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Some Applications of the Ottawa Texture Measuring System

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Contribution No. 694 from Engineering Research Service, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Some Applications of the Ottawa Texture Measuring System

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1.0 Introduction

The Ottawa Texture Measuring System (OTMS), introduced in 1971, was developed to provide a general purpose system for measuring the mechanical and rheological properties of food and agricultural products. The system comprises of an electric motor driven press, an electronic system for recording force deformation and time and a selection of test cells to handle various types of tests on a range of products undergoing linear deformations at a constant rate. By selecting components of the system it can be arranged to have the operational flexibility required for research applications. Once a measuring technique has been developed for a specific product, the same basic system can be used in production and quality control applications. The difference between the research and quality control units is primarily the provision of variable or fixed deformation rates (i.e. different motors and controls) and the use of a strip-chart recorder or digital peak force indicator. A feature of the system is convenience in standardizing the force measuring system and the availability of a range of texture test cells that are interchangeable (mechanically) within the system without the need for adaptation to the selected attachment system.

The system has been available commercially since about 1974 and systems or various components (e.g. test cells) have been widely distributed. The purpose here was to review some of the applications made by researchers outside Engineering Research Service. There have been numerous applications of the equipment several which cannot be reported here because of commercially confidential aspects. The survey cannot, therefore, be considered complete. A number of users, known to the author, were contacted to give a brief summary of their applications. These are listed in the report. The report also serves to assemble an up to date list of references covering applications made by Engineering Research Service and to show in detail how the test cells can be adapted to operate in Instron Testing Machines by available attachments.

2.0 Reported Applications

The applications are listed with only the brief information requested in the survey. The intention was not to give complete procedural details but rather indicate that a product was tested and if useful results were obtained.

1. Contributed by: Dr. A.S. Szczesniak, Central Research Department, General Foods Corporation, Technical Center, White Plains, New York 10625.

   Product: Raw meat paste

   Test cell used: 50 cm^2 OTMS with perforated plate extrusion insert with 1.1 cm diameter holes.

   Deformation mechanism: Instron Model TM

   Method of controlling sample size: Weight 300 g

   Deformation rate cm/min: 2.5

   Approximate maximum force kg: 100

   Readings taken from curves: Steady extrusion force

   Outcome: Method able to detect differences due to variations in the water/solids content

2. Contributed by: Dr. A.S. Szczesniak, Central Research Department, General Foods Corporation, Technical Center, White Plains, New York 10625.

   Product: Ground cooked meat

   Test cell used: 10 cm^2 OTMS with wire extrusion insert

   Deformation mechanism: Instron Model TM

   Method of controlling sample size: Volume - fill cell to capacity

   Deformation rate cm/min: 25.4

   Approximate maximum force kg: 100

   Readings taken from curves: Hardness, cohesiveness, chewiness and maximum force using the Minnesota method. See Breene and Barker, J. Texture Studies 6, 459, 1975.

   Outcome: Method gave poor resolution in detecting decrease in resistance caused by enzymatic digestion and values did not follow the logical order expected on the basis of other mechanical measurements and the severity of the enzymatic treatment; eliminating small variations in sample weight did not alleviate the situation.

3. Contributed by: Prof. William M. Breene, Dept. of Food Science & Nutrition, University of Minnesota, St. Paul, Minnesota 55108.

Product: Textured vegetable products and ground beef by the Minnesota method

Test cell used: 10 cm^2 OTMS with 8 wire extrusion insert

Deformation mechanism: Instron Model TM

Method of controlling sample size: Volume - cell filled and lightly packed to capacity

Deformation rate cm/min: 5

Approximate maximum force kg: 35

Readings taken from curves: Hardness, cohesiveness, extrudability, chewiness, maximum force, average maximum force, packability (see references)

Outcome: The method separated different rehydrated commercial soy protein products and cooked ground beef: soy mixtures into textural classes. Maximum force and average maximum force were the parameters which detected the greatest differences between textural classes. The results indicated substantial predictability of sensory evaluations from the Minnesota instrumental method on 8 commercial textured soy protein products and their mixtures with ground beef.

References

Breene, W.M. and Barker, T.G. 1975. Development and application of a texture measurement procedure for textured vegetable protein. J. Texture Studies 6: 459 - 472.

Loh, J. and Breene, W.M. 1977. Texture analysis of textured soy protein products: Relations between instrumental measurement and sensory evaluation. J. Texture Studies (in press).

4. Contributed by: Prof. William M. Breene

Product: Popped popcorn - Preliminary method

Test cell used: 10 cm^2 OTMS with 4 - 0.25 mm thick cutting blades in a grid

Deformation mechanism - Instron Model TM

Method of controlling sample size: Volume

Outcome: Appears to work and will be published shortly

5. Contributed by: Prof. William M. Breene, Dept. of Food Science & Nutrition, University of Minnesota, St. Paul, Minnesota 55108.

Product: Cheese - Preliminary method

Test cell used: 10 cm^2 OTMS with 4 - 0.25 mm thick cutting blades in a grid

Outcome: Not reported

6. Contributed by: A.H. Martin, Research Station, Agriculture Canada, Lacombe, Alberta T0C 1S0.

Product: Raw and cooked beef

Test cell used: Warner-Bratzler Meat Shear of the OTMS using 1 blade

Deformation mechanism: OTMS Research model

Method of controlling sample size: Cores cut from meat 2 cm diameter

Deformation rate cm/min: 19.8

Approximate maximum force kg: 7

Readings taken from curves: Maximum force

Outcome: For cooked meat from many thousands of muscles tested over several years from different breeds of animals consistently show that Warner Bratzler force readings correlate well with sensory analysis (r = 0.68 to 0.88). Results also show a) no relationship between raw and cooked tenderness; b) the Armour meat tenderometer probe on raw meat does not predict cooked tenderness; c) the OTMS wire extrusion cell does not predict tenderness from raw or cooked meat; d) muscle pH values do not predict tenderness.

Reference

L'Hirondelle, P.J. and Martin, A.H. 1975. Evaluation of methods of assessing tenderness on raw and cooked beef muscle. Can. J. Animal Sci. 55: 519 - 525.

7. Contributed by: Prof. M.C. Bourne, Dept. of Food Science & Technology, Cornell University, Food Research Laboratory, Geneva, New York 14456.

Product: Fresh ungraded peas

Test cell used: 30 cm^2 OTMS wire extrusion cell - N.B. the cell standardized for peas

Deformation mechanism: Instron - Floor model

Method of controlling sample size: Weight - 150 g

Deformation rate cm/min: 20

Approximate maximum force kg: 250

Readings taken from curves: Maximum force

Outcome: Satisfactory

8. Contributed by: Germain Samoisette, Station de Recherches, Canada Agriculture, C.P. 457, St. Jean, Quebec, J3B 6Z8.

Product: Fresh apple

Test cell used: Puncture test set and compression cell

Deformation mechanism: OTMS Research model

Method of controlling sample size: None

Deformation rate cm/min: 20

Approximate maximum force kg: 10

Readings taken from curves: Maximum force

Outcome: Results do not agree with fruit pressure tester readings

9. Contributed by: Germaine Samoisette, Station de Recherches, Canada Agriculture, C.P. 457, St. Jean, Quebec, J3B 6Z8.

Product: Fresh peas (graded)

Test cell used: 30 cm^2 OTMS wire extrusion cell. N.B. the cell standardized for peas

Deformation mechanism: OTMS research model

Method of controlling sample size: Peas graded by size 1 to 5 and cell filled to capacity

Deformation rate cm/min: 15

Approximate maximum force kg: 100

Readings taken from curves: Maximum force

Outcome: Works very well

10. Contributed by: Germain Samoisette, Station de Recherches, Canada Agriculture, C.P. 457, St. Jean, Quebec, J3B 6Z8.

Product: Fresh and stored onions

Test cell used: Compression

Deformation mechanism: OTMS Research model

Method of controlling sample size: None

Deformation rate cm/min: 15

Approximate maximum force kg: 3.2

Readings taken from curves: Deformation to cause a force change of 2.8 kg from automatic system

Outcome: Works very well

11. Contributed by: J.A. Kitson, Food Processing Section, Research Station, Agriculture Canada, Summerland, B.C. V0H 1Z0.

Product: Canned apple sections

Test cell used: 30 cm^2 OTMS wire extrusion cell

Deformation mechanism: OTMS Research model

Method of controlling sample size: Weight of drained product

Deformation rate cm/min: 16.25

Approximate maximum force kg: 50

Readings taken from curves:

Outcome: With large containers the contents must be mixed before testing since texture is influenced by position of the fruit in the can. This is due to differences in processing received, syrup stratification and varying diffusion rates through the can volume.

12. Contributed by: Dr. R.J. Forrest, Animal Science, Research Station, Agriculture Canada, Agassiz, B.C. V0M 1A0.

Product: Cooked meat (Longuissimus, Dorsi and Round Muscles)

Test cell used: Warner-Bratzler meat shear cell of the OTMS using 1 or 3 blades

Deformation mechanism: OTMS Research model

Method of controlling sample size: Raw samples cut 8 cm thick are cooked in a microwave oven, cooled to approximately 4 - 6°C and cores are taken using a 21 mm standard cork borer that has been dipped in a light cooking oil, i.e. Mazola oil, and and allowed to drain.

Deformation rate cm/min: 10

Approximate maximum force kg: 28 using 3 blades, 10 using 1 blade

Readings taken from curves: Maximum force

Outcome: Results show that the O.T.M.S. will show a difference in the tenderness of cooked meat and that the 3 blade method would appear to be more reliable than a single blade when used to shear the cores.

13. Contributed by: Dr. B.B. Chubey, Horticultural Crops Section, Research Station, Agriculture Canada, P.O. Box 3001, Morden, Manitoba R0G 1J0.

Product: Baked and boiled potatoes

Test cell used: OTMS extrusion cell with perforated plate

Deformation mechanism: OTMS Research model

Method of controlling sample size: Cubes to fit internal cell dimensions

Deformation rate cm/min: 20

Approximate maximum force kg: 10

Readings taken from curves: Maximum force

Outcome: Satisfactory

14. Contributed by: Dr. B.B. Chubey, Horticultural Crops Section, Research Station, Agriculture Canada, P.O. Box 3001, Morden, Manitoba R0G 1J0.

Product: French fries

Test cell used: Texture test system single blade meat shear cell

Deformation mechanism: OTMS Research model

Method of controlling sample size: 10 fries in a single layer

Deformation rate cm/min: 6

Approximate maximum force kg: 2.5

Readings taken from curves: Maximum force

Outcome: Not totally satisfactory, occasionally crisp skin was forced into slot before maximum force (cutting) occurred causing an abnormally high peak force.

15. Contributed by: Dr. B.B. Chubey, Horticultural Crops Section, Research Station, Agriculture Canada, P.O. Box 3001, Morden, Manitoba R0G 1J0.

Product: Cooked field peas

Test cell used: OTMS extrusion cell equipped with a perforated plate

Deformation mechanism: OTMS Research model

Method of controlling sample size: Weight of dry peas

Deformation rate cm/min: 16

Approximate maximum force kg: 10

Readings taken from curves: Maximum force

Outcome: Not satisfactory - one hard pea in a cooked sample gave a false reading

16. Contributed by: Dr. B.B. Chubey, Horticultural Crops Section, Research Station, Agriculture Canada, P.O. Box 3001, Morden, Manitoba R0G 1J0.

Product: Cooked field peas

Test cell used: 3.175 mm diameter puncture probe

Deformation mechanism: OTMS Research model

Method of controlling sample size: Individual peas tested on an improvised template

Deformation rate cm/min: 16

Approximate maximum force kg: 16

Readings taken from curves: Maximum force

Outcome: Excellent for reproducibility but slow - needs to be automated

17. Contributed by: Dr. W.P. Mohr, Smithfield Experimental Farm, Agriculture Canada, P.O. Box 340, Trenton, Ontario, K8V 5R5.

Product: Fruit pressure testers

Test cell used: Compression

Deformation rate cm/min: Static

Approximate maximum force kg: 30

Readings taken from curves: Used to verify calibration of the fruit pressure tester scales

Outcome: Provides a useful accurate standard

18. Contributed by: Dr. W.P. Mohr, Smithfield Experimental Farm, Agriculture Canada, P.O. Box 340, Trenton, Ontario, K8V 5R5.

Product: Whole fresh apples

Test cell used: Puncture test probe from fruit pressure tester

Deformation mechanism: OTMS Quality control model

Deformation rate cm/min: 18

Approximate maximum force kg: 10

Readings taken from curves: Maximum force

Outcome: Useful test for supplementing fruit pressure tests of apple firmness - maturity

19. Contributed by: Dr. W.P. Mohr, Smithfield Experimental Farm, Agriculture Canada, P.O. Box 340, Trenton, Ontario, K8V 5R5.

Product: Apple sauce

Test cell used: Back extrusion, 60 mm diameter with 59.5 mm diameter extrusion plunger 9.5 mm thick

Deformation mechanism: OTMS Quality control model

Method of controlling sample size: volume

Deformation rate cm/min: 18

Approximate maximum force kg: 40 (high frequency recorder)

Readings taken from curves: Average force and amplitude of force fluctuations during extrusion

Outcome: Useful and reflects effect of particle size to evaluate graininess. Clearly separates smooth and grainy samples

References

Voisey, P.W. and Mohr, W.P. 1975. Development of an instrumental test of apple sauce graininess. Rept. 7316-510. Eng. Res. Service.

20. Contributed by: Dr. W.P. Mohr, Smithfield Experimental Farm, Agriculture Canada, P.O. Box 340, Trenton, Ontario, K8V 5R5.

Product: Fresh tomatoes for canning as whole fruit

Deformation mechanism: OTMS Quality control model

Test cell used: 30 cm^2 OTMS wire extrusion cell with an extrusion grid of 9 wires

Method of controlling sample size: Weight 225 g of tomatoes each cut into 12 pieces. Tested with and without skin

Deformation rate cm/min: 18

Approximate maximum force kg: 50

Readings taken from curves: Maximum force

Outcome: Readings related to wholeness retention of fruit after canning. Readings with skin were about double those without.

References

Voisey, P.W. and Mohr, W.P. 1976. Some instrumental techniques for measuring fruit firmness-related properties and skin strength of fresh tomatoes and for predicting wholeness retention after canning. Rept. 7307-575. Eng. Res. Service.

21. Contributed by: R.A. Genge, Horticultural Research Institute of Ontario (HRIO), Vineland Station, Ontario L0R 2E0

Product: Clingstone peaches and apples

Deformation mechanism: OTMS Research model

Test cell used: Compression

Method of controlling sample size: Cylindrical core cut from fruit

Deformation rate cm/min: 1.0

Approximate maximum force kg: 10

Readings taken from curves: Modulus of elasticity from slope of initial portion of curve, yield stress from 0.2% offset point and energy from area under curve.

Outcome: Measurements examined in relation to resistance of fruits to impact and bruising. Machine operated satisfactorily but the quasi statically measured responses did not related to bruising under dynamic loading.

22. Contributed by: R.U. Chudyk, Horticultural Research Institute of Ontario (HRIO), Vineland Station, Ontario L0R 2E0.

Product: Fresh and frozen and thawed tomatoes

Deformation mechanism: OTMS Research model

Test cell used: 4.75 mm diameter puncture probe

Method of controlling sample size: Slices 6.4 mm thick obtained with special slicer and penetration readings taken in the inner and outer pericarp

Deformation rate cm/min: 5

Approximate maximum force g: 500

Readings taken from curves: Bioyield force

Outcome: There were differences in readings relative to a) maturity and b) freezing procedures

References: Details of similar tests shown in Voisey, P.W. and Mohr, W.P. 1976. Some instrumental techniques for measuring fruit firmness-related properties and skin strength of fresh tomatoes and for predicting wholeness retention after canning. Rept. 7307-575. Eng. Res. Service

23. Contributed by: R.U. Chudyk, Horticultural Research Institute of Ontario (HRIO), Vineland Station, Ontario LOR 2E0.

Product: Fresh Strawberries

Deformation mechanism: OTMS Research model

Test cell used: 2.4 mm diameter puncture probe

Deformation rate cm/min: 5

Approximate maximum force g: 200

Readings taken from curves: Bioyield force

Outcome: Differences in texture observed relative to a) maturity and b) freezing treatment

24. Contributed by: T. Fuleki and F.I. Cook, Horticultural Research Institute of Ontario (HRIO), Vineland Station, Ontario LOR 2E0.

Product: Canned Clingstone Peaches

Deformation mechanism: OTMS Research model

Test cell used: Shear-Compression Cell Cat. CS-1 of the Texture Test System, Food Technology Corp., Rockville, Maryland.

Method of controlling sample size: Two peach halves

Deformation rate cm/min: 10

Approximate maximum force kg: 80

Readings taken from curves: Area under curve per 100 g of sample, slope and maximum force

References

Fuleki, T. and Cook, F.I. Relationship between maturity of clingstone peaches as measured by raw flesh color of the halves and color, flavor and texture of canned peaches. J. Food Sci. (in press)

25. Contributed by: W. Lay, Horticultural Research Institute of Ontario (HRIO), Vineland Station, Ontario LOR 2E0.

Product: Sweet and sour (fresh) cherries

Deformation mechanism: OTMS Research model

Test cell used: Special cell developed by ERS to hold cherry while stem pulled out

Deformation rate cm/min: 10

Approximate maximum force kg: 1

Readings taken from curves: Maximum force required to pull stem from cherry

Outcome: Results were consistent and showed varietal, maturity and chemical treatment effects

26. Contributed by: R.B. Smith, Horticultural Research Institute of Ontario (HRIO), Vineland Station, Ontario L0R 2E0.

Product: Raw Peaches

Deformation mechanism: OTMS Research model

Test cell used: 2.4 mm diameter puncture probe

Method of controlling sample size: Peaches sorted for ripeness using the internal quality analyzer

Deformation rate cm/min: 10

Approximate maximum force kg: 0.5

Readings taken from curves: Bioyield force

Outcome: Readings separated peaches into 3 distinct ripeness groups and suggested that inducing ripeness by various levels of ethylene treatment did not soften the peaches. The bioyield point suggested that the peaches were firmer after treatment.

27. Contributed by: R.B. Smith, Horticultural Resaerch Institute of Ontario (HRIO), Vineland Station, Ontario L0R 2E0.

Product: Processed clingstone peaches

Deformation mechanism: OTMS Research model

Test Cell used: 20 cm^2 OTMS wire extrusion cell with wire grid replaced by solid insert to convert it to a back extrusion cell.

Method of controlling sample size: 175 g

Deformation rate cm/min: 10

Approximate maximum force kg: 60

Readings taken from curves: Maximum force and area under the curve

Outcome: Treatment by ethylene to induce ripeness had no significant effect on softening of the product.

28. Contributed by: R.J.B. Bingham, Processors & Growers Research Association, The Research Station, Great North Road, Thornhaugh, Peterborough PE8 6HJ, England.

Product: Fresh Peas

Test cell used: 30 cm^2 OTMS wire extrusion cell equipped with a 9 - 2.4 mm diameter wire grid

Deformation mechanism: Instron Table Model 1140

Method of controlling sample size: Cell filled to capacity. The method and equipment can be considered to be the same as the OTTAWA PEA TENDEROMETER.

Deformation rate cm/min:

Approximate maximum force kg: 270

Readings taken from curves: Maximum force

Outcome: Comparisons with readings from the FMC pea tenderometer showed that there is a linear relationship with Ottawa Pea Tendeormeter (OPT) readings and the OPT offers notable advantages as a replacement for the FMC machine.

References

Bingham, R.J.B. 1976. Evaluation of a new texture measuring system. Tech. Memorandum No. 22. Processors and Growers Research Assocation.

29. Contributed by: J.G. Schoonens, Peters Ice Cream (W.A.) Ltd., 92 Roe Street, Perth, Western Australia, G.P.O. Box U1939, Perth 6001, Australia

Product: Fresh peas

Deformation mechanism: Hand operated screw press

Test cell used: OTMS wire extrusion cell with 6 wire grid made of 3.2 mm diameter wires. Thus, the instrument represents a portable hand powered version of the OTTAWA PEA TENDEROMETER.

Method of controlling sample size: Fill cell to capacity

Deformation rate cm/min: Approximately 20 when screw turned at 1 revolution/sec

Approximate maximum force kg: 250

Readings taken from curves: Maximum force

Outcome: Data shows that bruising of peas or split skins affect the Ottawa Pea Tendeormeter (OPT) readings. Also the OPT readings are linearly related to Maturometer readings in establishing maturity of fresh peas.

30. Contributed by: E. Bilinski, Y.C. Lau and R.E.E. Jonas,
Industry Technology and Marine Service,
Department of Fisheries and the Environment,
Vancouver Technical Laboratory,
6640 N.W. Marine Drive,
Vancouver, B.C. V6T 1X2.

Product: Canned herrings

Deformation mechanism: OTMS Research Model

Test Cell used: Modified shear-compression cell of the Texture Test System using 4 blades and reducing cell area from 66 x 66 mm to 66 x 28 mm.

Method of controlling sample size: weight 15 g

Deformation rate cm/min: speed setting at 30

Approximate maximum force kg: 60

Readings taken from curves: Maximum force

Outcome: The firmness of various commercial canned products from herring was determined. Products having a firmness ranging from 25 to 40 kg (Kramer Shear Compression Cell) had the most desirable texture. An increase in the firmness of canned Pacific herring was observed following freezing or brining of the raw material. Holding of herring on ice or in RSW before canning or storing of the finished canned product had no marked effect on the firmness of canned flesh.

Reference: Bilinski, E., Lau, Y.C. and Jonas, R.E.E. 1977. Objective measurement and control of the firmness of canned herrings. Tech. Rept. No. 727. Fisheries and Marine Service, Fisheries and Environment Canada, Vancouver. June.

Other applications known to the author but in early stages so that reports were not included are:

a) Cow Peas — Prof. D. Stanley,
Dept. of Food Science,
Univ. of Guelph,
Guelph, Ont. N1G 2W1

b) Cherries — J. Kitson,
Agriculture Canada,
Research Station,
Summerland, B.C. V0H 1Z0.

3.0 ADAPTORS TO UTILIZE OTMS CELLS ON THE INSTRON TESTING MACHINE.

Because many establishments are already equipped with a table model Instron, adaptors have been developed so that all the OTMS texture test cells can be easily installed on the Instron. These adaptors are available from:

Queensboro Instruments,
645 Brierwood Ave.,
Ottawa, Ont. K2A 2J3.

The adaptors comprise essentially a combined drip tray-slide assembly into which the normally stationary component of the texture test cell fits and a 2.54 cm diameter chuck to hold the moving component. The actual adaptors used depend on a number of factors and choices that should be specified when ordering them:

1. The model of Instron to be adapted.
2. The type of force transducer used, Instron or other.
3. The position of the texture test cell - above or below the moving crosshead. Note for precise deformation measurements compression testing should be done below and tensile testing above the crosshead to eliminate the effect of any backlash in the drive screw mechanism.
4. The position of the force transducer-above or below the texture test cell.
5. The means available to calibrate the force transducer.

The various arrangements are shown in the following figures to illustrate the possible combinations of adaptors and accessories and how to calibrate the force transducers.

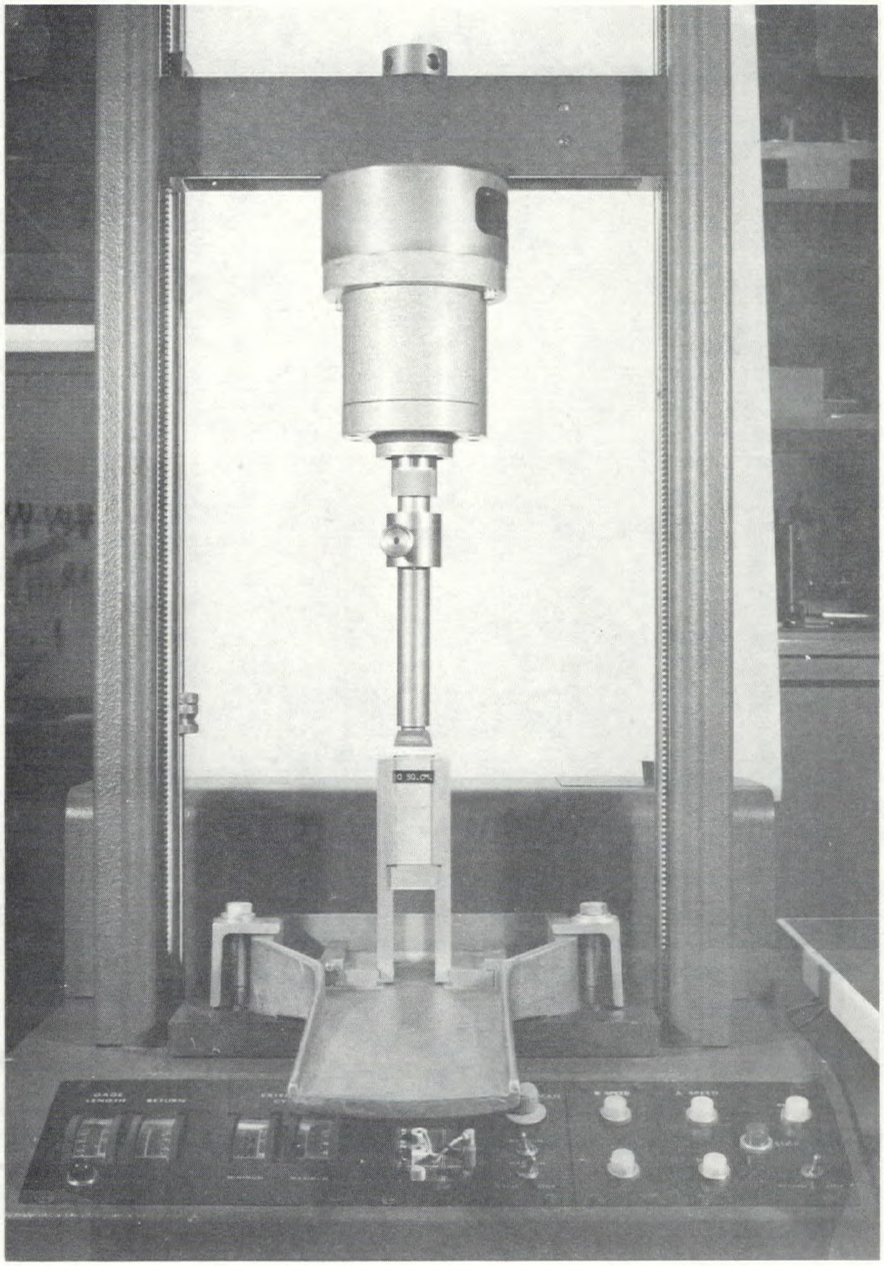

Figure 1. Operating below the crosshead with the Instron force transducer above the OTMS wire extrusion test cell. The slide-drip tray combination is clamped to the base (allowing alignment) and holds the stationary test cell component. The load cell is attached to the crosshead and an adaptor used to attach the standard OTMS chuck to hold the moving component of the test cell.

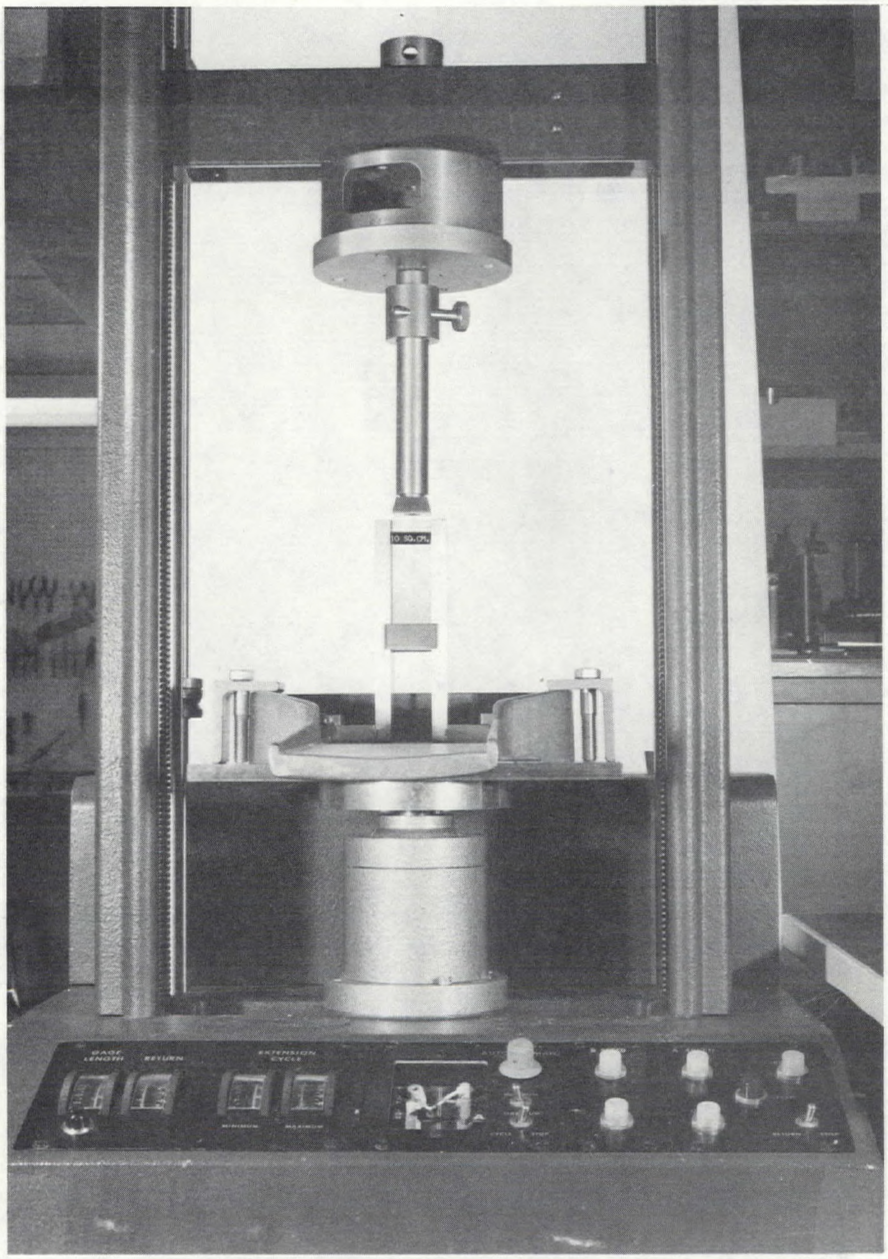

Figure 2. Operating below the crosshead with the Instron force transducer below the texture test cell. The slide drip tray is clamped on the load cell compression table and adaptors hold the standard OTMS chuck on the crosshead. The compression table must be drilled by the user to attach the slide-drip tray clamping plate.

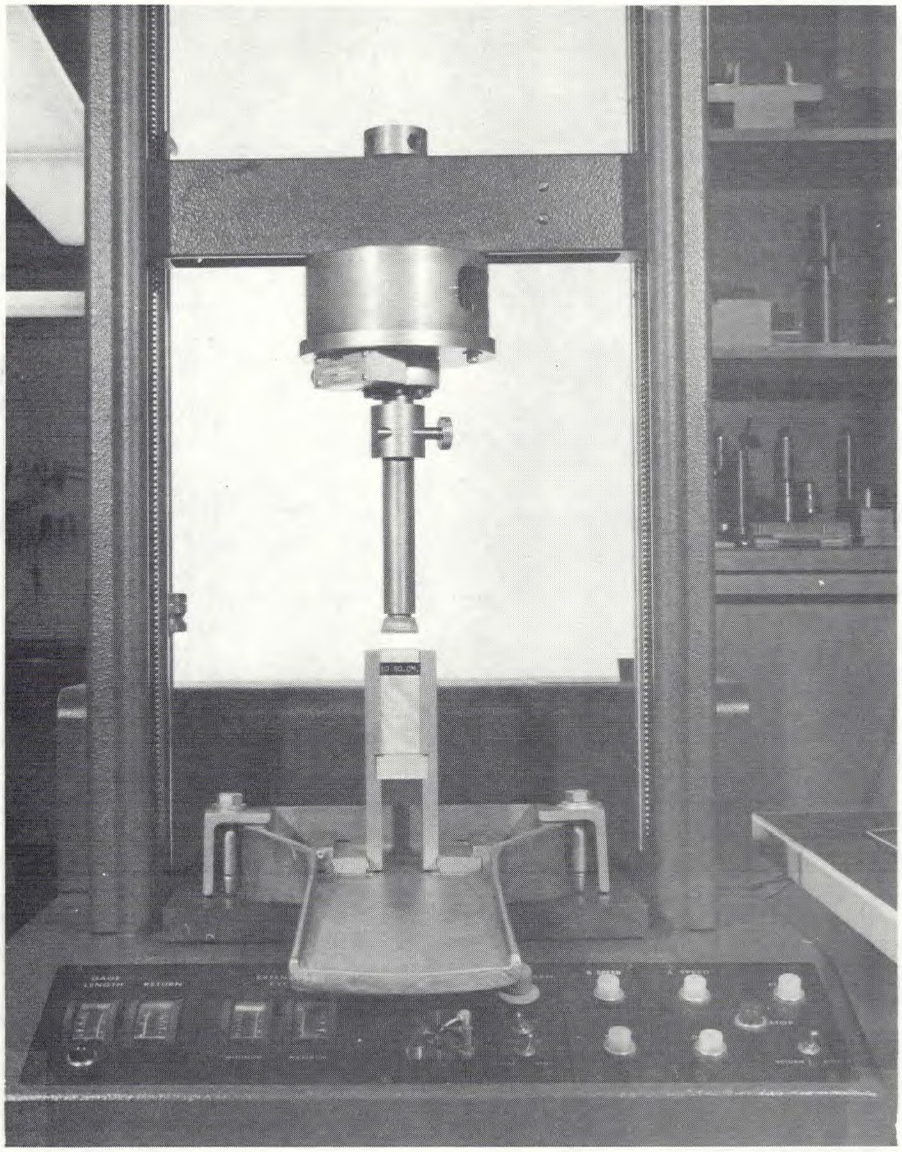

Figure 3. Operating below the crosshead with a Strainsert model FLIU force transducer above the texture test cell.

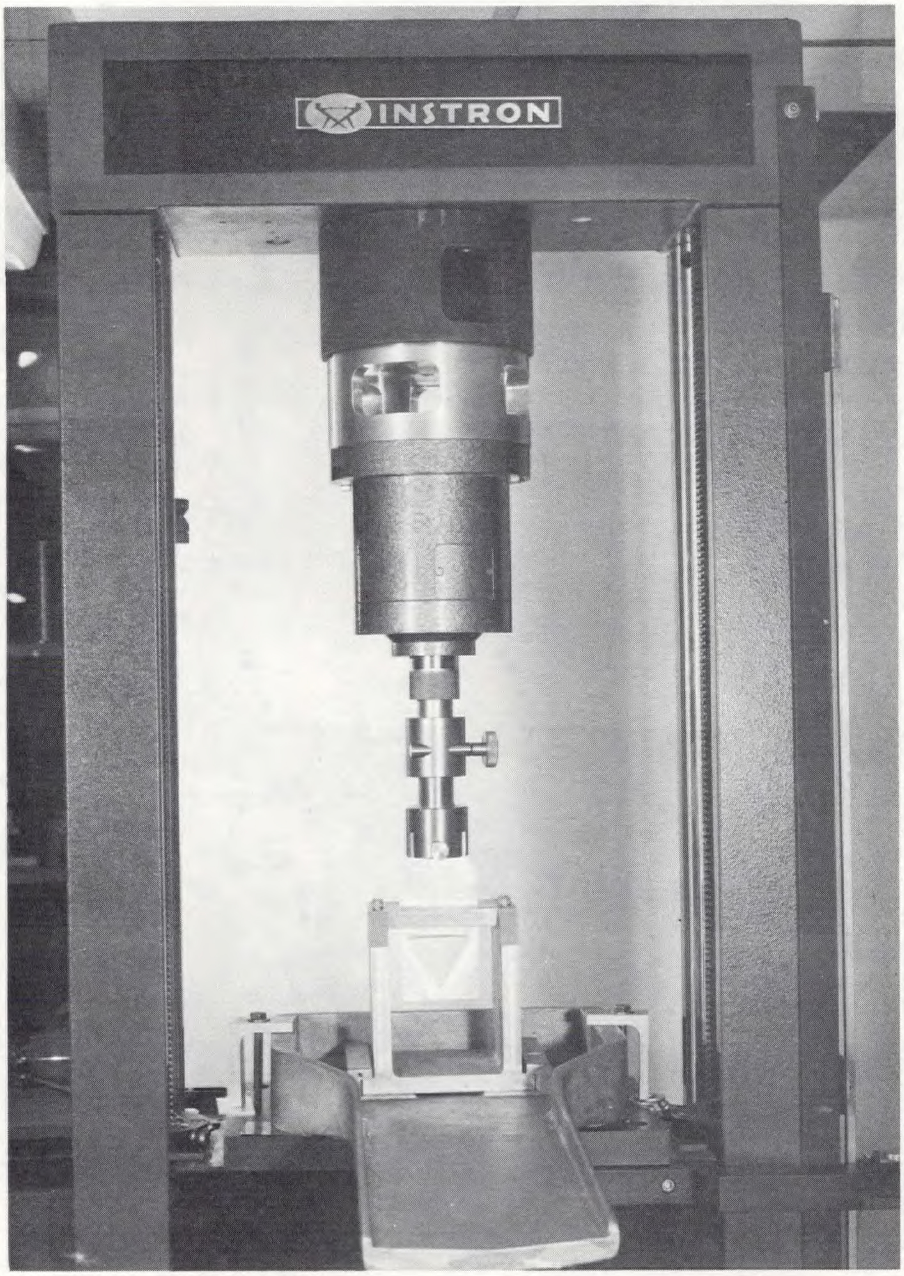

Figure 4. Operating above the crosshead with the Instron force transducer above the OTMS Warner-Bratzler meat test cell. The slide-drip tray is clamped to the crosshead facilitating alignment.

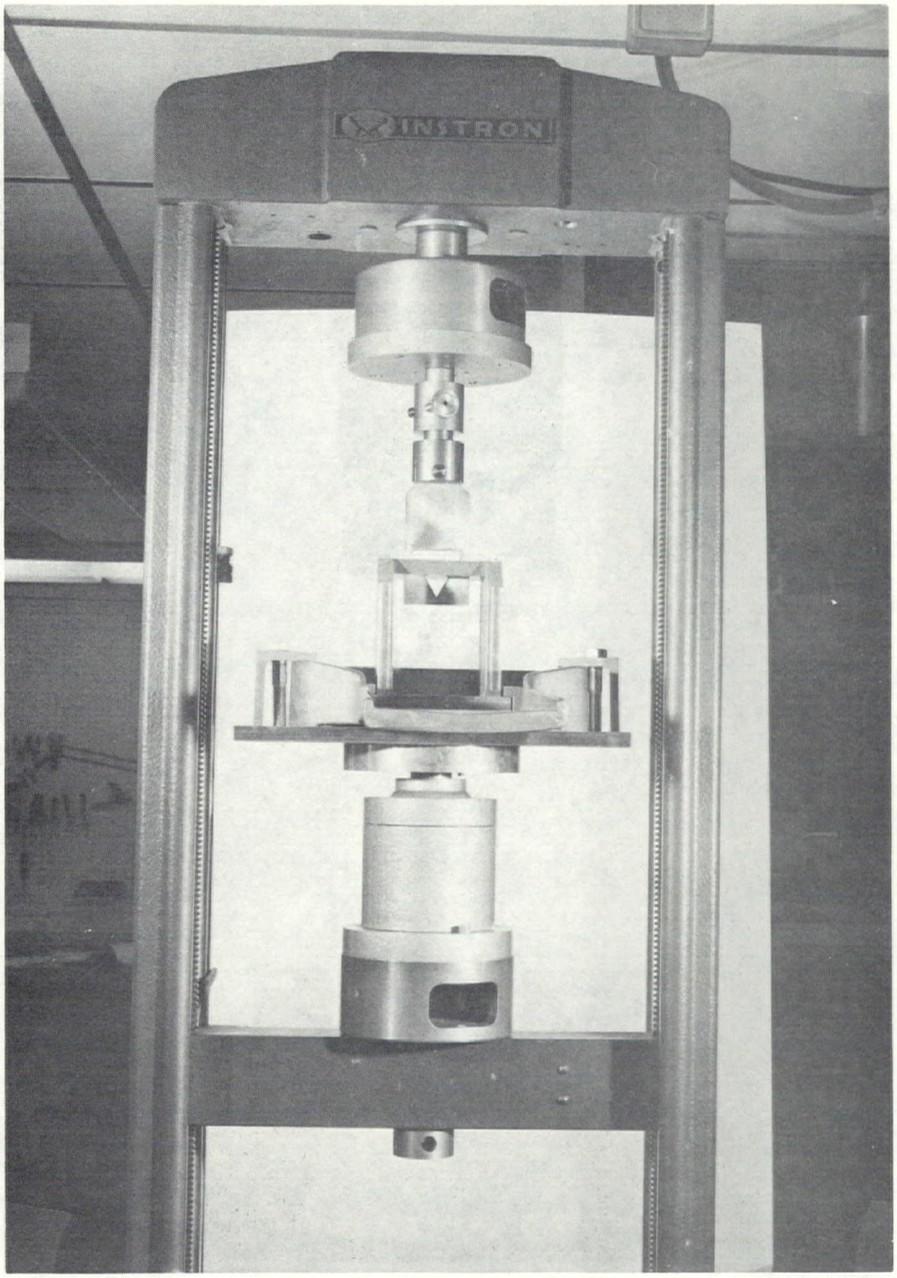

Figure 5. Operating above the crosshead with the Instron load cell below the texture test cell.

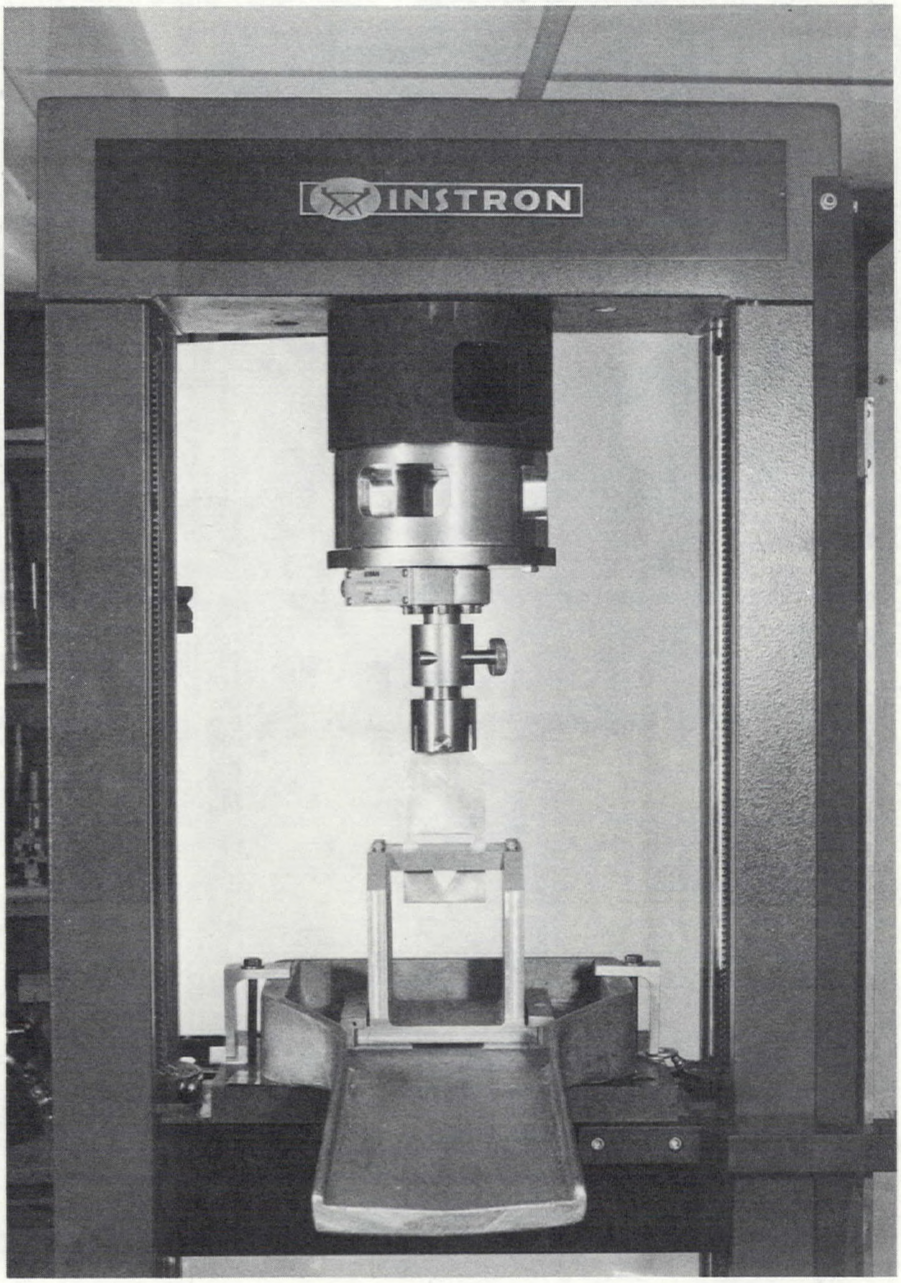

Figure 6. Operating above the crosshead with a Strainsert model FLIU force transducer above the texture test cell.

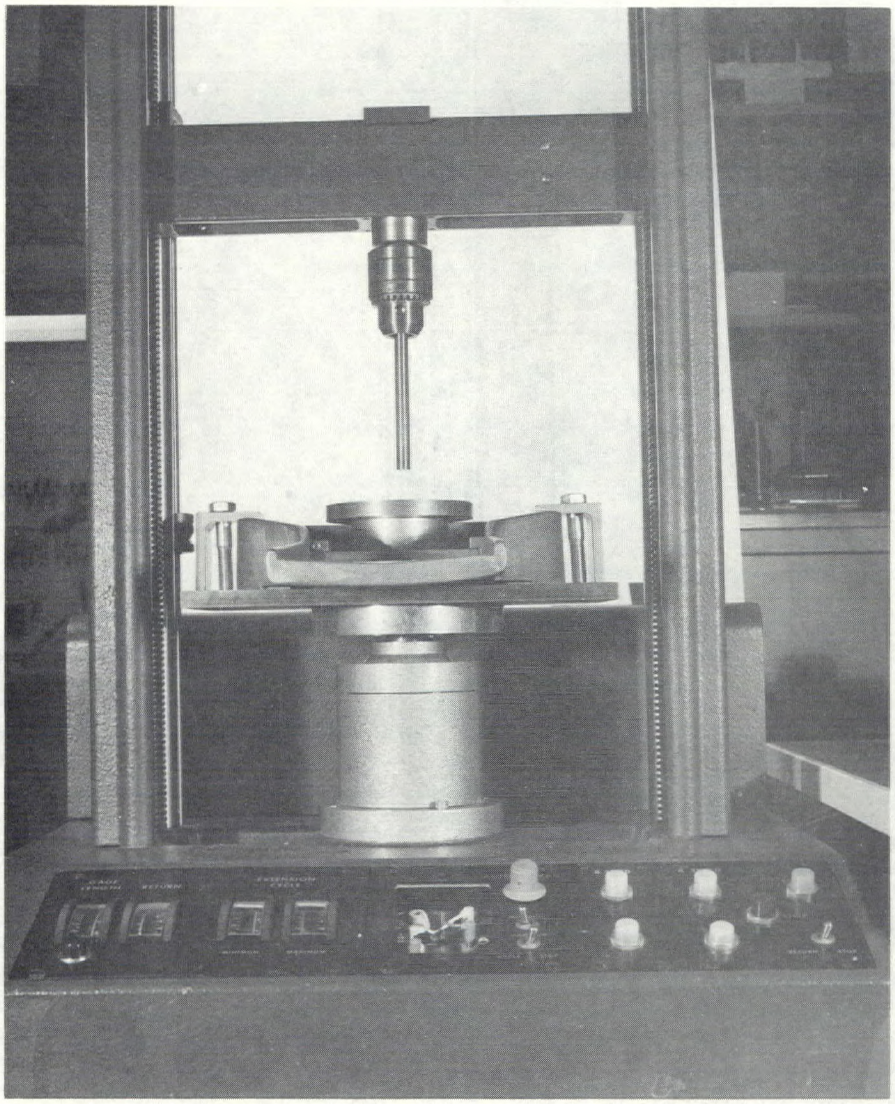

Figure 7. View showing how a plate is bolted to the Instron compression table on top of the force transducer. The clamps then hold the drip tray to this plate. Arrangement shown for puncture testing using the OTMS puncture and compression test cells.

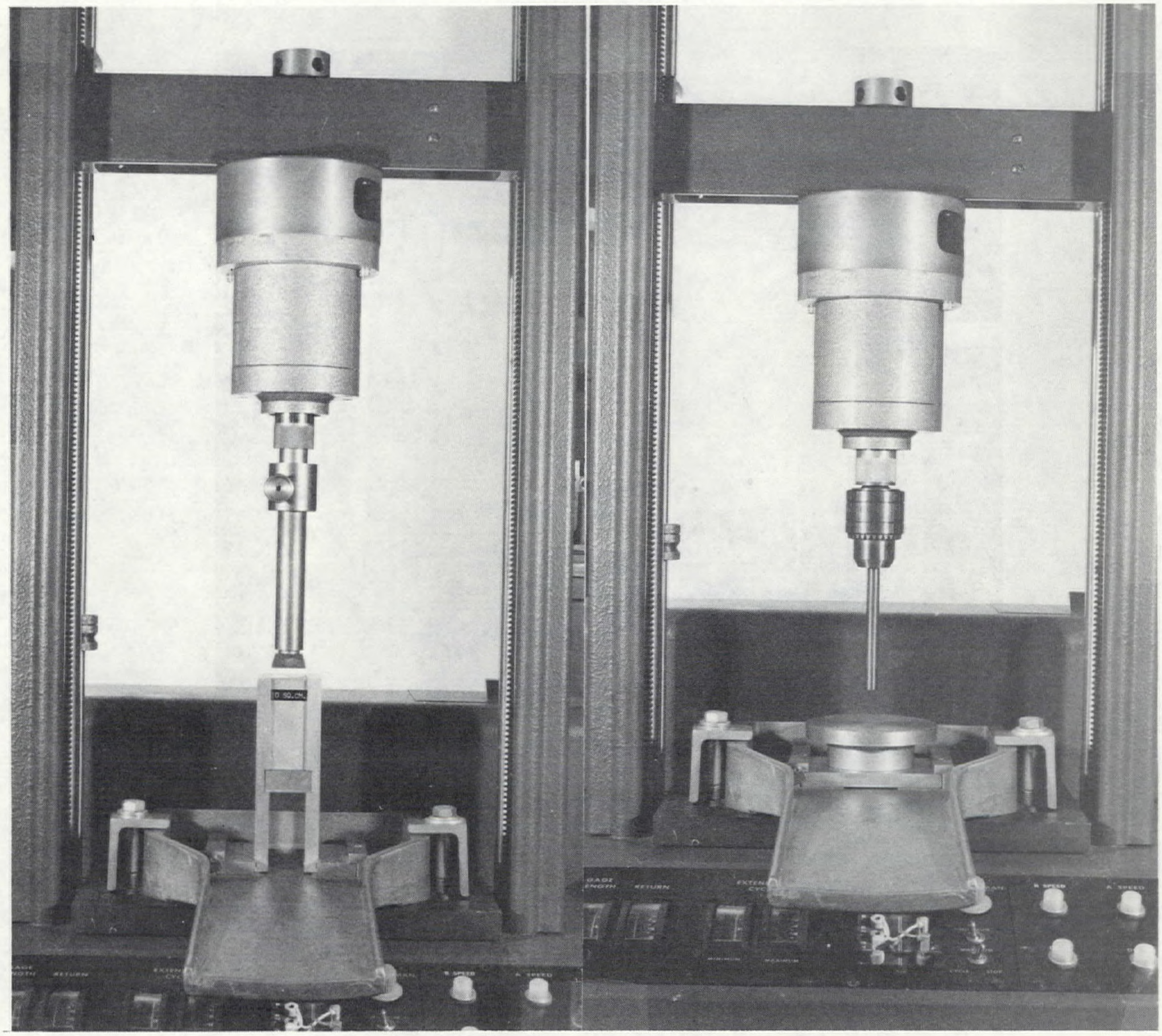

Figure 8. Two test set ups with the Instron force transducer mounted on the crosshead above the texture test cell. This eliminates the need to tare each sample weight and minimizes the dead weight carried by the transducer.

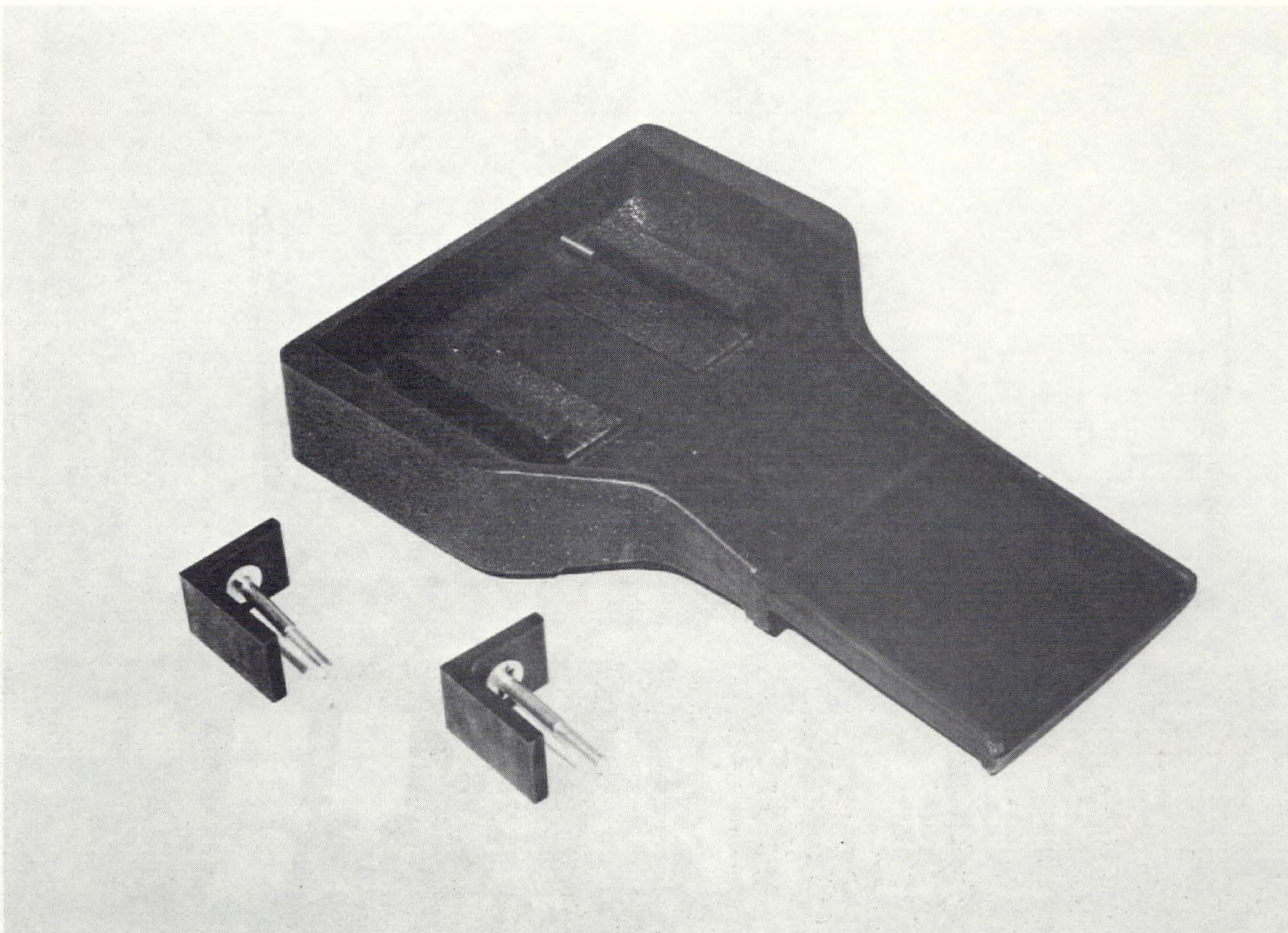

Figure 9. The slide-drip tray and clamps.

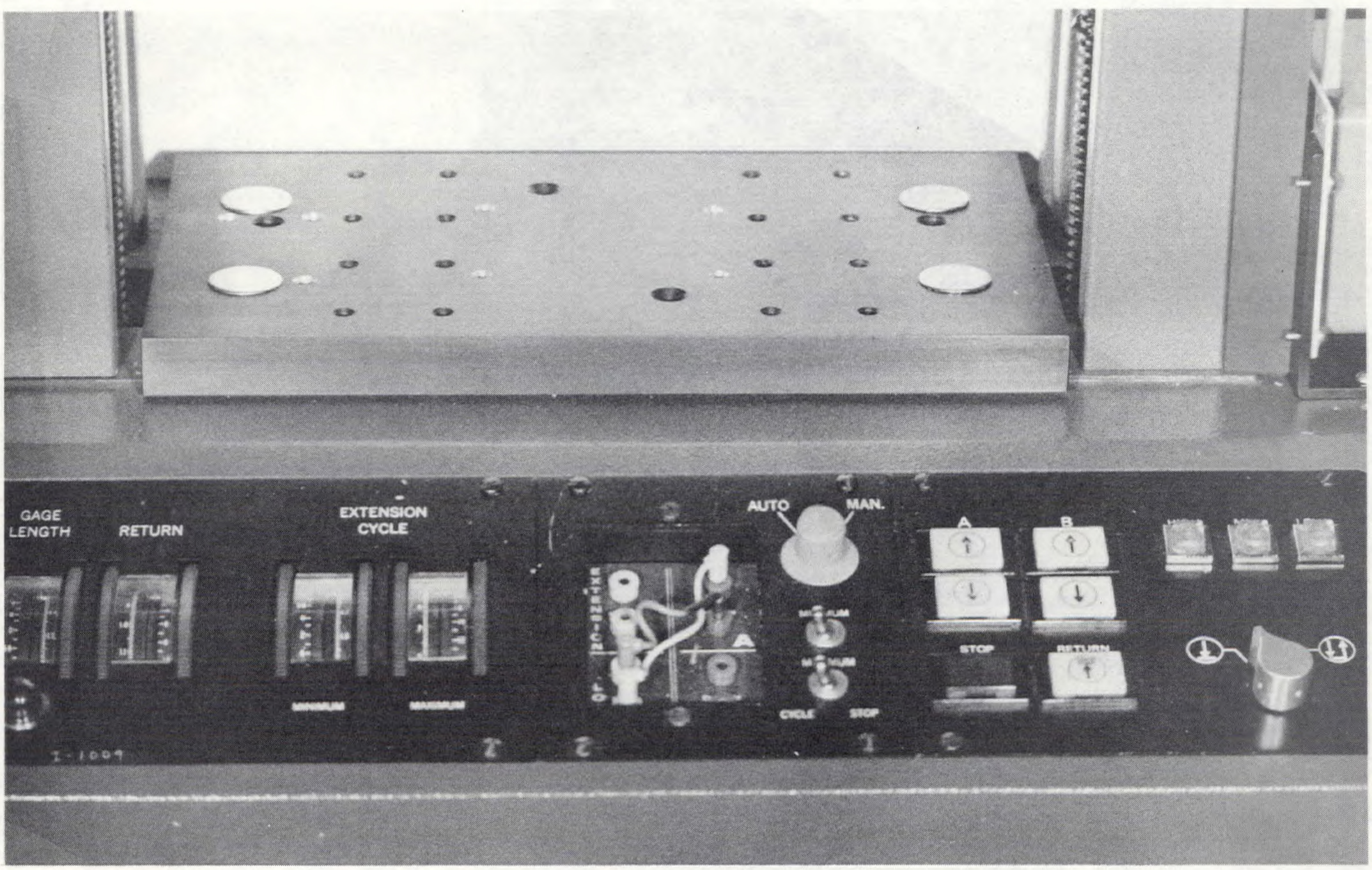

Figure 10. A heavy plate for bolting to the base of the Instron model TM-M. Tapped holes in the plate allow various accessories including the OTMS adaptors to be conveniently clamped to the Instron base.

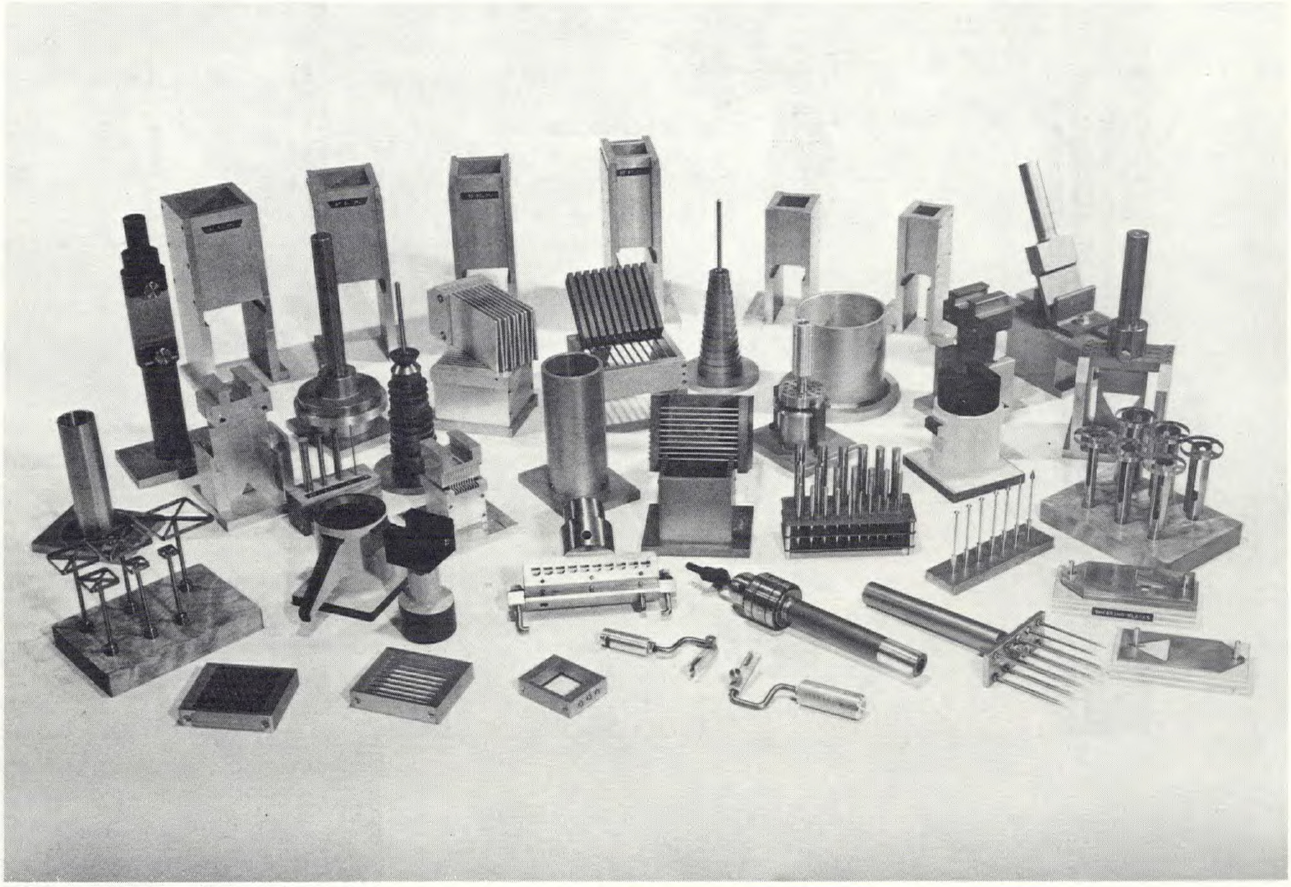

Figure 11. Some of the texture test cells from the OTMS and other systems (e.g. Texture Test System, Food Technology Corp., Rockville, Maryland) that can be utilized in the Instron when equipped with the various adaptors.

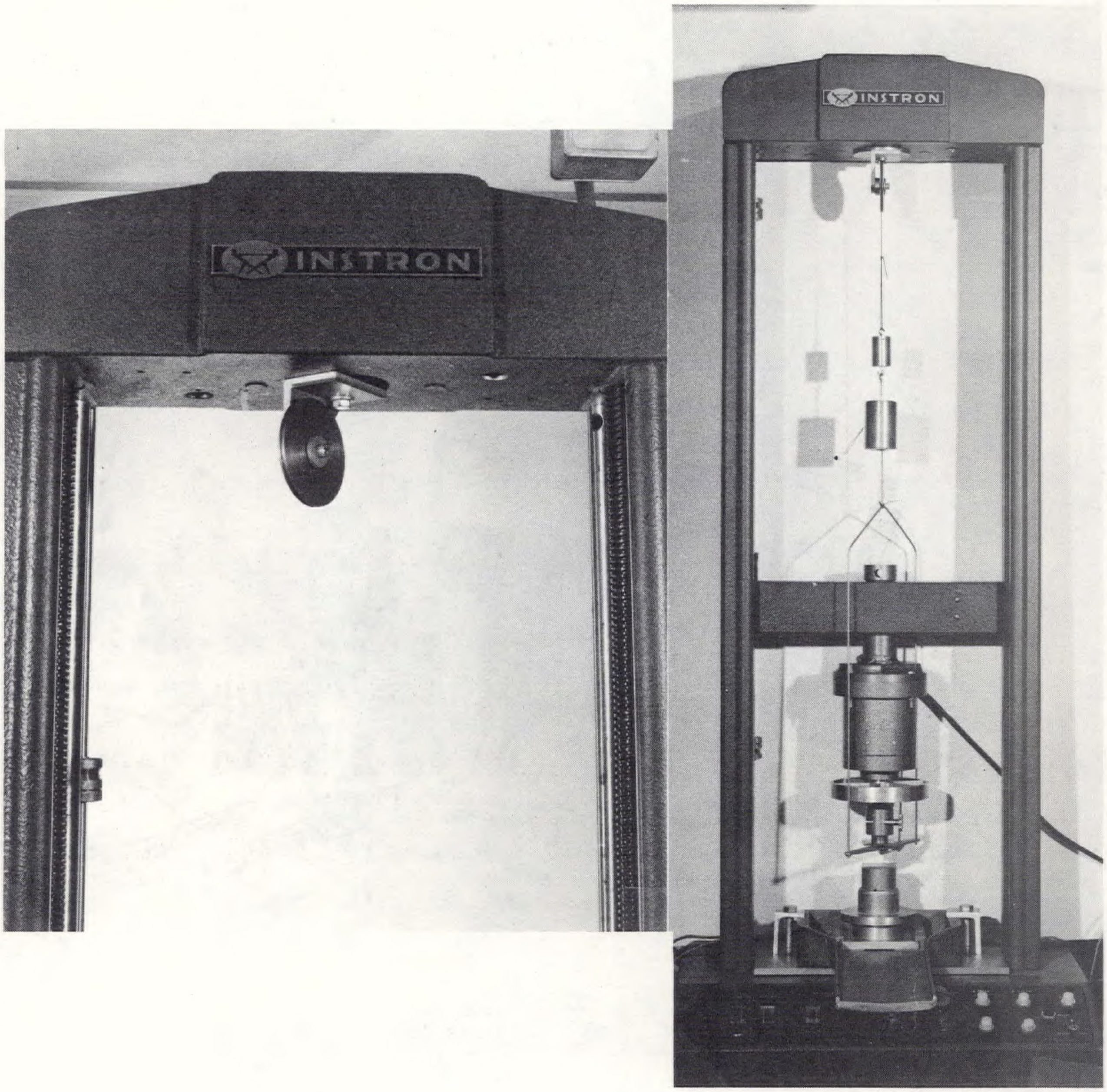

Figure 12. Calibrating the force transducer-compression. A ball bearing pulley is attached to the top of the Instron frame. A pulley, cord and wire frame then allow weights to apply compressive force to the transducer when it is mounted below the crosshead and above the texture test cell.

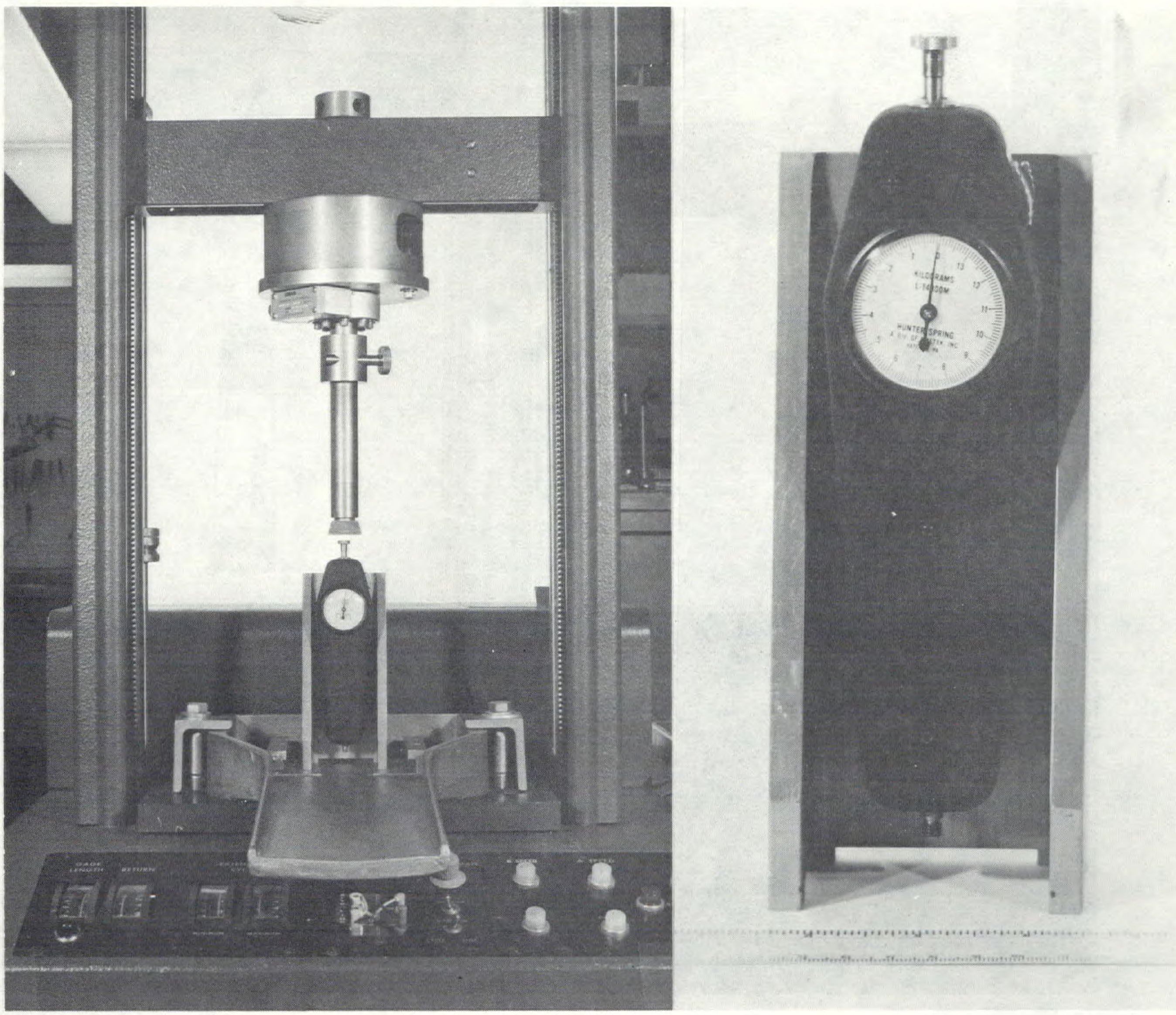

Figure 13. Calibrating the force transducer-compression. A spring scale force gauge is mounted in a stand to apply compressive calibration forces to the force transducer.

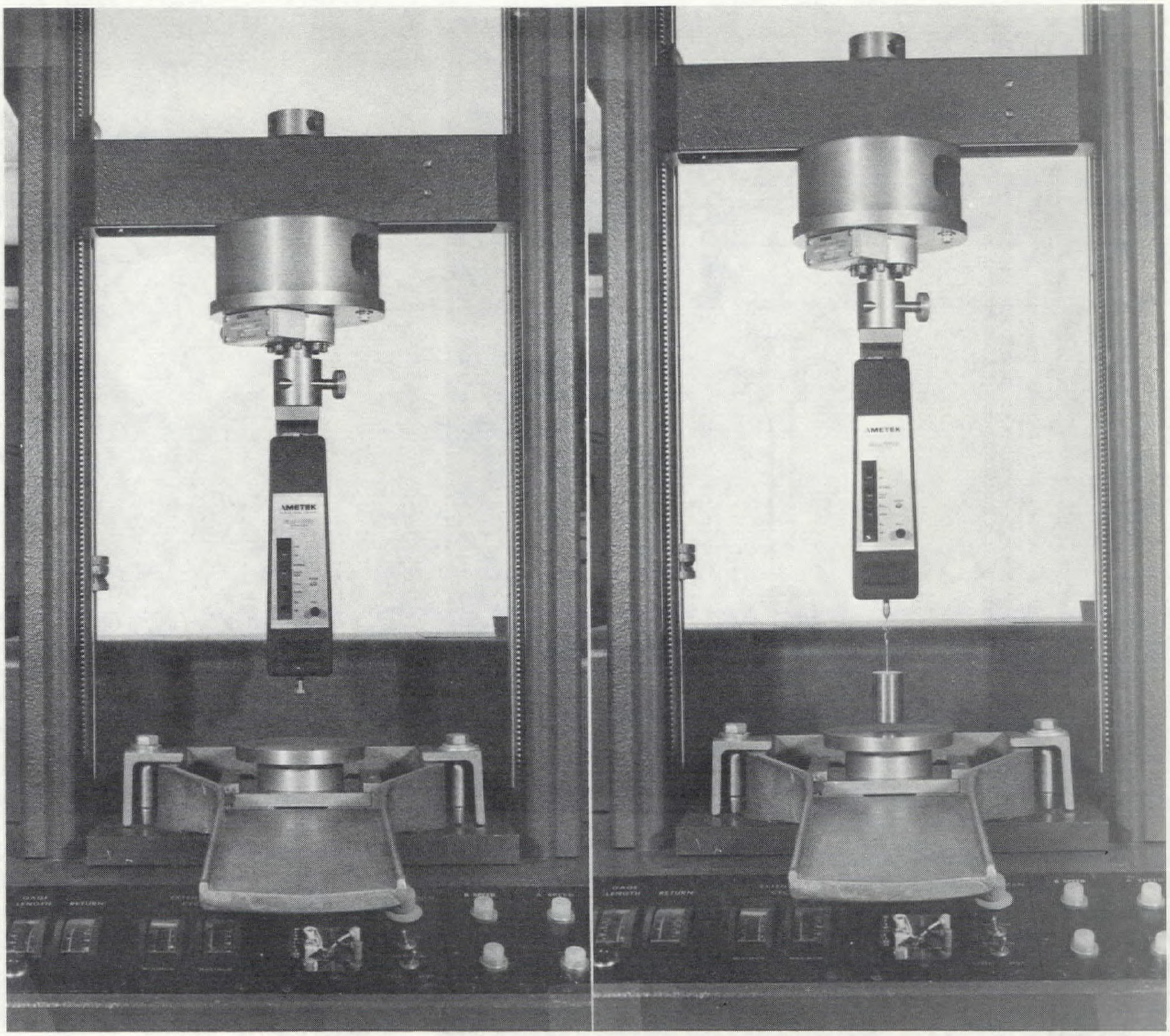

Figure 14. Calibrating the force transducer-tension/compression. A solid state digital force gauge is held on the crosshead mounted force transducer to apply tensile or compressive calibration forces. For tensile testing a weight can still serve as the final standard.

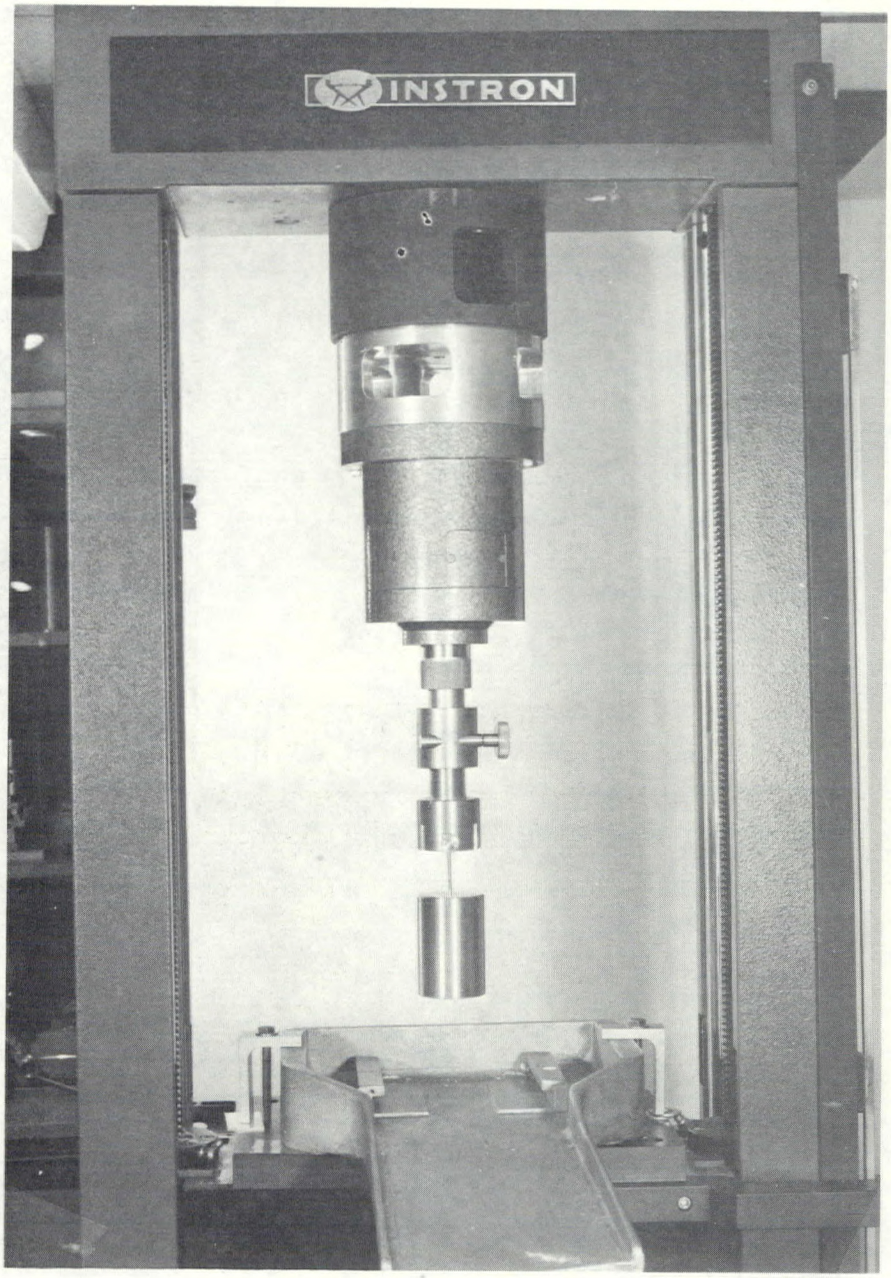

Figure 15. Calibrating the force transducer in tension by direct weight application.

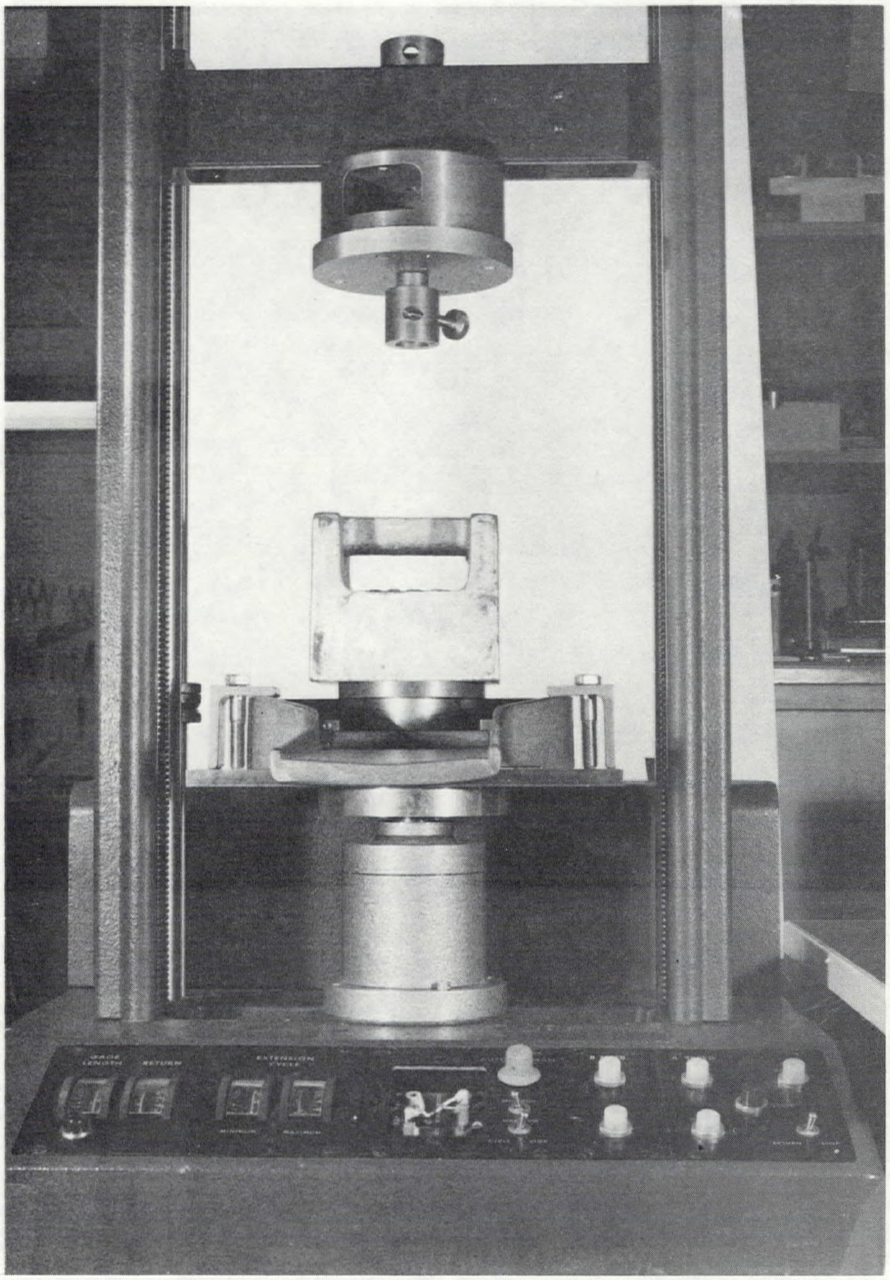

Figure 16. Calibrating the force transducer in compression by direct weight application.

4.0 REFERENCES TO APPLICATIONS OF THE SYSTEM BY ENGINEERING RESEARCH SERVICE

The following lists references to OTMS accessories, equipment, associated techniques and applications that have been evaluated by Engineering Research Service in cooperation with other establishments. The applications are listed by product. The objective is to bring together groups of references according to subject or product for convenience. For example a number of texture test cells or techniques are discussed in the references that were developed by ERS using other systems which have since been adapted to the OTMS.

4.1 Reviews providing background information

deMan, J.M., Voisey, P.W., Rasper, V.F. and Stanley, D.W. 1976. Rheology and texture in food quality. AVI Publishing Co., Westport, Connecticut, 588 pp.

Voisey, P.W. 1971. Modernization of texture instrumentation. J. Texture Studies 2: 129-195.

Voisey, P.W. 1975. Effect of mechanical properties on the design of food quality control instruments and their application. Design Applications of Mechanical Properties of Solid Food Materials, University Park, Pa. August.

Voisey, P.W. 1975. Instrumental measurement of food texture. In Theory, Determination and Control of Physical Properties of Food Materials. ed. ChoKyun Rha, D. Reidel Co., Dordrecht, Holland. pp. 65-130.

Voisey, P.W. and deMan, J.M. 1976. Applications of instruments for measuring food texture. In Rheology and Texture in Food Quality. eds. J.M. deMan, P.W. Voisey, V.F. Rasper and D.W. Stanley. AVI Publishing Co., Westport, Connecticut, pp. 142-243.

Voisey, P.W. 1976. Instrumental measurement of food texture. In Rheology and Texture in Food Quality. eds. J.M. deMan, P.W. Voisey, V. Rasper and D.W. Stanley. AVI Publishing Co., Westport, Connecticut. pp. 79-141.

Voisey, P.W. 1976. The influence of mechanical properties on the interpretation of results from food texture tests in research and quality control. Proc. 1st Int. Cong. Engng. & Food, Boston, August.

Voisey, P.W. 1976. Optimizing instrumental measurement of mechanical properties of food materials. Workshop on Characterization of Mechanical Properties of Food Materials, Continuing Education Center, Rutgers Univ., The State Univ. of New Jersey, New Brunswick, N.J. November.

4.2 The Ottawa Texture Measuring System and other instrumental systems developed by Engineering Research Service

Voisey, P.W. 1971. The Ottawa texture measuring system. J. Can. Inst. Food Sci. Technol. 4: 91-103.

Voisey, P.W. 1971. Systems for the measurement of food texture. Bull. 6930, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W., MacDonald, D.C., Kloek, M. and Foster, W. 1972. The Ottawa texture measuring system - An operational manual. Bull. 7024, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. and Kloek, M. 1975. Supplementary instructions for the texture measuring system assembled for the St. Jean Research Station. Rept. 7415, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W., MacDonald, D.C., Kloek, M. and Foster, W. 1975. Matériel utilisé a Ottawa pour la mesure des textures. Rept. 7024, Eng. Res. Service, Ottawa.

Voisey, P.W. and Randall, C.J. 1977. A versatile food rheometer. J. Texture Studies

4.3 Instrumental Method for Measuring Deformation (Firmness) Adaptable to OTMS and Other Systems

Voisey, P.W. and Crête, R. 1973. A technique for establishing instrumental conditions for measuring food firmness to simulate consumer evaluations. J. Texture Studies 4: 371-377.

Voisey, P.W., Buckley, D.J. and Crête, R. 1973. Evaluation of a system for measuring small deformations in the physical testing of foods. Rept. 7221, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W., Buckley, D.J. and Crête, R. 1974. A system for recording deformations in texture tests. J. Texture Studies 5: 61-75.

Voisey, P.W. and Buckley, D.J. 1974. Apparatus for routine measurement of food deformation in texture tests at low deformation rates. J. Can. Inst. Food Sci. Technol. 7: 162-165.

4.4 Instrumental Artifacts

Voisey, P.W. and Kloek, M. 1975. Instron recorder pen response. J. Texture Studies 6: 379-384.

Voisey, P.W. and Kloek, M. 1975. Control of deformation in texture tests. J. Texture Studies 6: 489-506.

Voisey, P.W. 1975. Selecting deformation rates in texture tests. J. Texture Studies 6: 253-257.

4.5 Interpretation of Force - Deformation Curves

Voisey, P.W. 1977. Interpretation of force deformation curves from the shear compression cell. J. Texture Studies .

Voisey, P.W. and Larmond, E. 1977. Instrumental multiple texture profile analysis of cooked ground beef patties and smoked beef. J. Texture Studies

4.6 Texture Test Cell Development and Standardization

Voisey, P.W. 1970. Test cells for objective textural measurements. J. Can. Inst. Food Technol. 3: 93-102.

Voisey, P.W. and Larmond, E. 1974. Some observations on texture test cell interchangeability. J. Can. Inst. Food Sci. Technol. 7: 16-21.

Voisey, P.W. and Reid, W.S. 1974. Effect of friction on the performance of texture test cells. J. Texture Studies 5: 239-248.

Voisey, P.W. 1977. Effect of blade thickness on readings from the FTC shear compression cell. J. Texture Studies

4.7 Tobacco

Voisey, P.W. and Walker, E.K. 1972. Influence of certain factors on tobacco measurements of filling value and force relaxation after compression by the Delhi method. Rept. 6813, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. and Walker, E.K. 1972. Apparatus for the measurement of tobacco filling value and cigarette firmness. Tobacco Sci. 14: 40-43.

Voisey, P.W. and Walker, E.K. 1974. Evaluation of a new technique for measuring compressibility of cigarettes. Tobacco Sci. 28: 154-156.

Walker, E.K. and Voisey, P.W. 1972. Comparison of sample preparation and mechanical measurement techniques for the determination of the filling value of cut tobacco. Tobacco Sci. 16: 78-81.

Walker, E.K. and Voisey, P.W. 1974. Influence of moisture levels on the filling value of cut tobacco. Tobacco Sci. 18: 37-39.

Walker, E.K. and Voisey, P.W. 1974. Measurement of cigarette firmness and its relationship to filling value of the cut tobacco. Tobacco Sci. 18: 128-131.

4.8 Cooked and Uncooked Spaghetti

Evans, G. 1973. Effects of polyphosphate addition in spaghetti. Thesis Pres. Faculty of Graduate Studies, Univ. of Guelph.

Evans, G.C., deMan, J.M., Rasper, V. and Voisey, P.W. 1975. Effect of polyphosphate addition in spaghetti. J. Can. Inst. Food Sci. Technol. 8 (2): 102-108.

Larmond, E. and Voisey, P.W. 1973. Evaluation of spaghetti quality by a laboratory panel. J. Can. Inst. Food Sci. Technol. 6: 209-211.

Voisey, P.W. and Walker, E.K. 1970. Apparatus for the measurement of tobacco filling value and cigarette firmness. Tobacco Sci. 14: 40-43.

Voisey, P.W. and Larmond, E. 1972. The comparison of textural and other properties of cooked spaghetti by sensory and objective methods. Rept. 7008, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. and Larmond, E. 1973 . Exploratory evaluation of instrumental techniques for measuring some textural characteristics of cooked spaghetti. Cereal Sci. Today 18 (5): 126-133, 142-143.

Voisey, P.W. and Larmond, E. 1973 . A comparison of the textural properties of several spaghetti varieties and some observations on the accuracy of an objective technique. Rept. 7008-1, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. and Larmond, E. 1974. Sensory and objective evaluation of cooked spaghetti texture. Proc. Canadian-Italian Durum Symposium, Winnipeg, Manitoba, September.

Voisey, P.W., Larmond, E. and Wasik, R. 1976. Factors affecting the multi-blade shear cell test of spaghetti texture. Rept. 7008-631, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. and Wasik, R. 1977. Measuring the strength of uncooked spaghetti by the bending test. J. Can. Inst. Food Sci. Technol.

Voisey, P.W., Larmond, E. and Wasik, R. 1977. Comparison of spaghetti made from different durum wheat varieties by sensory and instrumental tests. Rept. 7008-680, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W., Larmond, E. and Wasik, R. 1977. Measuring the texture of cooked spaghetti texture. 1. Firmness. J. Can. Inst. Food Sci. Technol.

Voisey, P.W., Larmond, E. and Wasik, R. 1977. Measuring the texture of cooked spaghetti. 2. Stickiness. J. Can. Inst. Food Sci. Technol.

4.9 Meat

Larmond, E., Petrasovits, A. and Hill, P. 1969. Application of multiple paired comparisons in studying the effect of aging and finish on beef tenderness. Can. J. Animal Sci. 49: 51-58.

Larmond, E. and Petrasovits, A. 1972. Relationship between Warner-Bratzler and sensory determinations of beef tenderness by the method of paired comparisons. J. Can. Inst. Food Sci. Technol. 5 (3): 138-144.

Randall, C.J., Raymond, D.P. and Voisey, P.W. 1976. Effect of various animal and vegetable protein materials on replacing the beef component in a meat emulsion system. J. Can. Inst. Food Sci. Technol. 9: 216-221.

Randall, C.J. and Voisey, P.W. 1977. A method for measuring the texture of meat and the effect of nitrite and salt addition on the texture of cured meats. J. Texture Studies

Randall, C.J. and Voisey, P.W. 1977. Effect of meat protein fractions on textural characteristics of meat emulsions. J. Can. Inst. Food Sci. Technol.

Voisey, P.W. and Hansen, H. 1967. A shear apparatus for meat tenderness evaluation. Food Technol. 21: 355-360.

Voisey, P.W. and Larmond, E. 1974. Examination of factors affecting performance of the Warner-Bratzler meat shear test. J. Can. Inst. Food Sci. Technol 7: 243-249.

Voisey, P.W., Randall, C.J. and Larmond, E. 1975. Selection of an objective test of wiener texture by sensory analysis. J. Can. Inst. Food Sci. Technol. 8: 23-29.

Voisey, P.W. 1976. Engineering assessment and critique of instruments used for meat tenderness evaluation. J. Texture Studies 7: 11-48.

Voisey, P.W., Larmond, E. and Kloek, M. 1976. Comparison of methods of testing the texture of hamburger patties to develop techniques for testing textured vegetable protein. Rept. 7430-600, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. and Larmond, E. 1977. The effect of deformation rate on the relationship between sensory and instrumental measurements of meat tenderness by the Warner-Bratzler method. J. Can. Inst. Food Sci. Technol.

4.10 Fish

Voisey, P.W. 1972. The texture of canned herrings. Rept. 7022-1, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. 1971. Use of the Ottawa texture measuring system for testing fish products. Rept. 7022, Eng. Res. Service, Agr. Can., Ottawa.

4.11 Vegetables - Beans

Sefa-Dedeh, S., Stanley, D.W. and Voisey, P.W. 1977. Studies on cowpeas. 1. Effect of soaking time and cooking conditions on texture. Annu. Conf. Can. Inst. Food Sci. Technol., Guelph. August.

Voisey, P.W. and Larmond, E. 1970. The measurement of baked bean texture - A comparison of objective and sensory evaluation. Rept. 6930, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. and Larmond, E. 1971. Texture of baked beans - A comparison of several methods of measurement. J. Texture Studies 2: 96-109.

Voisey, P.W. and Dean, P.R. 1971. Measurement of consistency of reconstituted instant potato flakes. Amer. Potato J. 48: 88-96.

Voisey, P.W. and Larmond, E. 1971 . The measurement of cooked soybean toughness. Rept. 7026, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. and Larmond, E. 1971 . The effect of storage time before processing on baked bean texture. Rept. 6930-1, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. 1973. Some measurements of baked bean texture. Rept. 7222, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. and Mohr, W.P. 1976. Some instrumental techniques for measuring fruit firmness - Related properties and skin strength of fresh tomatoes and for predicting wholeness retention after canning. Rept. 7307-575, Eng. Res. Service, Agr. Can., Ottawa.

4.12 Fruits

Voisey, P.W. and Mohr, W.P. 1975. Development of an instrumental test of apple sauce graininess. Rept. 7316-510, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. 1977. Examination of operational aspects of fruit pressure testers. J. Can. Inst. Food Sci. Technol.

4.13 Miscellaneous

Voisey, P.W. 1971. Preliminary evaluation of a technique for measuring the consistency of canned puddings. Rept. 7141, Eng. Res. Service, Agr. Can., Ottawa.

4.14 The Ottawa Pea Tenderometer (OPT)

The OPT represents an example where the background research was done to assemble a quality control model of the OTMS for a specific application, namely, the measurement of fresh pea maturity and establishing the price paid to the grower which is based on weight and tenderness. The objective was to develop a replacement for the FMC pea tenderometer.

Pearson, C.A. and Raynor, D. 1975. Comments on an article by Peter Voisey. J. Texture Studies 6: 393-398.

Voisey, P.W. and Nonnecke, I.L. 1971. The performance of the F.M.C. pea tendeormeter with particular reference to its accuracy of measurement in the grading of peas to establish the price paid to the grower. Rept. 6820, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. and Nonnecke, I.L. 1971. Measurement of pea tenderness. 1. An appraisal of the F.M.C. pea tenderometer. J. Texture Studies 2: 348-364.

Voisey, P.W. and Nonnecke, I.L. 1972. Measurement of pea tenderness. 3. Field comparison of several methods of measurement. J. Texture Studies 3: 329-358.

Voisey, P.W. and Nonnecke, I.L. 1972. Measurement of pea tenderness. 4. Development and evaluation of the texture test cell. J. Texture Studies 3: 459-477.

Voisey, P.W. and Nonnecke, I.L. 1972. The performance of the F.M.C. pea tenderometer - 1971 tests. Rept. 6820-1, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. and Nonnecke, I.L. 1972. Some problems associated with the measurement of pea maturity and tenderness. Rept. 6820-2, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. and Kloek, M. 1973. Measurement relating to pea tendeormeter calibration. Rept. 6820-3, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W., Heeney, H.B. and Nonnecke, I.L. 1973. The effect of variety on the relationships between readings from instruments for measuring pea maturity and tenderness. Rept. 6820-4, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. and Nonnecke, I.L. 1973. Some observations regarding pea tenderometer standardization. Rept. 6820-5, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. 1973. The interchangeability of instruments used to measure pea tenderness. Rept. 6820-6, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. and Nonnecke, I.L. 1973. Summary of results - Pea tenderometer tests. Rept. 6820-7, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. 1974. Design and operational details of the Ottawa pea tenderometer. Rept. 6820-8, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. 1974. Readout stability of the Ottawa pea tenderometer. Rept. 6820-9, Eng. Res. Service, Agr. Can., Ottawa.

Voisey, P.W. and Nonnecke, I.L. 1973. Measurement of pea tenderness. 2. A review of methods. J. Texture Studies 4: 171-195.

Voisey, P.W. and Nonnecke, I.L. 1973. Measurement of pea tenderness. 5. The Ottawa pea tenderometer and its performance in relation to the pea tenderometer and FTC texture test system. J. Texture Studies 4: 323-343.

Voisey, P.W. 1974. Measurement of pea tenderness. 6. An observation on pea tenderometer performance in relation to standardization. J. Texture Studies 5: 51-59.

Voisey, P.W. 1975. Reply to comments by Pearson and Raynor on an article by Peter Voisey. J. Texture Studies 6: 394-398.

5.0 List of Equipment Available Commercially

The OTMS and its accessories is manufactured by:

Canners Machinery Ltd.,
P.O. Box 190,
Simcoe, Ontario N3Y 4L1
Canada

Their current catalog lists the following items as being available:

The Press

a) Basic press unit

b) 15 cm/min constant speed motor, 110 volt, 60 cycle, single phase

c) 2-29 cm/min variable speed motor with controls for automatic and single cycling and limit operation, 110 volt, 60 cycle, single phase

Load Cells

a) 1000 lb load cell

b) 2500 lb load cell

c) Other capacities available on request

Recording systems

A1-Package - Daytronic Digital Indicator, strain gage input module, peak memory module, all mounted and wired in cabinet with drawer.

A2-Package - Daytronic Meter read indicator, strain gage input module, peak memory module, all mounted and wired in cabinet with drawer.

B1-Package - same as A1, with addition of single channel strip recorder 10".

B2-Package, same as A2, with addition of single channel strip recorder 10".

Connector coil cord required with each of above packages to connect to load cell.

Transformer 220/50 to 110/50 output for operation of system at 220 volts.

Texture Test Cells and Adaptors

Model #	Description
D-1433	10 cm^2 wire extrusion cell, complete
D-1434	15 cm^2 wire extrusion cell, complete
D-1435	20 cm^2 wire extrusion cell, complete
D-1436	30 cm^2 wire extrusion cell, complete
D-1437	40 cm^2 wire extrusion cell, complete
D-1438	50 cm^2 wire extrusion cell, complete
	Above test cells are complete with test cell body, wire grid, perforated plate (for sizes 20 through 50 inclusive only), plunger rod and plate. The size of the cell is the horizontal area of the cell's working volume.

Accessories to convert the above cells into rectangular back extrusion cells.

D-1439	20 cm^2 back extrusion set
D-1440	30 cm^2 back extrusion set
D-1441	40 cm^2 back extrusion set
D-1442	50 cm^2 back extrusion set
	Above accessories are complete with blank grid, plunger rod and back extrusion plate.
D-1443	Leak-proof back extrusion set (round), complete with 5 cell bodies, 17 parallel plunger plates, 4 tapered plunger plates, 1 plunger rod and 1 plunger plate holder (cell bottom not removeable).
D-1447	Standard back extrusion set (round), complete with 5 cell bodies, 17 parallel plunger plates, 4 tapered plunger plates, plunger rod and 1 plunger plate holder (cell bottom removeable).
D-1451	Bottom load cell adaptor (to install load cell on OTMS base for special applications)

Model #	Description
D-1452	Puncture test set, complete with short and long drill chuck adaptor, Jacobs chuck, 12 punches and punch holder.
D-1453	Warner Bratzler Meat Shear Cell, complete with one set of 3 blades with standard triangle shape opening and blade storage holder. Other openings in blades are available upon request, at extra charge.
D-1457	Commercial Warner Bratzler Meat Shear Cell Adaptor
D-1459	Compression Test Set
D-1461	Kramer Meat Shear (single blade). Requires Kramer Cell Adaptor for use with OTMS Press.
D-1463	Kramer Cell Adaptor (required for adapting single and multi-blade Kramer Shear and other cells for the Texture Test System to the OTMS press)
D-1466	Christel Pea Tenderometer Cell
D-1469	Armour Meat Tenderness Probe
D-1470	Spaghetti Tensile Attachment, complete with base
D-1471	Bending Test Cell
D-1473	Cone Penetrometer Set (short). Includes 9 probes and storage holder
D-1474	Cone Penetrometer Set (long). Includes 7 probes and storage holder
D-1475	Bite Test Attachment
D-1478	Fruit Crushing Test Cell
D-1480	Chuck Adaptor Shaft (long). Threaded to fit 6B1/2-20 Jacobs chuck 6-1/4"
D-1481	Chuck Adaptor Shaft (short). Threaded to fit 6B 1/2-20 Jacobs chuck 3-1/4"

Model #	Description
D-1482	Standard Compression Base
6B 1/2-20	Jacobs Chuck

Other cells available, with prices and information supplied on request.

6.0 List of Establishments Equipped with the OTMS or Using Its Components

The following establishments are known by the author to have an OTMS or components of the system in addition to those who contributed the results in section 2.0

M.S. Kaldy,
Agriculture Canada,
Research Station,
Lethbridge, Alberta
T1J 4B1

R.E.C. Layne,
Agriculture Canada,
Research Station,
Harrow, Ontario.
NOR 1GO.

R. Stark,
Agriculture Canada,
Research Station,
Kentville, N.S.
B4N 1J5.

W. Donders,
Canadian Canners Ltd.,
1101 Walkers Line,
Burlington, Ontario.

General Foods Ltd.,
Research Dept.,
520 William St.,
Cobourg, Ont.

Central Food Technological
Research Institute,
Mysore 2A, India.

Massey University,
Food Technology,
Palmerston North,
New Zealand.

Navimor
Foreign Trade Enterprises,
Matejka 6, Gdansk, Wrzenszsz,
Poland.

The University of Alberta,
School of Household Economics,
Room B22,
Edmonton, Alta.
T6G 2H1

State Stores Board,
50 Margaret Street,
Brisbane, Queensland,
Australia.

Strojimport
Foreign Trade Co. Ltd.,
Vinohradska 185, Praha 3,
Czechoslovakia

Agriculture Canada,
Research Station,
P.O. Box 20280,
Fredericton, N.B.
E3B 4Z7.

Del Monte Corporation,
San Francisco.

Dept. of Fisheries & Environment,
Fisheries & Marine Service,
501 University Crescent,
Winnipeg, Manitoba
R3T 2N6.