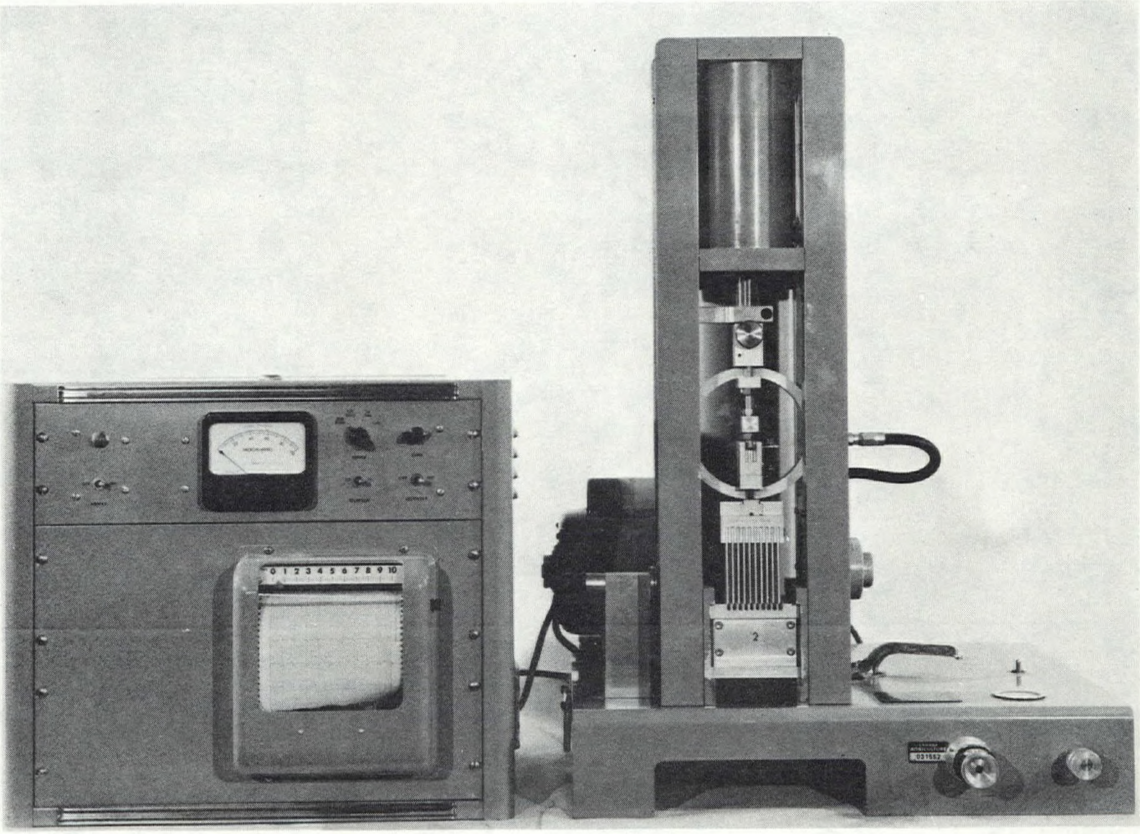

Figure 1. An early model of the Texture Test System.

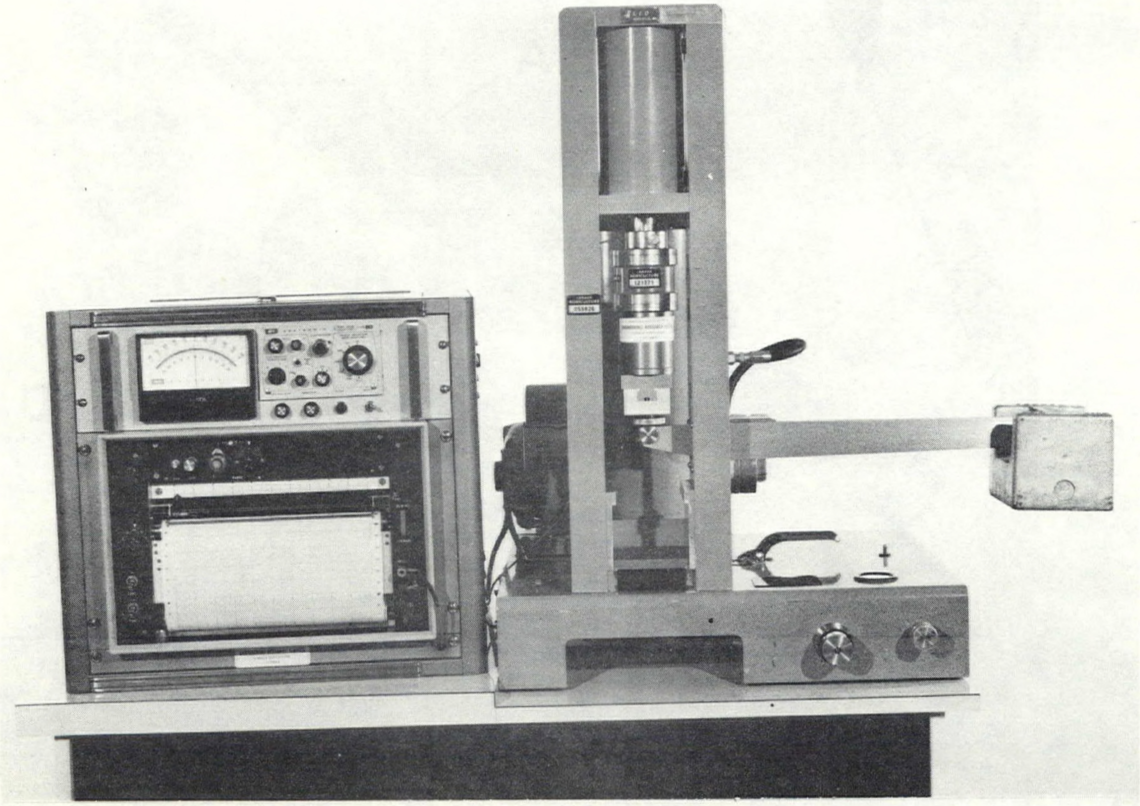

Figure 2. A modified texture test system with improved hydraulic controls; a strain gage force transducer and an independent force-time recording system (Voisey, 1972).

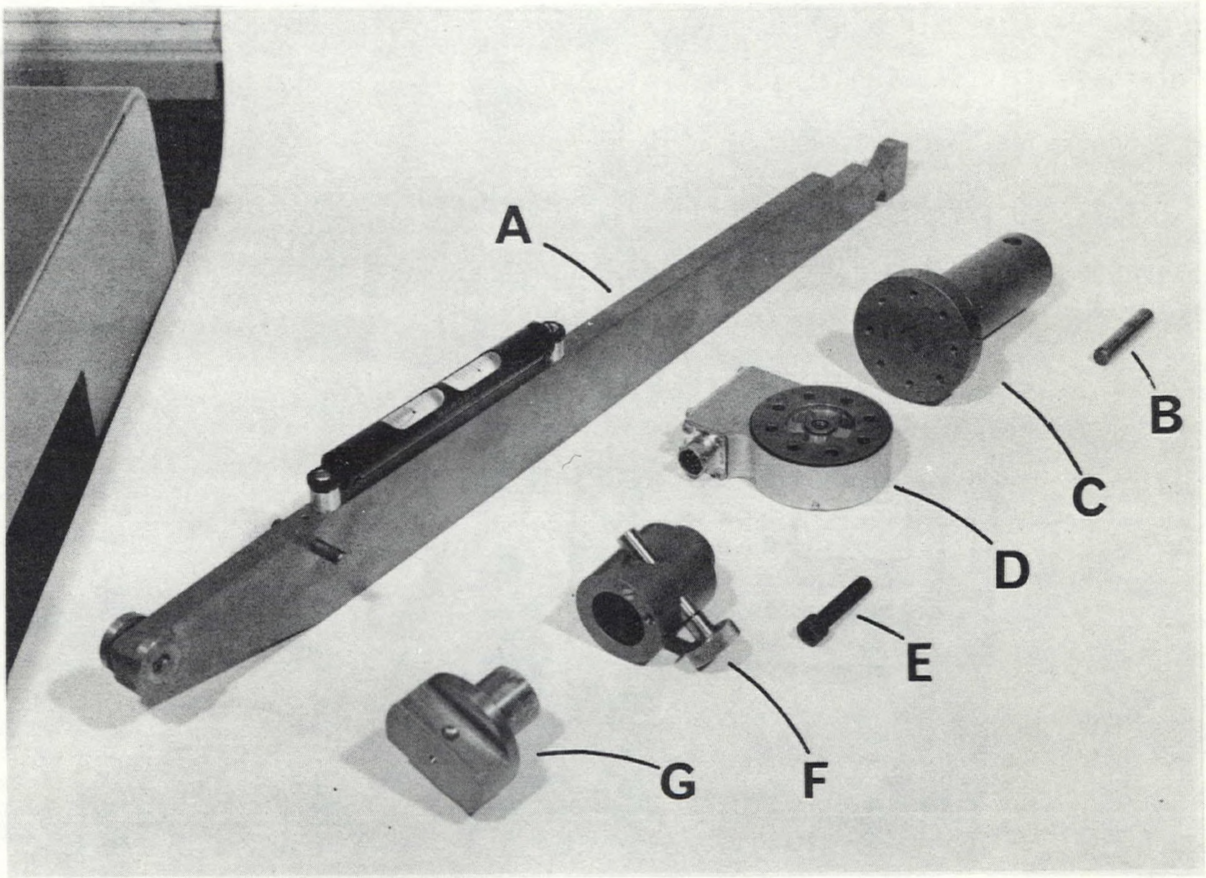

Figure 3. Components for the modification. A. calibration lever with precision level; B. pin to hold shaft to hydraulic ram; C. shaft to extend ram length with flange for force transducer attachment; D. force transducer (454 kg capacity); E. bolt to attach chuck to transducer; F. 2.54 cm diameter chuck (of the Ottawa Texture Measuring System) to attach to the transducer; G. adaptor on which the upper moving component of the texture test cell slides.

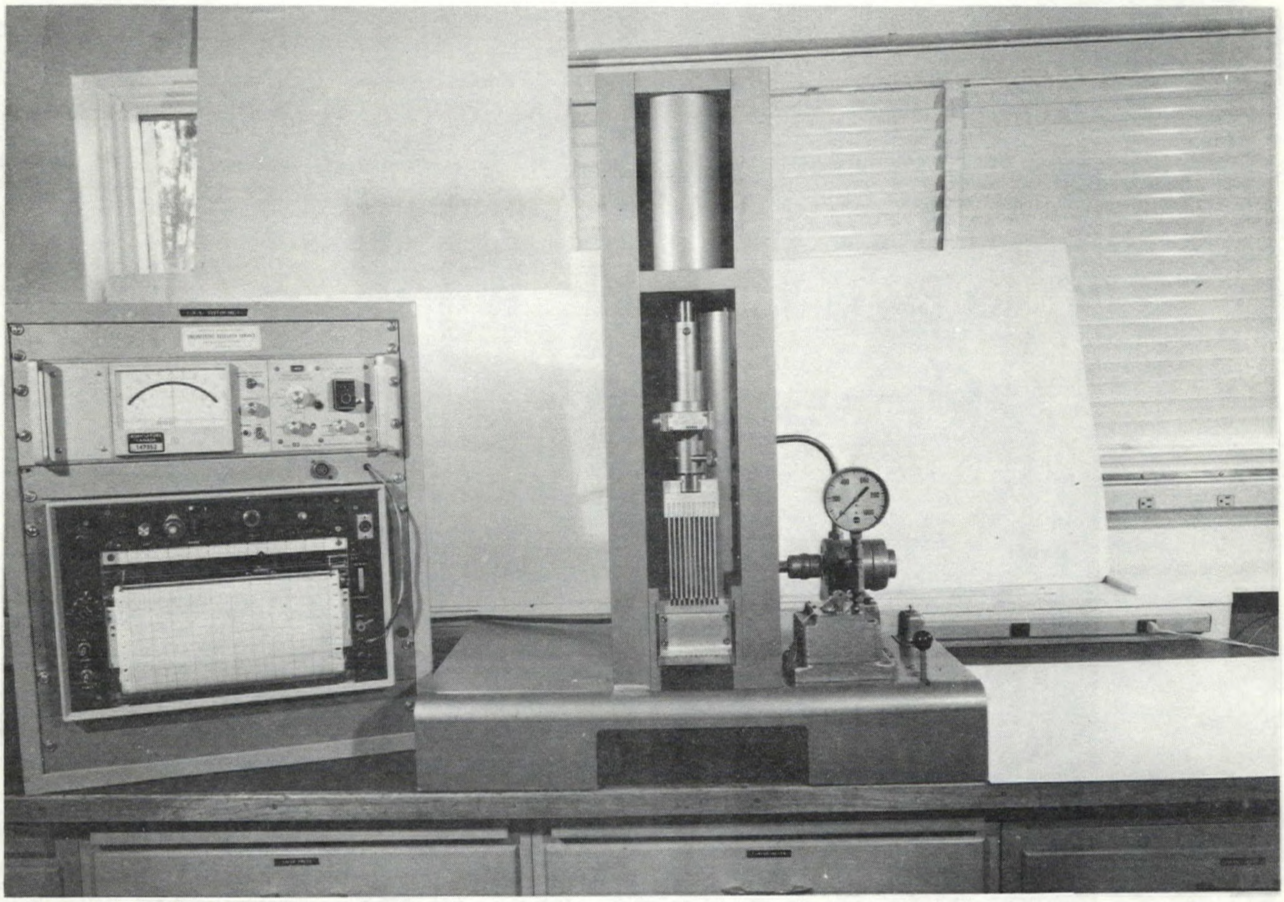

Figure 4. The modified press ready for operation with the shear compression test cell in place. The independent recording system (see Voisey, 1971) is at the left.

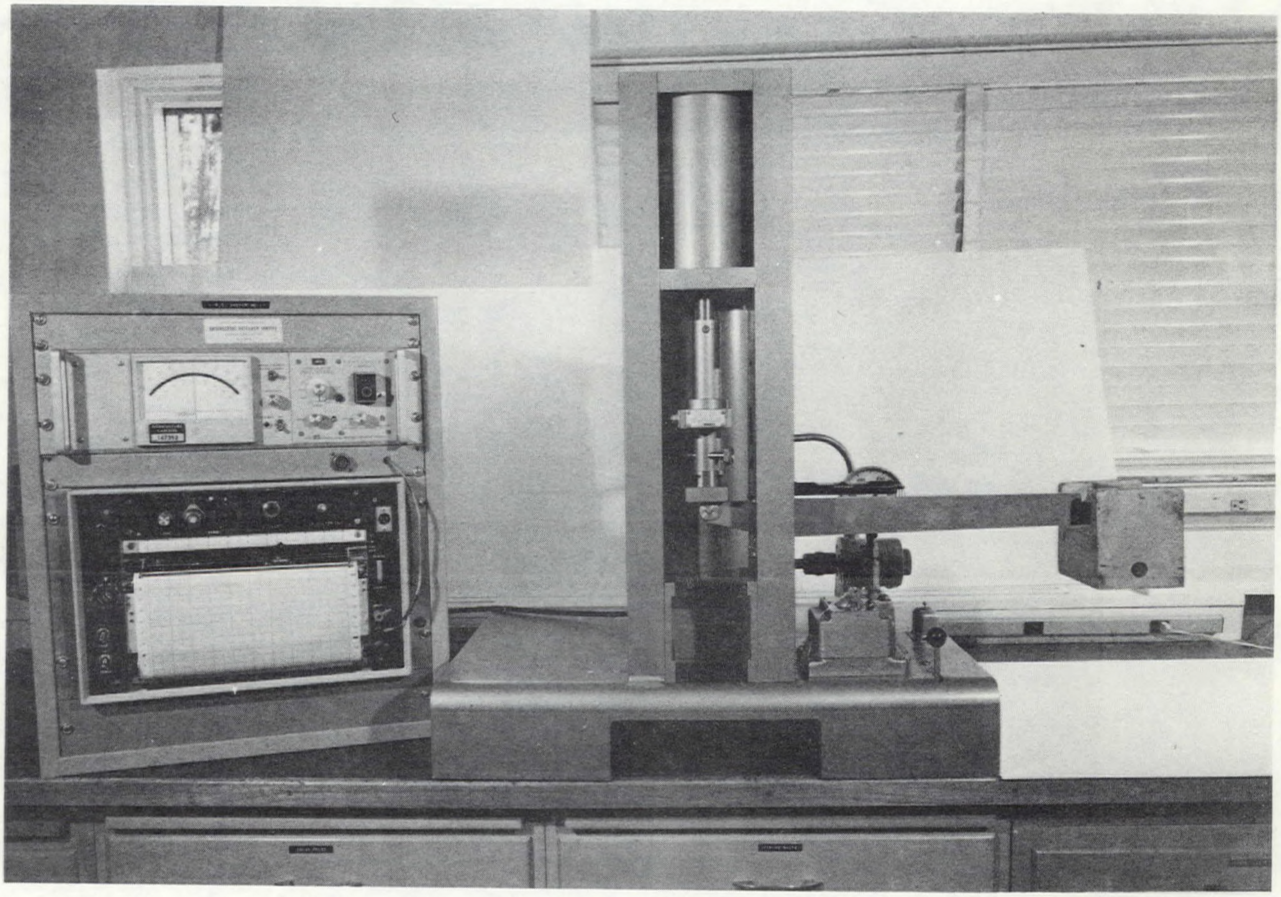

Figure 5. Calibrating the force transducer with the lever and a weight.

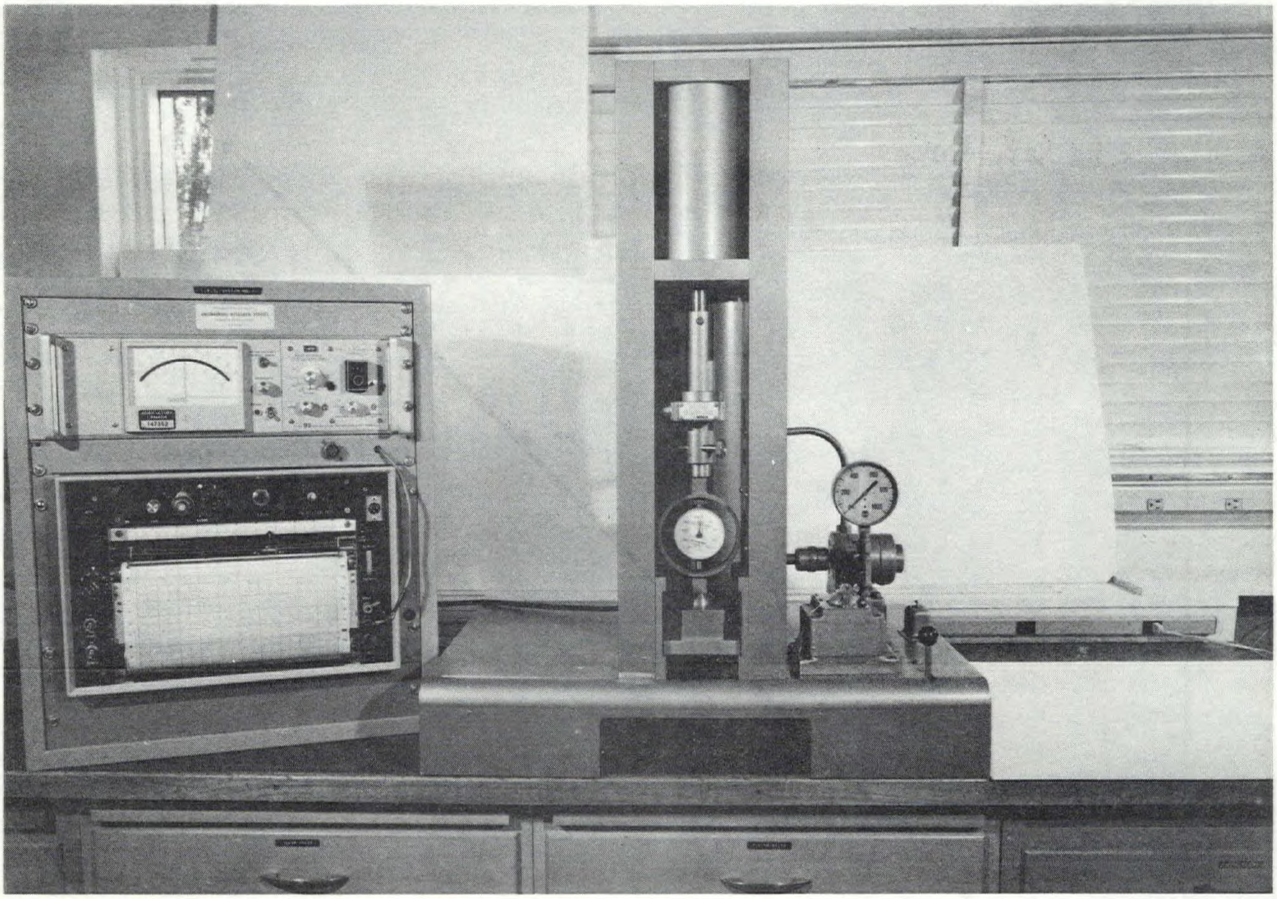

Figure 6. Calibrating the force transducer with a proving ring.

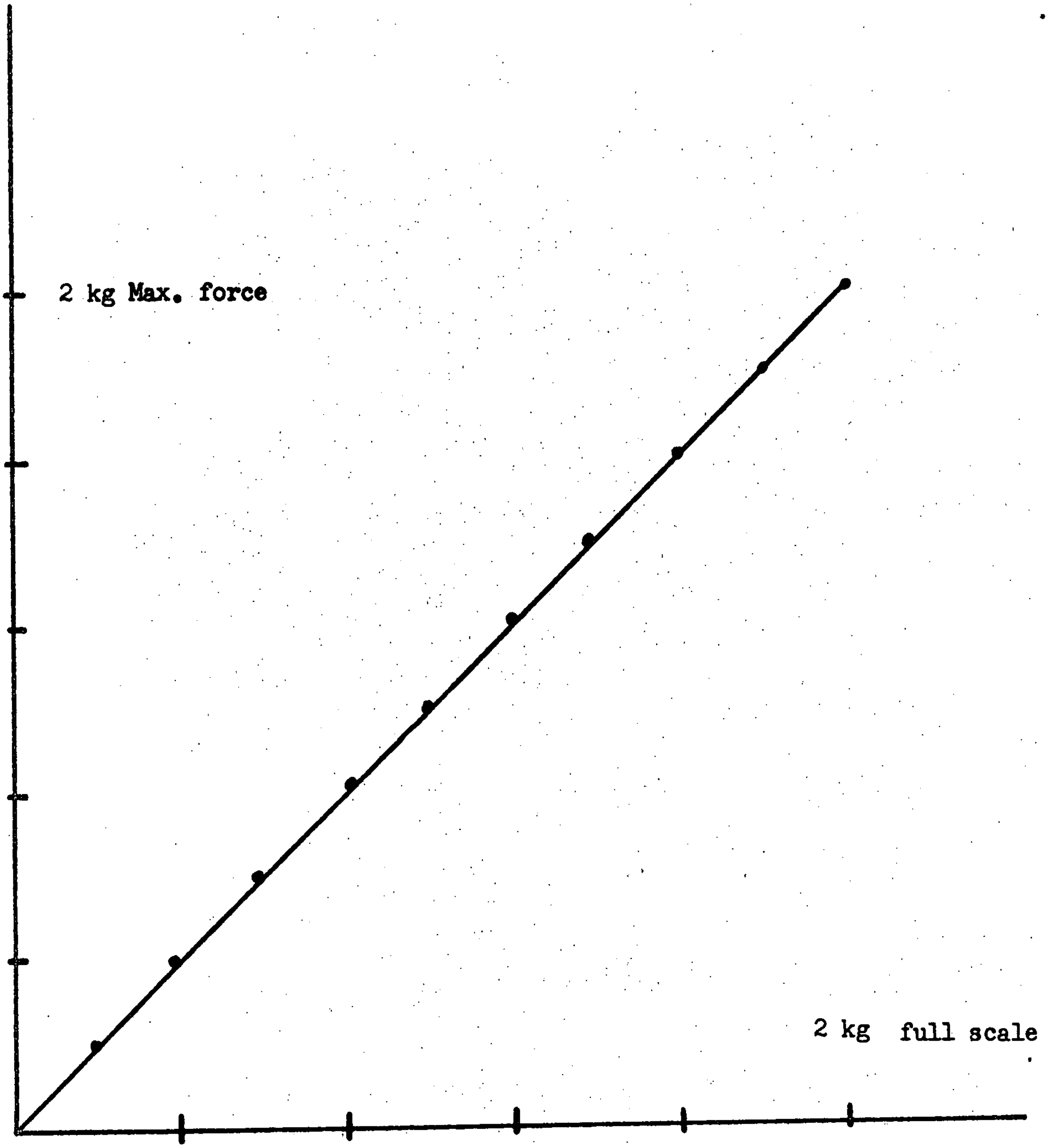

Figure 7. Calibration curve for 454 kg capacity transducer at its maximum sensitivity

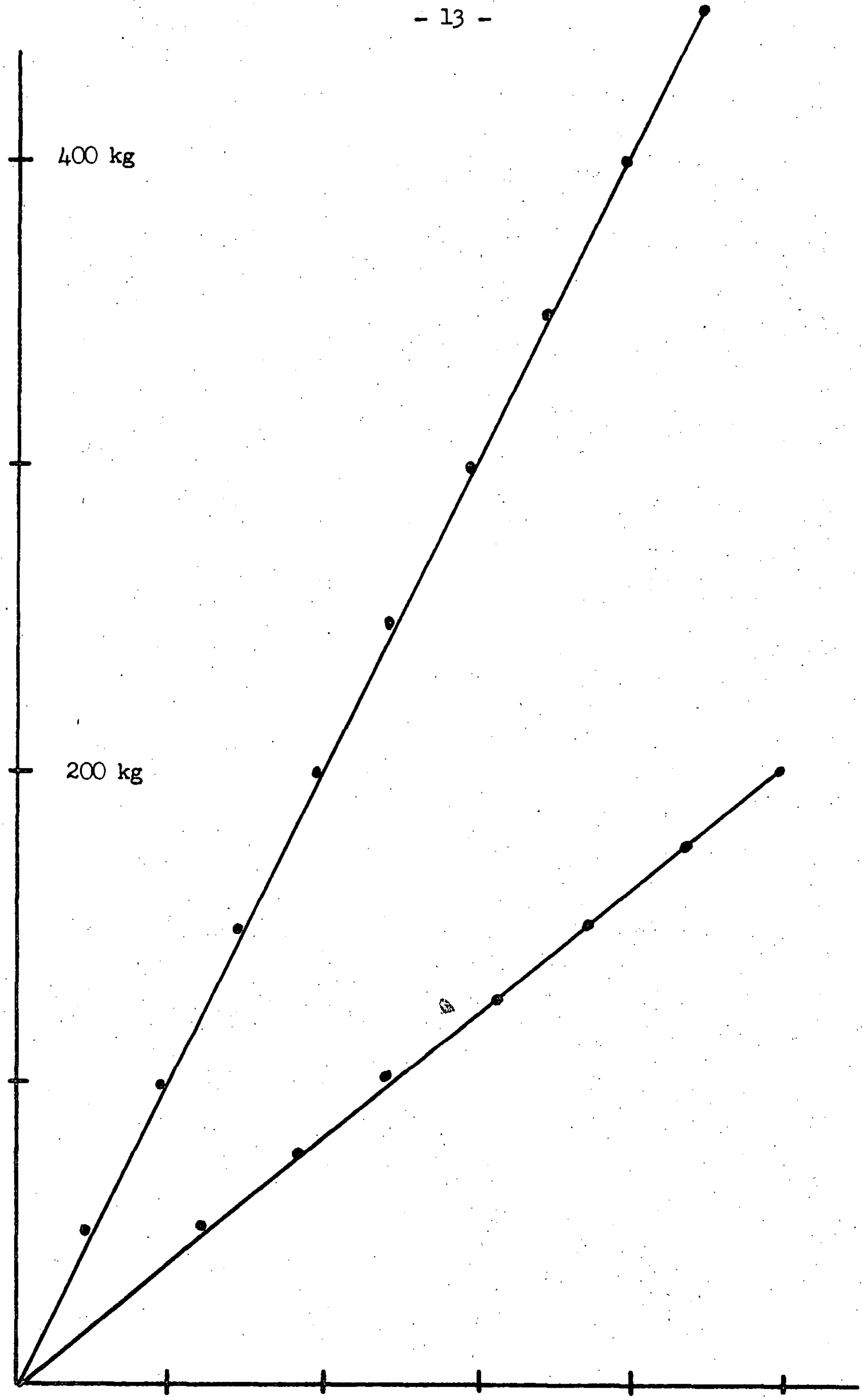

Figure 8. Typical transducer calibration curves using 200 and 500 kg as full-scale chart reading.

Appendix 1

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Canadien de Science et Technologie Alimentaire, Vol. 5, No 1

Updating the Shear Press[1]

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Abstract

Modifications are described to improve the operational flexibility and accuracy of early models of the Kramer Shear Press. The shearing blades of the shear-compression cell are machined so that they conform to the blade shape used in machines currently manufactured. Control and selection of ram speed is improved by replacing the needle valve in the hydraulic circuit with a flow valve. However, it is concluded that simple hydraulic controls do not provide accurate speed control for textural measurements. A motor driven screw press is considered preferable.

The method of recording force during testing is improved by using a strain gaged load cell, an amplifier and a strip-chart recorder with a 25 cm wide chart. This provides full-scale chart ranges of 25 to 1500 Kg with one load cell. The force recording system described could also be used to advantage with currently manufactured shear presses. Chart speed is independent of the press ram speed. A simple method of load cell calibration is also demonstrated.

It is concluded that because of inadequate speed control early models of the shear press are not suitable for texture tests.

Résumé

La flexibilité d'opération et la précision des modèles anciens de la presse à cisaillement Kramer ont été améliorées par des modifications appropriées. Les lames de cisailles de cellule à compression sont usinées de façon à correspondre à la forme des lames en usage sur les modèles nouveaux. Le contrôle et la sélection de la vitesse du piston sont améliorés par la substitution d'une valve d'écoulement à la valve à pointeau du circuit hydraulique. Il est cependant observé que les simples contrôles hydrauliques ne contrôlent pas la vitesse avec précision pour mesurer la texture. Une presse à vis motorisée est considérée supérieure.

La méthode d'enregistrement de la force au cours du mesurage a été améliorée par l'incorporation d'une cellule de charge jaugée, d'un amplificateur et d'un enregistreur à bande avec une bande de 25 cm de largeur. Ceci donne une marge de diagramme allant de 25 à 1500 kg avec une cellule de charge. Ce système d'enregistrement de la force pourrait aussi servir avantageusement avec les presses à cisaillement modernes. La vitesse du geaphique est indépendante de celle du piston de la presse.

Il est conclu que les anciens modèles de presse à cisaillement ne conviennent pas aux mesures de la texture à cause du contrôle de vitesse inadéquat.

Introduction

The Kramer Shear Press (K.S.) has become the most popular instrument for objective measurements of food texture since its introduction two decades ago (Kramer et al. 1951, a, b; Kramer and Aamlid, 1953). Since that time it has undergone a series of modifications such as the development of different texture test cells (Ang et al. 1963; Hartman et al. 1963), the addition of electronic force recording (Decker et al. 1957) and different methods of interpreting the data (Backinger et al. 1957). The K.S. has, thus, evolved into a versatile instrument (Anon, 1968, 1969; Kramer, 1957, 1961) and procedures for testing a wide range of products have been established, for example, peas (Anon, 1970). The machine, however, has remained essentially the same in operating principle and has been copied by other workers (Evans and Bicknell, 1962).

The K.S. has been widely used and its results compared with sensory tests and other instruments (e.g. Voisey, 1970; Voisey and Larmond, 1971). The most commonly used texture test cell utilized is the multiblade shear-compression cell. Interpretation of data from this attachment has, in recent years, improved, particularly with regard to the effect of sample weight (Szczesniak et al., 1970). The instrument is used mainly for research and is also applied to production quality control.

The K.S. has been manufactured by: Allo, Rockville, Maryland; L.E.E., 625 New York Ave., N.W., Washington D.C. and is currently manufactured by Food Technology Corp., 11425 Isaac Newton Square South, Reston, Virginia 22070 (F.T.C.). The latter company also provides a technical information support service through a series of bulletins describing different applications of the press. The early production units sold by "Allo" are now becoming obselete because of the control used for the hydraulic ram and the improved machines now available. It is also becoming uneconomic to repair the electronic systems of the older units which are based on outmoded tube circuits.

The purpose here is to describe a number of modifications and additions that can be used to update older models of the K.S. economically. These changes offer the advantages of modern texture instrumentation (Voisey, 1971) including operational flexibility greater than K.S. instruments currently manufactured. The changes can be made to units that were equipped with an electronic recording facility, or units where only a direct mechanical reading load cell was originally installed. The new electronic recording facilities can also be added to machines currently manufactured.

Ram speed in early units was not controlled precisely, and for manufacturing economy it was necessary to drive the recorder chart by connecting it mechanically to the ram movement. With improved speed control the chart speed can be independent. Thus, the time (i.e. deformation) axis of the force-deformation curve can be expanded or contracted to accentuate features on the curve. Deformation is then determined from the relationship between ram and chart speed.

Description

Three changes are made: a) the shearing blades of the texture test cell are modified; b) the hydraulic ram speed control circuit is improved and c) a new electronic force system added. The existing load cell, recording system and a cable mechanism driving the recorder chart are removed and discarded.

The Texture Test Cell: Currently manufactured shear-compression cells have the ends of the blades at an angle of 2.5° to the horizontal. The blades are arranged so that the resulting slope is in opposite direc-

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[1] Contribution No. 241 from Engineering Research Service.

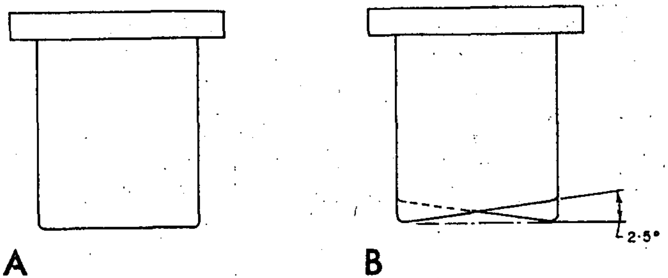

Fig. 1. Modification of shearing blades. A. original configuration; B. new configuration.

tions for adjacent blades (Figure 1B). Early models of the cell had the ends of the blades square (Figure 1A). This difference will obviously give results which, in theory, are not interchangeable between cells. The old cells can be modified by machining the ends of the blades. This is easily accomplished where the blades can be removed from their mounting block, but some of the cells were originally welded together so that machining the ends of the blades is more difficult. An alternative is to purchase a new shear-compression cell, particularly if the cell on hand is damaged or worn.

Ram Speed Control: The rate of deformation in any texture test instrument should be constant because the properties of many foods are time dependent. The speed of the ram in early models of the press was controlled by a needle valve (N, Fig. 2A) which restricted the flow of oil to the hydraulic cylinder. This does not provide accurate repeatable ram speeds because the flow is greatly affected by oil temperature, which increases with time of operation. This problem is reduced by replacing the needle valve with an inexpensive flow valve (F, Fig. 2B) (Model 2F23-R3-3-3-15 Fluid Controls Inc., Box 49, Mentor, Ohio 44060). A similar modification is included in current production models of the press. In the Allo machine the needle valve is placed in the pressure supply line above the piston (Fig. 2A), whereas the flow valve in the F.T.C. instruments is placed in the return line below the piston (Fig. 2G). To modify the Allo the flow valve was placed in the same position as the needle valve since this required a minimum of changes to the hydraulic piping.

The size of the valve required was determined from the volume of the hydraulic cylinder and the range of ram speeds required.

Estimated cylinder diameter	= 3.0 in
Ram stroke	= 3.5 in
Volume of cylinder	≅ 25 in^3
(Assuming 231 in^3/gallon)	
Oil per stroke	≅ 0.11 gallons
Original minimum time for ram stroke (measured)	15 sec
Maximum oil flow rate	≅ 0.43 gallons /min

The valve selected from the range available has an adjustable flow range of 0 to 1 gallon/min according to the manufacturers specification.

Incorporation of the valve involves modifying the hydraulic piping and adding a bypass line from the flow valve to the oil reservoir. The hand knob of the flow valve at which the flow rate is selected has a total range of about 3.5 turns. To facilitate selection of the knob position, it is replaced by a 10 turn counting dial normally used to indicate potentiometer settings on electronic instruments. This allows setting the knob position within one hundreth of a revolution.

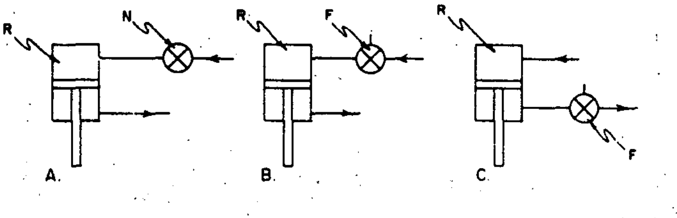

FIG 2

Fig. 2. Hydraulic control circuit for selecting ram speed. A. Original Allo machine; B. Modified Allo; C. F.T.C. machine; R. ram of press; N. needle valve; F. flow valve.

Force Recording System: Strain-gages are bonded to the inside of a tube to form a load cell (Figure 3) (Perry and Lissner, 1955). An adaptor screwed into the top of the cell fits over the end of the press ram and clamps it in position. A spacer screwed into the bottom of the tube supports the slide to which the moving blade assembly of the shear-compression cell is attached (Figure 4). The spacer is required to position the blades correctly relative to the fixed or box portion of the cell.

The load cell is connected to an amplifier (Model 300D-91 Daytronic Inc., Dayton, Ohio) which is, in turn, connected to a potentiometer type strip-chart recorder. The recorder selected is a general purpose multi-input range, multi-chart speed unit (e.g. Model SPG5V Riken Denshi, B. H. McGregor, P.O. Box 156, Toronto, Ontario) that can also serve as a recorder for other laboratory applications. This has an immediate advantage in that a wider chart (25 cm) is then available to give increased resolution of measurement. It should be noted that many other existing amplifier-recorder combinations could be used if a system were at hand (e.g. for the Instron Universal testing machine).

To facilitate calibration of the load cell a lever is balanced on a pivot mounted on the side frame of the

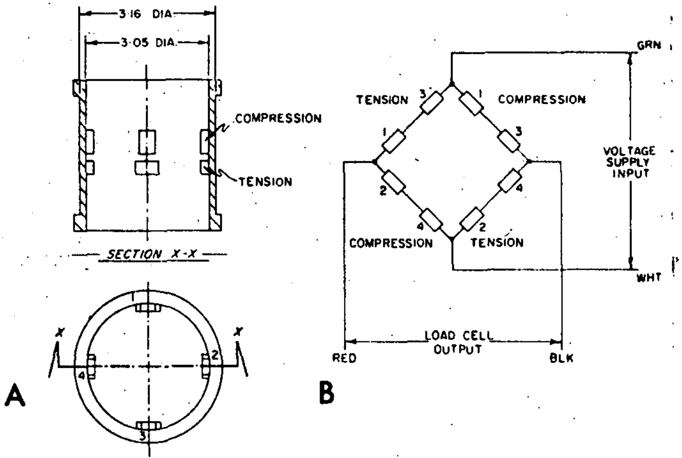

Fig. 3. A. arrangement of strain gages inside load cell tube; B. circuit diagram for strain gage connections.

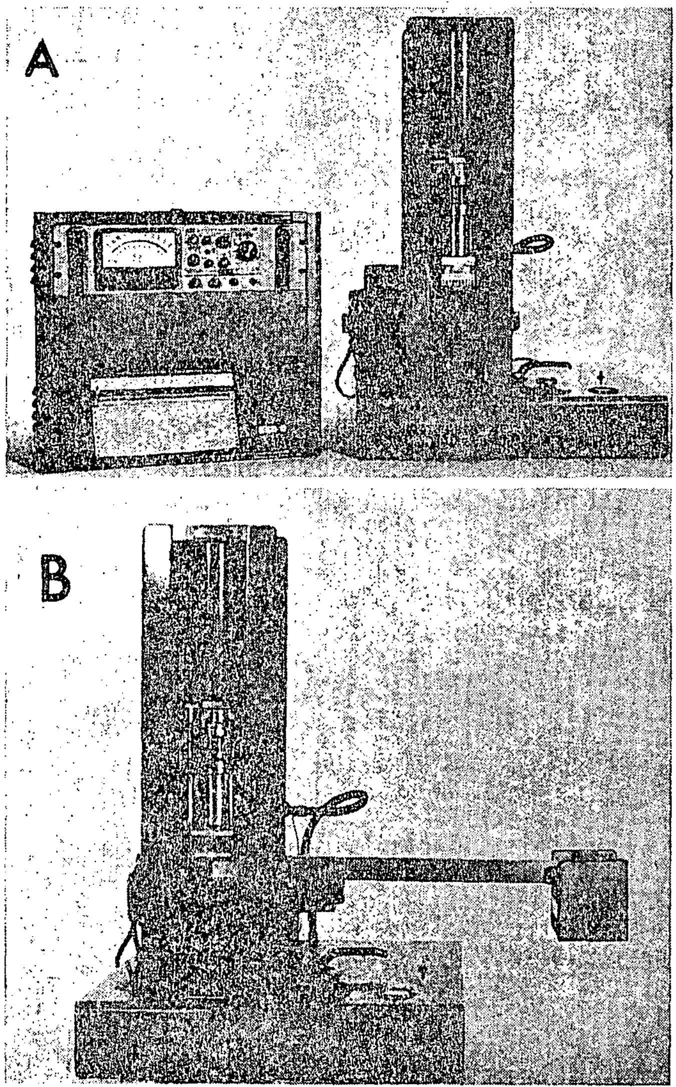

Fig. 4. A. The modified press; B. press with calibration attachments installed.

press (Figure 4B). One end of the lever rests on a protective block placed over the slides at the bottom of the load cell spacer. The free end of the lever emerges to the side of the press and weights are suspended on the end to apply force to the load cell. The lever provided a mechanical advantage of 5, thus, for each Kg placed on the lever, 5 Kg is applied to the load cell. To calibrate the system the lever is installed and the amplifier adjusted to give zero on the recorder, thus, eliminating the weight of the lever from the record. The weight selected to give full-scale recorder pen movement is then placed on the lever and the amplifier adjusted until the pen is at full-scale. These adjustments are repeated until both settings are correct and the lever removed. Zero is then readjusted to correct for the loss of lever weight. The force applied to the load cell is proportional to the angle of the lever to the horizontal. To facilitate levelling a spirit level is installed on top of the lever and a screw adjustment incorporated into the protective block on the load cell. The level of the machine itself is not as critical because the calibration is a relative change between zero and full-scale load. Friction in the pivot point and contact point with the protective block is minimized. Rollers on the end of the lever form a line of contact with the block and grease is applied to the pivot.

During routine operation of the press, the shear compression cell, filled with a sample, is installed in the press. The recorder chart is started and the amplifier adjusted until the recorder reads zero and then the down stroke of the ram started. Thus, zero errors and drift are eliminated from the force records.

With the system described, digital recording of maximum force can be accomplished if desired (Voisey, 1971). A peak memory module (Daytronic type M) is added to the amplifier and an inexpensive digital panel meter used to display its output. Peak force is the most common parameter reported from shear press measurements, therefore, this is a useful addition. The digital readout can either supplement or replace the recorder and will provide even greater resolution of measurement (0.01%).

The ring type electronic load cell originally supplied with the press can be utilized instead of manufacturing the special cell. All that is required is to use a different amplifier plug in (Model 70 Daytronic Inc.) that will accept the output of the differential transformer type transducer used in these cells. Another alternative is to purchase a commercially manufactured load cell from the wide range available (Voisey, 1971).

Performance Tests

Load Cell: The load cell was tested by using both the weight and the lever system and a proving ring normally used to calibrate the press (F.T.C. Model R.C. 1 calibration standard). Loads were applied in increments increasing from zero to the maximum and back to zero to establish linearity and hysteresis in the relationship between force and recorder pen deflection. The results (Table 1) indicate that under practical operating conditions the recording system can be operated at full-scale loads ranging from 25 to 1500 Kg with maximum errors of ± 0.5%.

The original Allo recording system, even after adjustment to the manufacturers specifications, had non linearities up to 6.5% using the 250 lb and up to 3% for the 3000 lb load cell. When these two Allo load cells were connected to the new recording system, the maximum non linearity was 1%.

It was observed that to achieve accurate calibration with the lever system care had to be exercised in levelling the lever and placing the weights. It was found that the best method was to suspend the weights from the lever with a strong cord so that the distance of the center of gravity of the weights from the lever pivot could be controlled accurately. It was considered practical to calibrate up to about 250 Kg. At higher loads physical effort was excessive.

Ram Speeds: A displacement transducer (Model 7101-16, R.I. Controls Inc., Minneapolis, Minnesota 55424) was connected between the frame of the press and the ram. Thus, the position of the ram could be recorded on a strip-chart against time to determine a) the ram velocity and b) the variations in ram speed during the ram stroke. Test loads were simulated by

Table 1. Typical Calibrations — Kramer shear press conversion using Daytronic Model 300D-93 amplifier, Riken Denshi recorder and strain gage load cell.

Full Scale Load (Kg)	Amplifier Range Switch Position (%)	Recorder Input Range (mV)	Maximum Non Linearity (%)
1500	100	10	0.75
750	50	10	1.00
125	10	10	0.50
25	5	10	0.20

placing a heavy spring between the base and ram. This imposed a load increasing linearly from 0 to 175 Kg during the ram stroke. For comparison, tests were performed on an Allo press in its original configuration (needle valve), a modified Allo press (flow valve) and a recently manufactured F.T.C. press.

Speed Ranges: The range of operational speeds was determined for control valve settings ranging from the minimum to the point where the valves were wide open. The results indicated that the relationships between dial settings and ram speeds for the modified Allo (Fig. 5A) and F.T.C. (Fig. 5B) presses were not linear. The modified Allo had an operating range of 0 to 38 cm/min and the F.T.C. 0 to 50 cm/min compared to the original Allo range of 0 to 37 cm/min. It was observed that the stroke of two Allo presses were 8.71 and 8.75 cm respectively and of the F.T.C. press 8.81 cm.

At any given valve setting it was apparent that the average ram velocity was different for the unloaded and loaded conditions (Table 2). The speed change ranged from 14 to 36% for the Allo up to the point where the needle valve was fully open and flow was no longer being controlled. The change in speed due to load for the modified Allo was less than 3% at speeds above 4 cm/min which was comparable to the F.T.C. press. It was, however, obvious that at low speeds where the flow valves in the modified Allo and F.T.C. machines were near the closed position (i.e. very small oil flows) that load had a marked effect on speed. The effect of load was to both increase and decrease speeds in the machines except the unmodified Allo where speeds consistently increased.

Linearity of ram speed with stroke: It was observed that the position of the unmodified Allo ram was not linearly related to time, i.e. the velocity was not constant (Fig. 6A). This was reduced by addition

Table 2. Average speed, effect of load and changes in ram velocity at different valve settings for 3 machines.

Machine	Average Speed Unloaded[a] (cm/min)	Speed Change Under Load[b,d] (%)	Maximum Deviation in Speed From Average[c] Unloaded (%)	Maximum Deviation in Speed From Average[c] Loaded[d] (%)	Deviation From Linear Line[e] Unloaded (%)	Deviation From Linear Line[e] Loaded[d] (%)
Allo	1.9	+12	+5	+4	1.0	0.8
	6.9	+36	+9	+11	1.5	0.8
	14.8	+21	+7	+4	1.0	0.5
	22.4	+19	+4	+4	1.0	0.3
	31.3	+14	+7	+3	1.0	0.5
	35.9f	+1	+5	+4	1.0	0.5
	36.8	0	+7	+7	0.8	0.5
	37.2	0	+6	+4	0.5	0.3
	37.5	0	+5	+3	0.5	0.2
Modified Allo	1.8	—25	+7	+6	1.7	1.7
	3.1	—22	+6	+6	0.1	0.8
	6.4	0	+3	+5	0.2	0.5
	14.2	+1	+5	+8	0.5	0.5
	22.1	0	+1	+5	0.5	0.5
	31.9	—4	+3	+3	0.1	0.8
	35.5	+1	+3	+5	0.1	0.9
	36.4f	—1	+3	+4	0.1	0.8
	37.4	—2	+2	+5	0.2	0.7
	37.7	—1	+3	+5	0.1	0.3
F.T.C.	4.3	—6	+5	+5	1.0	0.7
	6.4	—1	+2	+3	0.3	0.5
	15.4	—3	+2	+7	0.3	0.5
	18.3	—1	+3	+7	0.1	0.5
	27.8	+1	+3	+4	0.2	0.5
	39.9	+1	+2	+3	0.0	0.8
	50.3	—7	+3	+5	0.2	0.0
	58.7f	—1	0	0	0.1	0.0

[a] From straight line between origin and full-scale.

[b] $$\frac{\text{Average speed loaded} - \text{Average Speed Unloaded}}{\text{Average Speed Unloaded}} \times 100\%$$

[c] Estimated from slope of position vs time curve (see text).

$$\frac{\text{Average Speed} - \text{Maximum Deviation Speed}}{\text{Average Speed Unloaded}} \times 100\%$$

[d] Load increasing from 0 to 175 Kg during ram stroke.

[e] Estimated (see text).

[f] Valve fully open.

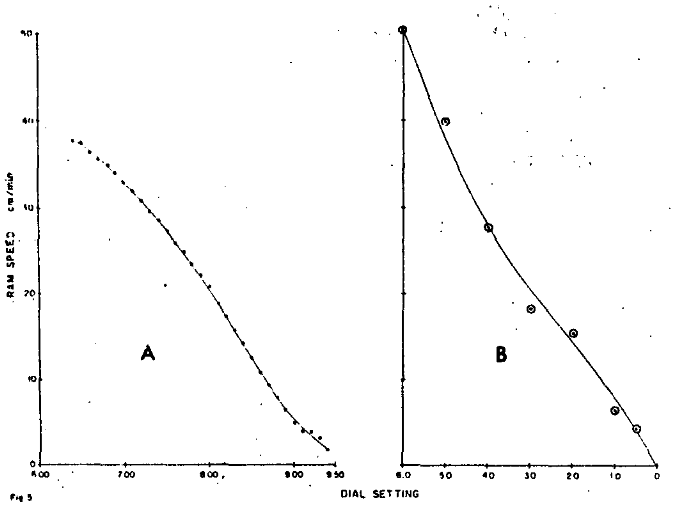

Fig. 5. Ram speed V. control valve dial setting. A. modified Allo press; B. F.T.C. press.

of the flow valve (Fig. 6B) and gave velocity control similar to that of the F.T.C. press (Fig. 6C). The machines were, therefore, operated over their speed ranges under both no load and simulated load conditions. The deviation of the ram speed from constant velocity was then estimated from the records by two methods. A straight line was drawn on the records from the origin (0, Fig. 6D) to the maximum distance travelled by the ram (F). This line was assumed to represent the average velocity since it would be the same as that determined by recording the time taken to complete the stroke using a stop watch. The deviation of the recorded line from the linear line was then measured and expressed as a percentage of full-scale (L). A second straight line (V-V) was drawn at a point on the curve where the slope was estimated to be at the maximum deviation from the average slope to calculate the velocity at that instant.

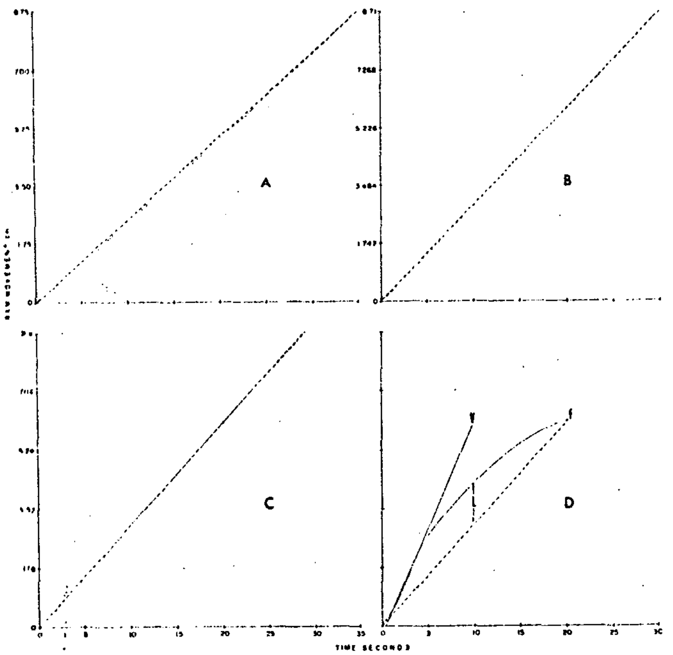

Fig. 6. Typical records of ram position Vs time. A. Allo press; B. Modified Allo press; C. F.T.C. press; D. estimation of velocity errors. Dotted lines represent constant velocity over ram stroke.

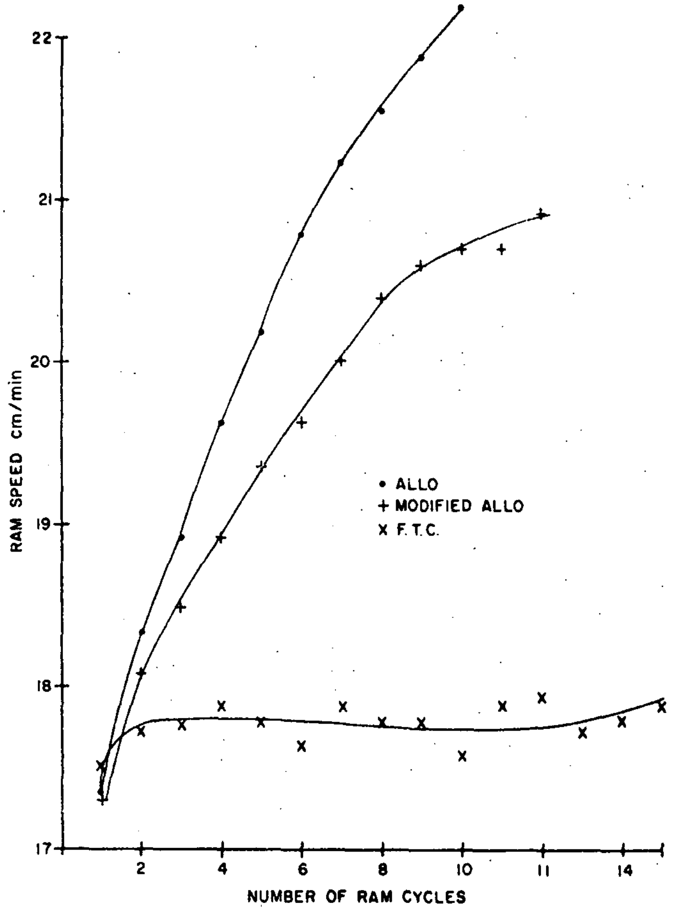

Fig. 7. Typical speed changes during warm up.

The results (Table 2) indicate that the ram velocity was not constant in the three machines. The changes in velocity varied with valve setting and in some cases were affected by the addition of a simulated load. The maximum speed deviation is expressed as a percentage of the unloaded speed since this is the parameter usually measured in setting up the press. Addition of the flow valve generally reduced the variation of speed during the stroke to about the same level as the F.T.C. machine. Velocity variations in the F.T.C. machine ranged from 2 to 7% depending on the speed and loading conditioning.

Ram speed changes during warm up: The F.T.C. operating manual claims that the ram speed is constant under all conditions. However, operators of Allo machines have observed that speeds do change considerably during testing, particularly during warm up. The three machines were, therefore, each tested during the warm up period at several speeds. The procedure used was to select a speed and cycle the ram up and down allowing a 5 min time lapse between each ram cycle to simulate reloading a sample into the texture test cell. The ram was cycled for a 90 min period at each speed and 24 hr allowed to elapse between

Table 3. Effect of running time[a] during warm up on ram speed (no load)

Machine	No. of Cycles	Average Speed During Test Cycles (cm/min)	Maximum Speed (cm/min)	Minimum Speed (cm/min)	Difference Between Speeds in Successive Cycles Maximum[b] (%)	Difference Between Speeds in Successive Cycles Minimum[b] (%)	Total Speed Change in Test Time[c] (%)
Allo	6	1.65	2.16	0.82	49	7	80
	11	20.42	22.58	17.35	6	2	26
	15	36.67	36.84	36.52	1	0	1
Modified Allo	8	2.83	2.60	1.63	14	1	34
	15	8.57	10.09	6.53	7	1	41
	13	19.72	21.33	17.34	4	0	20
	14	22.87	24.16	20.69	3	0	15
	17	34.49	36.35	24.16	2	0	38
F.T.C.	11	2.28	2.45	2.01	7	1	19
	15	17.76	17.87	17.50	1	0	2
	15	36.82	37.09	36.52	1	0	2

[a] Test span 90 min with a 5 min pause between cycles.

[b] $\frac{\text{First speed} - \text{Second speed} \times 100\%}{\text{First Speed}}$

[c] $\frac{\text{Maximum speed} - \text{Minimum speed}}{\text{Average Speed}}$

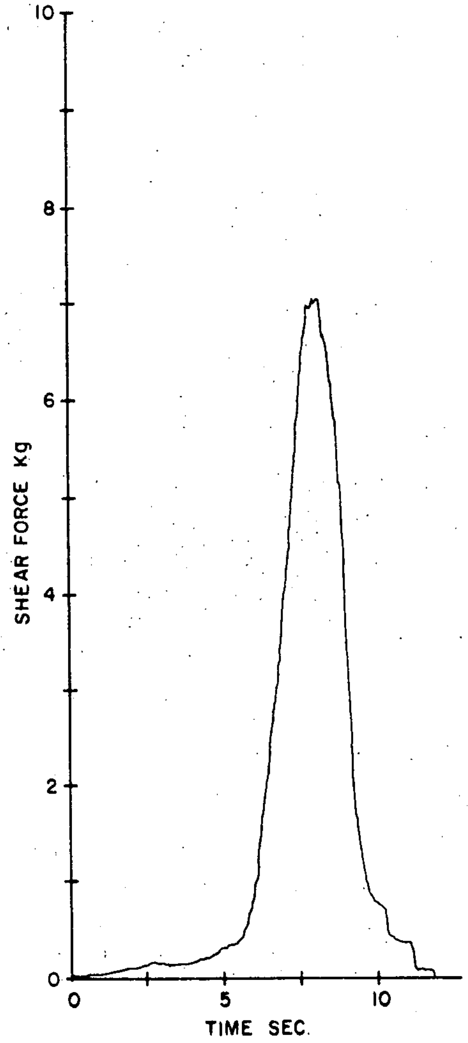

Fig. 8. Typical example — record of poultry meat tested in the meat shear cell.

each test speed so that the oil could cool.

The results (Table 3) indicate that, in all machines, speed changes considerably during warm up at slow speed settings. As the ram speed increases these changes are reduced. The addition of the flow valve to the Allo machine reduced the speed changes considerably to a performance comparable to the F.T.C. unit within the same range of speeds. Total speed changes over 90 min operation for both the modified Allo and F.T.C. press were still, however, highly significant.

Typical changes with time for the three machines operating at nominally the same speed at start up (Fig. 7) demonstrate this effect.

Discussion

The normal method of selecting compression speed in the K.S. is to time the ram stroke with a stop watch and many workers report only this time. This introduces the possibility of error between machines since it appears that the strokes of different machines are not the same. In the three machines tested there was a difference of 0.1 cm or 1.4%. This could be overcome by reporting ram velocity which would take into account any differences in ram stroke.

The fact that ram speed changes during warm up, particularly in unmodified Allo models should be recognized. The machines should be warmed up before selecting the test speed. Because speed is affected by load, the speed should be measured while testing a typical sample and then monitored continuously for all samples and adjusted when necessary. Use of the press at the extremes of the operating speed range should be avoided because of the inadequate speed control, particularly at the lowest speeds.

In all three machines the relationship between ram speed and time is not linear so the compression tests are not carried out at constant velocity. This should also be recognized since, in theory, this affects the result. The very inadequate speed control on the Allo machine makes it unsuitable for making precise textural measurements. The addition of a flow valve, which gives improved performance almost up to that of the F.T.C. machine, still does not provide sufficient precision for controlling long term accuracy and interchangeability between machines. The performance of the K.S. could be further improved by the addition of more sophisticated hydraulic controls and a heat exchanger to control oil temperature. These costs might be excessive, however, compared to using a synchronous motor and screw to drive the press.

In any instrument where a parameter is variable it is convenient if an accurate calibration curve can be established such as the control position vs ram speed (Fig. 5). In the K.S. establishing an accurate curve is difficult because of the effect of oil temperature. It is only practical to establish a curve to serve as a guide in selecting speeds. It is then necessary to go through the tedius procedure of measuring the speed and constantly checking it throughout the test. These findings support the author's contention (Voisey, 1971) that a motor driven screw is the most economical and efficient method of achieving constant deformation rates for texture test. Such systems provide speeds that are repeatable and constant within 0.1%.

The addition of a strain gaged load cell and recording system to the K.S. is useful since a wide range of test forces can then be recorded with a higher degree of resolution and with greater accuracy than before. Only one load cell is required, as opposed to the two needed to achieve the same capability as the system provided with the K.S. The system described coupled with careful calibration techniques provides greatly improved operational flexibility. For this reason it may be useful and more economical to purchase similar systems for use with the currently manufactured K.S. The operating principles of the K.S. are not changed by this addition and the results should, in theory, be unchanged. A typical example, in testing poultry meat in the meat shear cell is shown in Fig. 8.

The costs of the modifications are modest and depend on the technical support available to execute them. The hydraulic flow valve costs $80 and the 10 turn dial used costs approximately $10. The load cell, complete with calibration attachments is now available commercially, (Queensboro Instruments, Ottawa, Ont.) for about $250. The amplifier costs $500 (U.S.) and the recorder $560. Thus, total costs are about $1400. Additional expenditures, up to about $100, may be required if the recorder and amplifier are assembled and permanently wired in a cabinet.

Conclusions

Control of deformation rates in the Allo models of the K.S. is inadequate for textural tests. This can be partly eliminated by installing a flow valve in place of the needle valve used to control oil flow to the ram.

The use of a strain gaged load cell, amplifier and wide chart recorder is a useful addition since operational flexibility and accuracy are increased.

References

Ang, J. K., Hartman, J. and Isenberg, F. M. 1963. New applications of the shear press in measuring texture in vegetables and vegetable products. II. Correlation of subjective estimates of texture of a number of whole and cut vegetables and objective measurements made with several sensing elements of the shear press. Proc. Amer. Soc. Hort. Sci., 83: 735.

Anon. 1968. Texture-test systems designed to measure quality of foods. Can. Food Ind., 39(7): 53.

Anon. 1969. Texture-testing systems. Food Technology Corp., Reston, Virginia, 22070.

Anon. 1970. Grading tenderness - maturity of peas with the F.T.C. T-1300 tenderometer system. Bulletin. Food Technology Corps., Reston, Virginia, 22070.

Backinger, G. T., Kramer, A., Decker, R. W. and Sidwell, A. P. 1957. Application of work measurement to the Determination of Fibrousness in Asparagus. Food Technol., 11: 583.

Decker, R. W., Yeatman, N. N., Kramer, A. and Sidwell, A. P. 1957. Modification of the Shear Press for Electric Indicating and Recording. Food Technol., 11: 313.

Evans, G. and Bicknell, N. W. 1962. Load cell tenderometer for measuring the texture of peas and its possible use for automatic quality control. Proc. 1st. Int. Congr. Food Sci. Technol., 3: 405.

Hartman, J. D., Isenberg, F. M. and Ang, J. K. 1963. New applications of the shear press in measuring texture in vegetables and vegetable products. 1. Modifications and attachments to increase versatility and accuracy of the press. Proc. Amer. Soc. Hort. Sci., 82: 465.

Kramer, A., Aamlid, K., Guyer, R. B. and Rogers, H. P. 1951. New shear press predicts quality of canned limas. Food Eng., 23: 112.

Kramer, A., Burkhardt, G. J. and Rogers, H. P. 1951. The shear-press, a device for measuring food quality. Canner, 112: 34.

Kramer, A. and Aamlid, K. 1953. The shear press, an instrument for measuring the quality of foods. III. Application to peas. Proc. Amer. Soc. Hort. Sci., 61: 417.

Kramer, A. 1957. Food texture rapidly gaged with versatile shear press. Food Eng., 29 (1): 57.

Kramer, A. 1961. The shear press - a basic tool for the food technologist. Food Scientist, 5 (1): 7.

Perry, C. C. and Lissner, H. R. 1955. The strain gage primer. McGraw-Hill Book Co. Inc., New York.

Szczesniak, A. S., Humbaugh, P. R. and Block, H. W. 1970. Behaviour of different foods in the standard shear compression cell of the shear press and the effect of sample weight on peak area and maximum force. J. Text. Studies 1: 356.

Voisey, P. W. 1970. Test cells for objective textural measurements. Can. Inst. Food Technol. J., 3: 93.

Voisey, P. W. 1971. Modernization of texture instrumentation. J. Text. Studies, 2: 129.

Voisey, P. W. and Larmond, E. 1971. Texture of baked beans, a comparison of several methods of measurement. J. Text. Studies, 2: 96.

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