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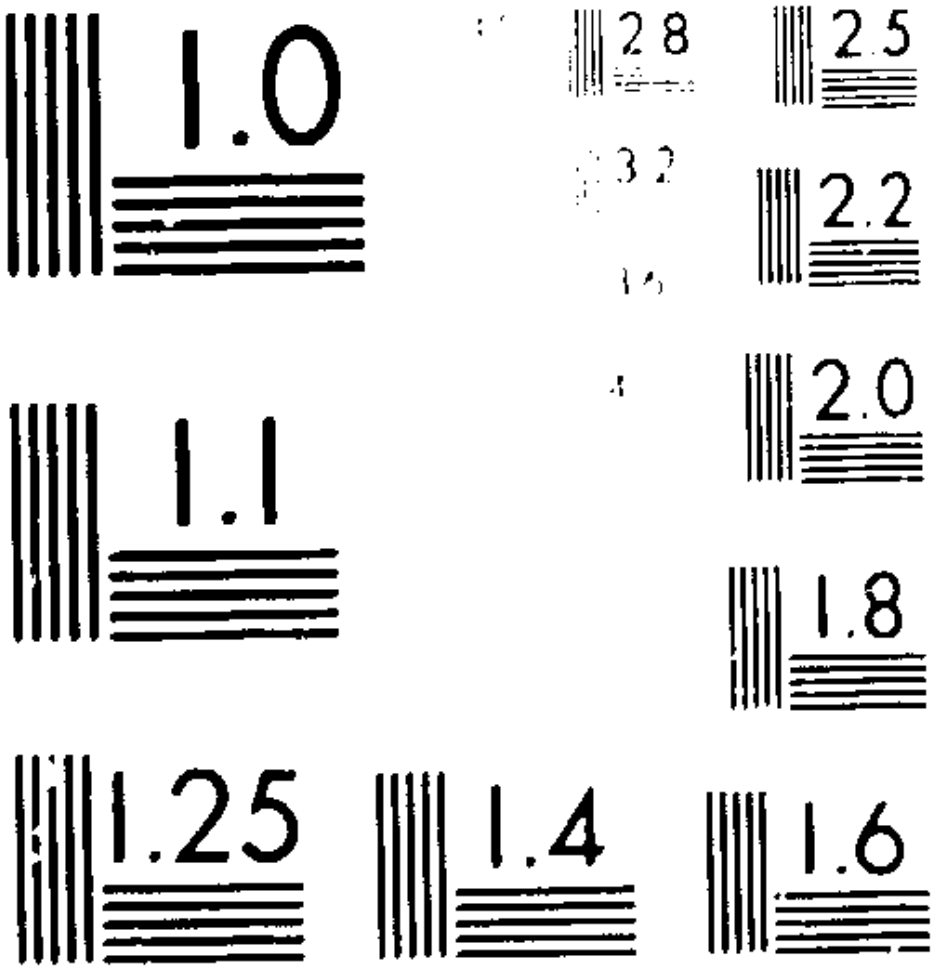
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MACHINES AND EQUIPMENT FOR QUALITY CONTROL OF FURNITURE *

by

Alfred Fink **

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Introduction

For many years now world consumer organizations have been calling for better systems of furniture quality control through product information. The basic idea behind this request was to improve construction details of the product. The transition from the craftsmen's skill to that of factory production, however, has caused the customer a certain anxiety. The use of new materials in connection with modern design has revealed problems which could not always be solved satisfactorily by the designing engineer. This rapid development (one could almost call it a "revolution") is the main reason for a reluctant and critical attitude on the part of the consumer. The chip-board, for example, is still widely rejected by the average consumer of modern furniture even though it was introduced to the market some 25 years ago. The request for detailed quality standards is therefore a logical development from the producers' and consumer point of view. On the one hand, quality standards should help the customer to realize the quality necessary for his purpose and on the other hand they should not hinder technological progress.

1. The Development of Quality Standards

The development of quality standards is presently in its first stage of being. Even the definition of the term "quality" is not easy to pinpoint, thus there is much argument over the term itself. Generally speaking, the term implies a function of durability, rigidity, material and workmanship, and one also gathers from it a sense of the cost of the item used in connexion with it. This, though, is not precisely what we are seeking. Therefore, one would choose the phrase "fitness for purpose" * rather than the term "quality" and with this definition it becomes possible to develop a system of standards based exclusively on objective features such as durability, rigidity and workmanship. Standardization is thus independent from material and competitive prices.

Since 1972 the International Organization of Standardization (ISO) has been entrusted with the task of developing a system of standards. Today there are approximately 50 countries represented by their national standardization organizations in the technical committee TC 136 "furniture"

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* A more appropriate phrase might be "Degree of Suitability".

of the ISO. The TC 136 has 9 sub-divisions and each of these working groups (WG) has its particular function. The work relating solely to the organization of the committees is given to another branch of the organization of standards. (Table 1 on the following page outlines the structure of the ISO/TC 136 Furniture Group).

In order to achieve reasonable standards for furniture it is important to classify them according to kind and function (according to room type). The following classification, for example, is used:

(a) storage units
(b) seating furniture
(c) tables
(d) upholstered beds
(e) other furniture

This subdivision into five basic groups covers all furniture. The basic groups again are divided according to the specific function in use (i.e. seating furniture is divided into chairs with arm-rest, chairs without, etc.) therefore making an exact determination of the individual piece of furniture possible.

The specific requirements of the piece of furniture defined above coincides with the area in which this piece of furniture is most often found. These areas are divided into:

(a) living area
(b) object area
(c) educational area
(d) office area
(e) special areas

These basic areas are further sub-divided as shown in Table 2 (page 4 of the text). This system allows for the definition of any piece of furniture in regard to its kind and purpose.

Table 1: Structure of the ISO/TC 136 Furniture 1/

SC	WG	TITLE	SECRETARIAT
1		Test Methods	Sweden (SIS)
	1	Storage Units and Tables	Sweden (SIS)
	2	Furniture for Seating	United Kingdom (BSI)
	3	Beds	Federal Republic of Germany (DIN)
	4	Fire Tests	United Kingdom (BSI)
2		Ergonomics	Vacant
3		Specification for Materials and Workmanship	Federal Republic of Germany (DIN)
4		Terms and Definitions	Romania (IRS)
5		Domestic Furniture	Federal Republic of Germany (DIN)
	1	Storage Units and Tables	Sweden (SIS)
	2	Furniture for Seating	United Kingdom (BSI)
	3	Beds	Federal Republic of Germany (DIN)
6		Office Furniture	France (AFNOR)
7		Furniture for Educational Institutions	Federal Republic of Germany (DIN)
	1	Plan Sizes for School Table Tops	Sweden (SIS)
8		Hospital Furniture	Sweden (SIS)
	1	Wheelchairs - Test Methods	United Kingdom (BSI)
	2	Wheelchairs - Type Classification	Sweden (SIS)
	3	Deleted	
	4	Wheelchairs - Reduction of Dimensions of Manual Wheelchairs for Transport and Storage Purposes	Netherlands (NNI)
9		Hardware for Furniture	France (AFNOR)
	1	General Classification and General Terminology	Austria (ON)

1/ Source: Annual Report for 1979 of the ISO/TC 136.

Table 2 1/

General Area	Special Area	Special Type / Type	Seating Chair Bench Chair with arm-rest Hammock chair	Storage Cupboard Stack Chest Additional	Tables Table Worktable	Beds Bed Couch	Special Special
Domestic	Sitting-eating Kitchen Children Bath/WC						
Object	Hotel Hall Shop						
Education	Kindergarten School University						
Office	Office						
Special	Hospital Laboratory Handicapt Garden Workshop						

1/ Source: R. Schubert "Möbelnormung und Möbelprufung", edit. Holz als Roh- und Werkstoff 37, 1979.

The following table shows a classification of individual tests, which are carried out in the same manner as in table 2.

Table 3 1/

General Area	Special Area	Special Type / Kind of Test: Product — Ergonomic, function measures; Durability, Workmanship; Security, Safety	Material — Mechanical; Chemical; Biological	Hard Ware — Mechanical; Chemical; Biological	Surface — Mechanical; Chemical; Biological
Domestic	Sitting-eating Kitchen Children Bath/WC				
Object	Hotel Hall Shop				
Education	Kindergarten School University				
Office	Office				
Special	Hospital Laboratory Handicapt Garden Workshop				

1/ Source: R. Schubert "Möbelnormung und Möbelprüfung", edit. Holz als Roh- und Werkstoff 37, 1979.

Tables 2 and 3 have to be combined in a tri-dimensional way (similar to a square block) and results in a number of 2,704 single test items. This huge number, however, should be viewed only in a theoretical way, as, in reality not every kind fo furniture is represented in each area. Also the single test items are not to be applied indiscriminately. The criteria of selection is: test items are selected according to the purpose of the respective peice of furniture. In this way the actual number of individual tests has decreased considerably.

This system was first developed in the Wilhelm-Klauditz Institute of the Fraunhofer Gesellschaft, Braunschweig, Federal Republic of Germany. It is (considering the final test report) a code system based on electronic data processing and thus gives an overall look at the complex field "furniture".

2. Testing Methods and Testing Machines

2.1 Storage Units

The storage unit range is, despite its variety of type and design, a comparatively unproblematic furniture group. The individual items are mostly independent from one another concerning particular function. Therefore, each piece of furniture can be tested according to its purpose. With a kitchen unit, for example, the basic functional elements are the following:

(a) carcase
(b) drawer
(c) pivot door
(d) shelf
(e) surface

A further breakdown can be determined as such:

(a) Testing of the Carcase

The frame is fixed to the ground. At the level of the working top a force of 300 N will be applied from the front and the side by a pneumatic cylinder. This test proves the rigidity of the corner joints. The decisive test criteria is the respective delfection under action of a force in relation to the unit height.

A fatigue test will not be applied since a kitchen unit is usually fixed to the building (wall) unit so that the corner joints are only under stress during transport and setting-up.

(b) Drawers

The drawer is a frequently used functional element, therefore the fatigue test must be used. Normal use can be imitated by simply closing and opening the draw quickly. Following the motion the course of acceleration must be sinusoid. Thus, a movement by a pneumatic means cannot be applied because of its jerky acceleration and straight direction. The medium velocity should be about 0.2 m/sec. Figure 1 shows the opening and closing speed of drawers.

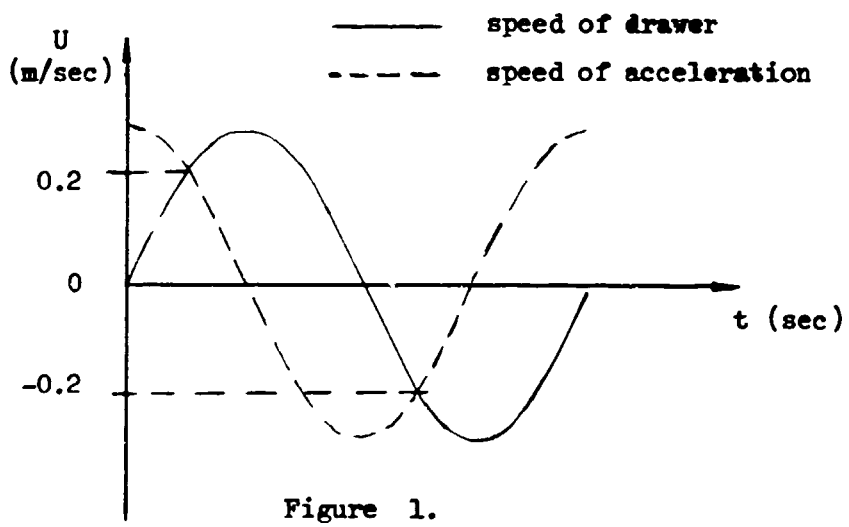


Figure 1.

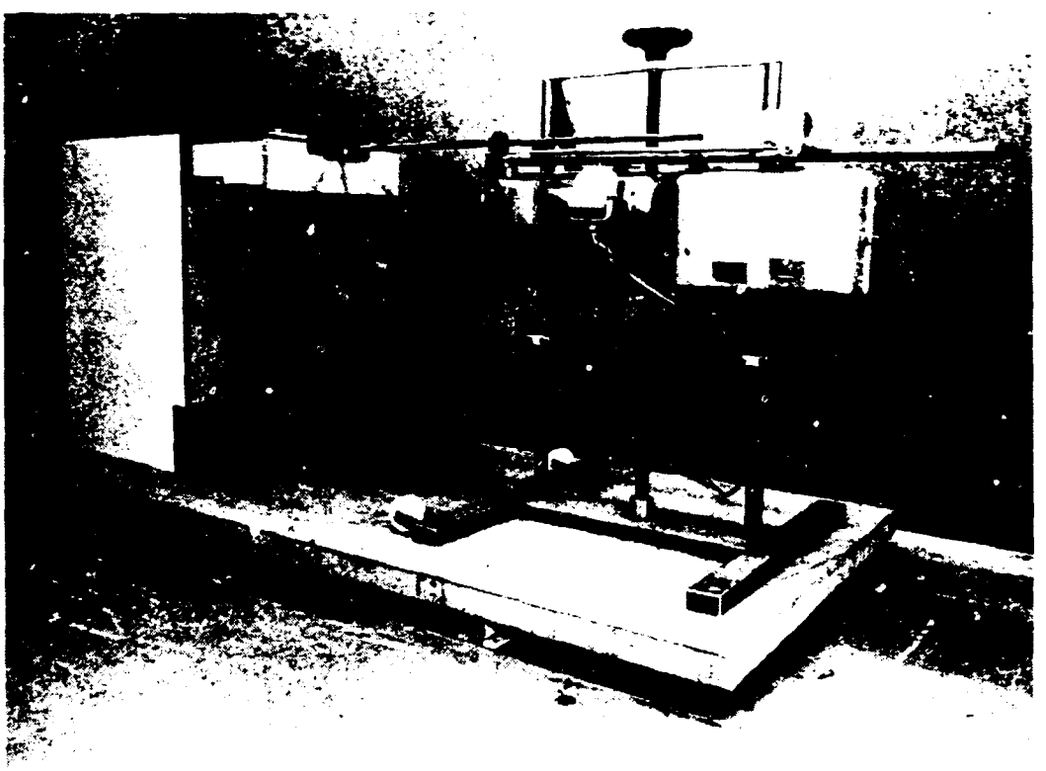
The best method to use would be an electric feed drive with eccentric transmission as depicted in the Photograph 1 on the following page.

The load of the drawer during the fatigue test is fixed at 6.6 N/dm^3 for the kitchen area, where drawers are to be filled with heavy goods. In the case of an average drawer with the inside dimentions of 400 mm x 430 mm x 110 mm = 18.92 dm^3 that yields to an overall load of 19.92 dm^3 x 6.6 N/dm^3 = 125 N, about 12.5 Kg. The number of testing cycles is set by the

number of operations per day and the period of utilization relating to calculation by the consumer. Kitchen drawers normally operate at 12 pulls per day for 10 years of utilization. Hence the number of cycles is calculated:

-Number of cycles = 12 x 365 x 10 = 43,800

which is about 40,000 cycles altogether.



Picture 1: Drawer tester with electric feed drive and eccentric transmission.

The friction in the form of the thermal load is a disturbing factor as far as the runner mechanism of drawers made of artificial material are concerned. These drawer runner systems are mostly used nowadays. This disturbing factor can be omitted by taking a break after every fifth cycle that corresponds to the time period of five cycles. The factors to be looked at are the modifications of the opening and closing forces as well as the sagging of the drawer caused by the wear of the material in the slide rail.

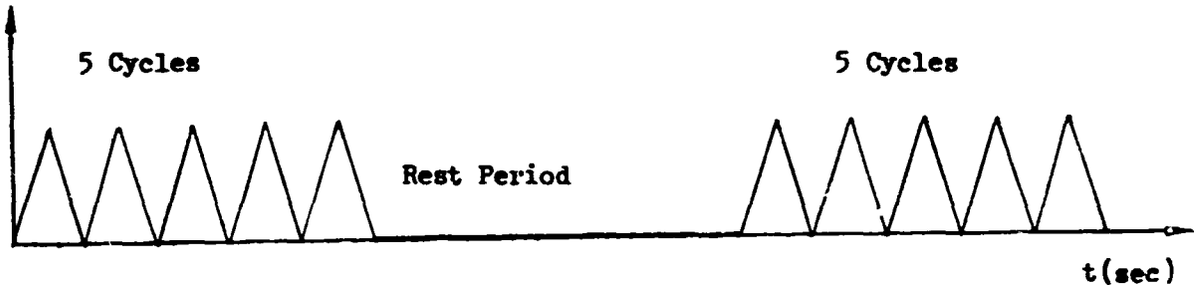


Figure 2: Modulus of testing doors.

(c) Pivot Doors

Here again pneumatic means will be used for the test process. The decisive criteria are: the sagging of the door against reference marks at the carcase, as well as rigidity of the hardware. The number of cycles again the calculation is based on the data applied for the drawer test but an additional load of 50 N for aggravation must be considered to gain results beyond measuring faults.

(d) Shelves

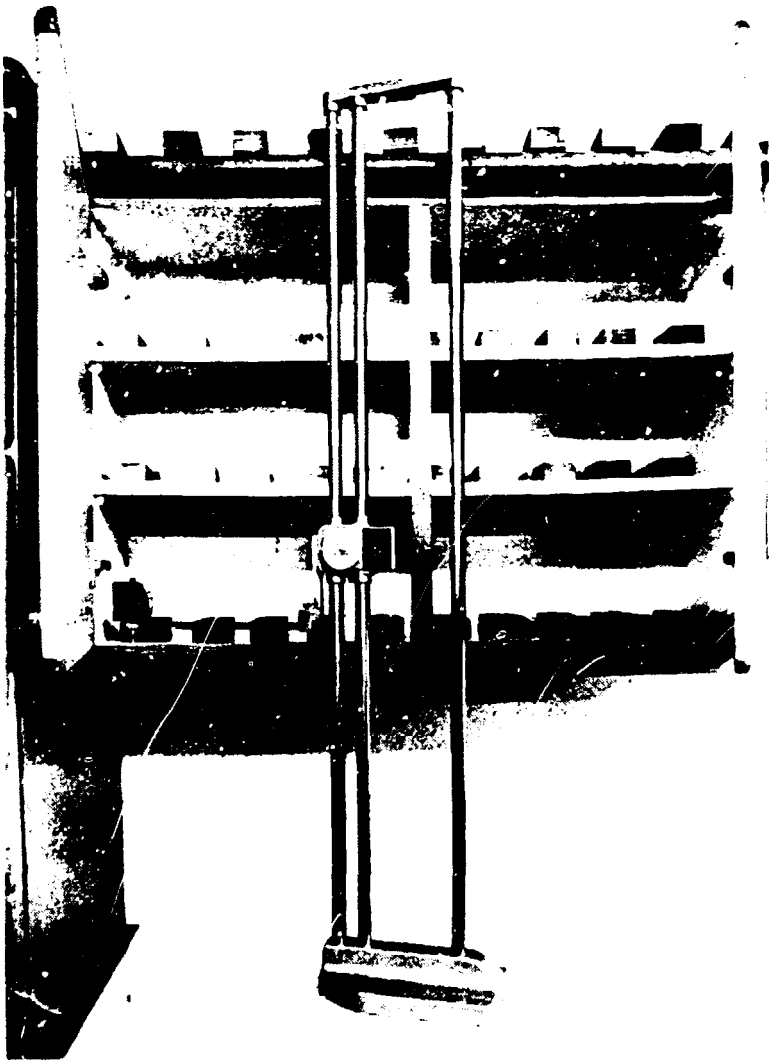
Quality criteria fo shelves is the deflection. The size of deflection depends on the size, laminate, the load and span. The test load corresponds here to double the actual load. In the case of kitchen units 85 kg/m^2 is the actual load corresponding to 170 kg/m^2 test load. The following formula features criteria for the deflection:

$$f = \frac{5}{384} \cdot \frac{x}{x} \cdot \frac{q}{E_t} \cdot \frac{x}{x} \cdot \frac{l}{I}^4 \qquad (1)$$

f = deflection in mm
q = overall load in N/mm
l = span in m
I = inertia ($\frac{b}{12} \cdot \frac{x}{x} \cdot h^3$ for rectangular cross-sections)
E_t = E-Modul after termination of the creep time = $\frac{Eo}{1 + p}$ (2)
p = creep factor

The formula (1) describes the deflection after terminating

the creep time. Through tests is was found that the creep time is terminated after approximately 28 days and that the loaded shelf does not deflect further on. The creep factor varies between 0.8 (good) and 2.5 (bad). The deflection test is controlled at intervals. (3 min, 1 hr, 1 day, 7 days, 14 days, and 28 days). Measure points are the supports and the centre of the shelf. The size of deflection refers to the span.



Picture 2: Deflection measurement of shelves.

After termination of the loading the setting capacility is measured which means that after unloading of the shelf the

remaining deflection, measured after 7 days is evaluated as constant deflection.

(e) Surface

Especially in the kitchen area the testing of the surface is essential. Here aggressive materials are frequently used. The test evaluates the effect of test liquids. The test series is based on the influence of test liquids. They range from simple salad oil to compounds like Ethyl-Butyl-Ester that is found in finger nail lacquer remover. The test liquids are poured on the surface and covered air tight by a glass bowl. 16 hours later the liquids are removed and the surfaces are cleaned with an ordinary cleanser. The evaluation of the influence is made after 3 days. In order to ensure that the light conditions always remain the same during the evaluation cycle, we use a mercury steam lamp. The distance from the examiner's eye to the test surface is 250 mm. The evaluation criteria are graded in the following way:

0) no visible change
1) hardly perceivable change in glass and colour
2) slight changes in gloss and colour
3) strong marks are visible, the structure of the surface is almost unchanged
4) the structure of the test surface is changed
5) the test surface is much changed or destroyed.

2.2 Seating Furniture

2.2.1 Upright Chairs

For the testing of upright chairs also the past 8 years of working on quality standards at ISO-level did not lead to an international agreement as to standard. The main reason is that an upright chair is one of the most complicated constructions in spite of its "primitive" appearance and clearly defined purpose. These are 2 basically different possibilities to solve this problem listed on the following page.

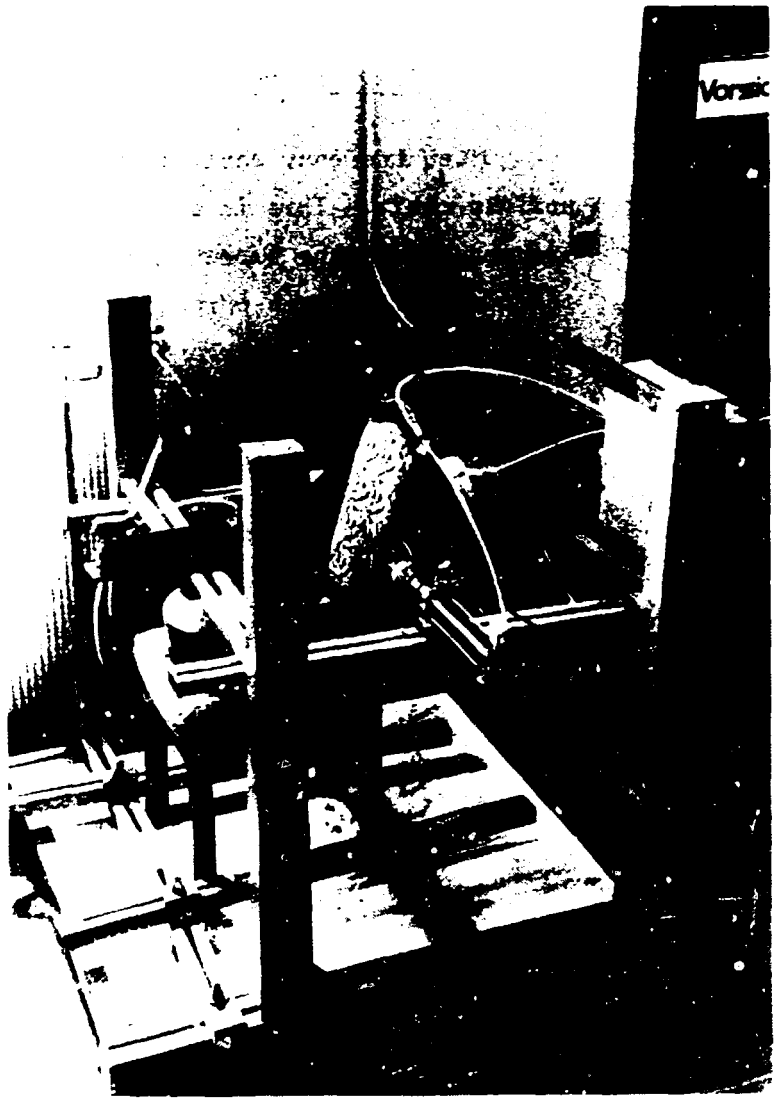
(1) The loading cases will be simplified and only one certain direction from where the loading is effective will be considered;
(2) Trying to make all possible loads centralized and securing a method which would guarantee this.

In the Federal Republic of Germany one chose the second possibility. Therefore, in the Deutsche Institut für Möbeltecknik (DMT) (The German Institute for Furniture Technology) a machine has been developed which meets the requirements. It consists of a frame that is mobile in all directions and that can be adjusted to all sizes of upright chairs. The test chair is held on the base, but can be tilted always over two legs of the chair in all directions. On each leg of the back a pneumatic cylinder draws and tilts the chair until two legs are 30 mm above the ground. The piston rod of the cylinder returns very fast so that the chair falls free and hits the ground heavily with the two legs lifted. With this method each imaginable movement is included.

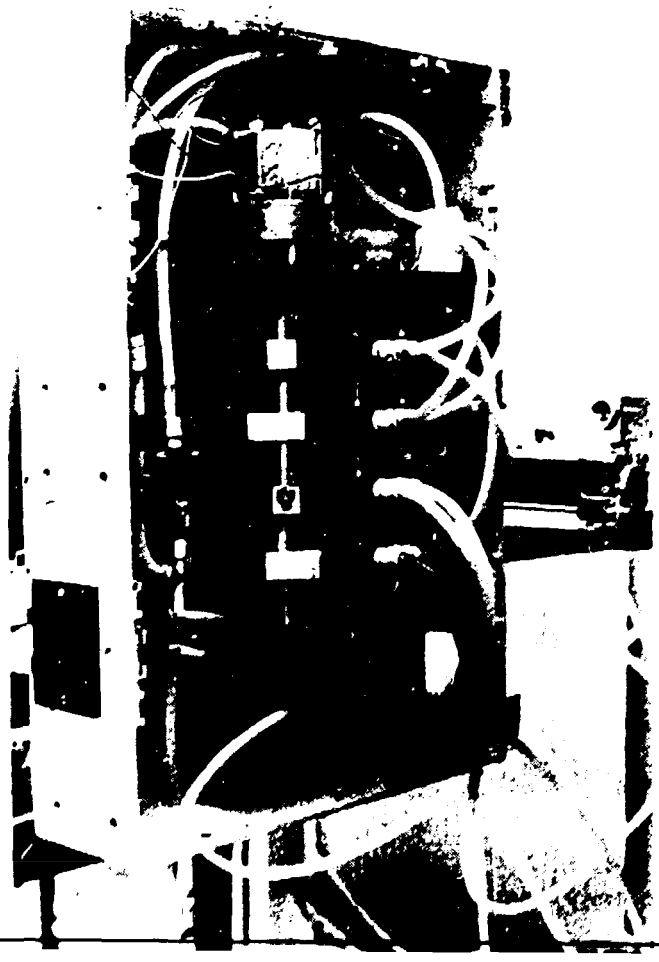
The control is effected by a camshaft which controls pneumatic valves. An electric motor moves according to the transmission 2 times per minute and sets the camshaft in motion (which is a cycle speed of two rotating cycles per minute = 8 cylinder operations). Changing the cam number the cycle velocity can be increased or decreased when necessary. The overall cycles correspond to the purpose area of teh chair to be tested.

Pictures 3 and 4 on the following page show a chair testing machine and the controls for chair testing machine respectively.

The criteria for evaluation are measured on the different joints. They may not loosen. The testing of the surface of the chair components is usually not so important however the arm-rests must be checked.



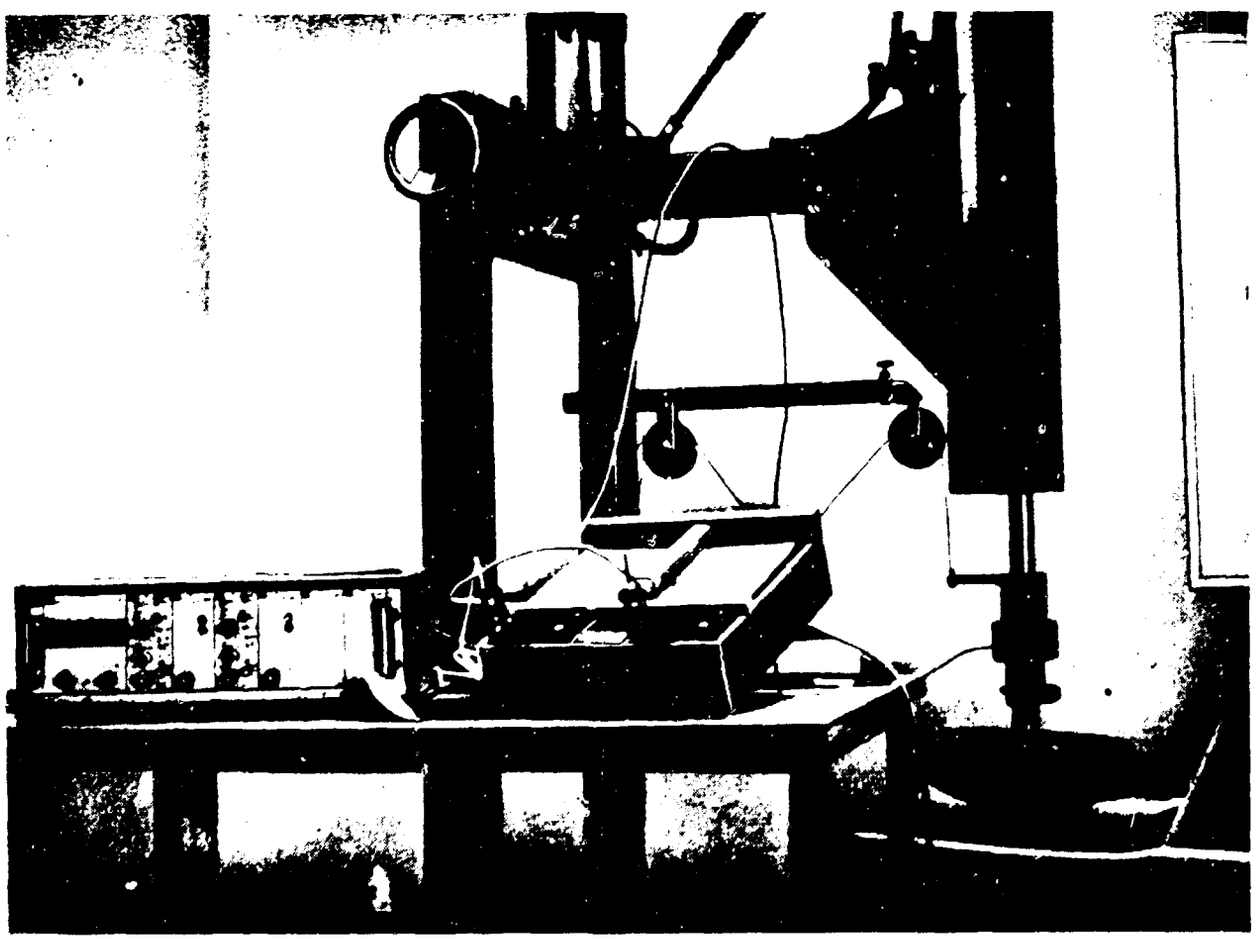
Picture 3: Chair testing machine.



Picture 4: Controls for chair testing machine.

2.2.2 Easy Chairs

Often the easy chair is thought of as simply a better form of the upright chair. This is absolutely not the case. The essential differences are in the expectation bearing in its use. While an upright chair serves certain purposes, the easy chair is mainly used to relax. Hence the loading is ergonomically completely different from the upright chair. The comfort here consists of a function of the elasticity of the sear. While investigating the elasticity one found a magnitude that can serve as measure. The testing machine has a relatively simple conception. As shown hereunder, an impact weight of 75 kg can be adjusted to a certain level by a pneumatic cylinder. The coupling of impact weight and piston rod stroke is done with electro magnetism.



Picture 5: Testing machine for easy chairs.

The cycle is controlled by a relay timing switch. The cycle intervals are adjustable from 1 second to 100 seconds. The evaluation data are based on:

(1) reaction power
(2) dynamical impression depth

The reaction power is measured with a pummet (DMS-technique for measuring) which is fixed to the impact weight. To measure the dynamic indentation depth the impact weight is coupled with an inductive displacement control. After launching the impact weight the measuring apparatus is switched on and the vibrations of the testing weight are scribbled by a UV-recorder.

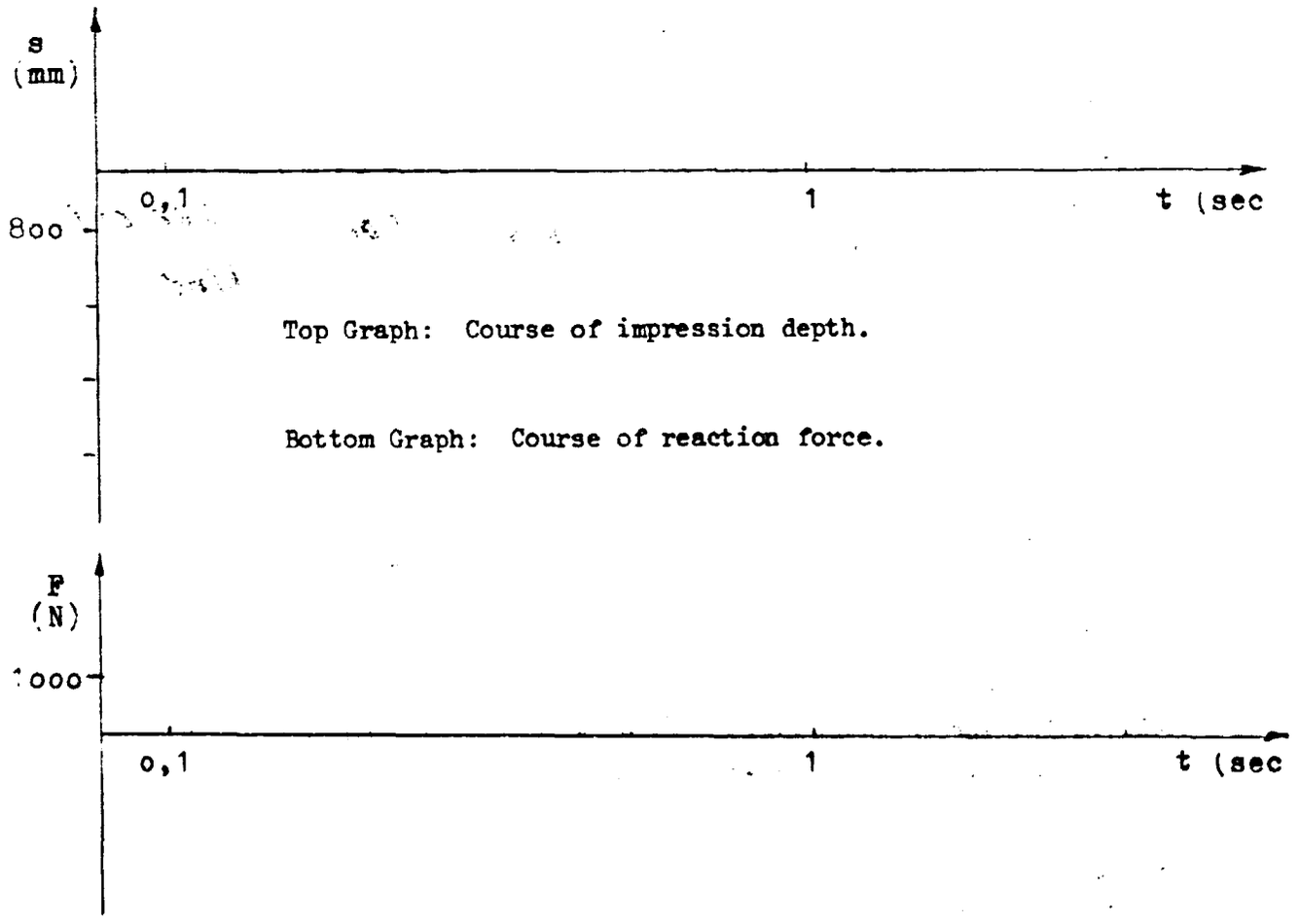


Figure 3: Simultaneous recorded test results of an easy chair.

This curve is almost exactly a homogeneous differential equation of the second degree of the form:

$$m \times a + k \times v + D \times s = 0 \qquad (3)$$
$$m \times s + k \times s + D \times s = 0$$

In this case:

m = amount of test weight

a = acceleration of the test weight

k = friction constant depending on velocity

v = velocity of the test weight

D = spring rate of the easy chair

s = dynamic indentation depth of the test weight

The formula (3) refers to the special solution:

$$(s-s_o) = s_{max}-s_o)\ e^{2m} - kt \times \cos wt$$

The computer solution shows that the k-value depends to a large extent on the fatigue of the upholstering. The DMT is running a trial test range which will be published soon. Based on the results it will be decided which conclusion can be drawn from the k-value in relation to the real comfort and wear. Measurements are taken at different heights. They range from 50 to 150 mm at a reaction force of a constant 1600 N.

2.3 Beds

While testing beds we have tc differentiate between two test items; (a) the rest surface, which is about the same of all types and (b) the special construction. The testing of the rest surface is primarily a testing of the mattress. This id done on a test bench especially developed for that purpose. Thes test bench consists of a loaded roll rolled across the mattress. Thereafter the deformation and change in thickness after 80,000 cycles is measured.

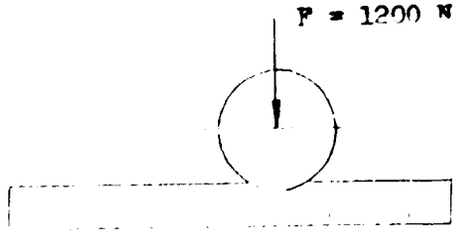
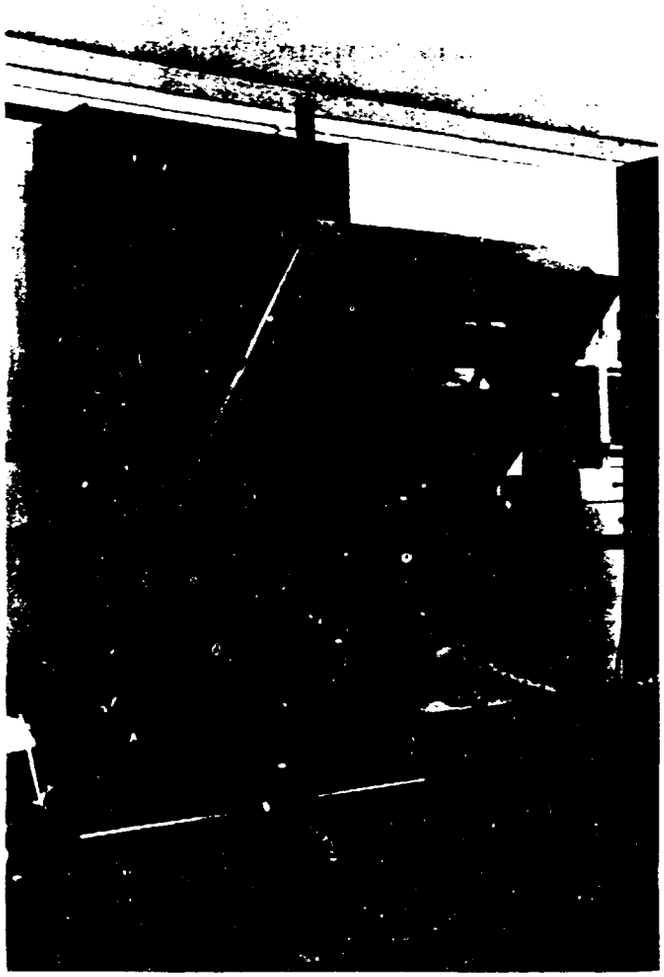


Figure 4: Testing principle for mattresses.

The construction is tested according to its purpose as, for example, for a flapping bed.



Picture 6: Flap bed testing equipment.

The testing equipment here again is set in operation pneumatically, as most testing machines for furniture are.

2.4 Tables

Testing tables is not complicated and is done with the same testing equipment described in chapter 2.1 (Carcases).

The testing machine is equipped with two additional cylinders in order to render possible movement in all directions. The frame is fixed and the table-top is loaded horizontally with 300 N. The deformation as against the frame after 1000 cycles is measured.

2.5 Individual Furniture

The so called "individual furniture" usually belongs to one of the preceeding groups as fas as construction or purpose are concerned. If this is not possible because the piece of furniture cannot be classified in any group, a special testing method with the testing apparatus is being developed by consumer organizations in co-operation with the producer. These developments, however, are an internal concern of the institutes and do not have general application.

3. Planning of an Institute for Furniture Testing

How to plan a testing Institute? First of all, the scope of activity must be established. "Scope" in this instance means the range of testing operations. For example:

(a) Quality tests in the sense of a quality means and quality guarantee for one or more producers and consumer co-operatives. (MI Stockholm).

(b) Independent institute for product testing in the sense of Fitness for Purpose (DMT Rosenheim).

(c) State-controlled institute operating on research orders (FIRA Stevenage).

In most cases it is impossible to adjust the needs of any particular testing centre to exactly these of the above, but there will be similarities. A pattern can be discerned from which specific operations can be done. Again, in most cases, an institute is subsidized by several bodies. And usually, the several donating partners financing the industry consist of the following:

- 40 per cent contribution from the State (also in the form of research orders;
- 30 per cent contribution from the industry concerned (also from

the ancillary industry;

- 30 per cent from self-generated funds gained through testing fees, distribution of quality certificates and training courses.

This type of financing prohibits any special dependency on the part of the industry.

To perform its duties the industry has several departments. They are, for instance:

A. Administration
B. Testing Laboratories
   1) material testing
   2) quality testing
   3) safety testing
   4) research
C. Outdoor service
D. Workshop

This organization, however, is a general concept only because there are cases which cannot be maintained by one of the above mentioned departments.

3.1 Basic equipment for furniture testing

Everybody knows that all beginnings are problematic and hence the question on the basic implementation. In short, there is no sure procedure. As a rule, however, one must keep in mind that these institutes are not manufacturing facilities, therefore, it is suggested that the most modern, up-to-date equipment is installed. (In this way huge problems can be later avoided and this route is well worth the larger initial investment).

Concerning the layout of the institute, it is important to plan with a vision of future expectations always in mind. For example, for comparison testing of 20 built-in kitchen units 200 m^2 are easily covered. And, if the industry is located in a tropical country exposed to strong climatic changes and especially to

humidity, the department should be (at least partially) airconditioned in order to keep the test conditions as constant as possible. Besides using compressed air too, it is absolutely necessary to run electric testing units. Many tests are carried out in the form of static load and with these compressed air has proved to serve best. The plant should be rather over than under-dimensioned, because it is almost impossible to calculate in advance the amount of air that is needed.

The testing machines are mainly self-developed. This is the reason why a workshop with the basic metal and wood processing machinery must be equipped for the manufacture of all jigs, templates and specialized testing equipment. Heavy duty equipment should be manufactured out of doors. Measuring equipment has to be available and ranging from the inch scale to the precision balance (with electronic amplifier especially for research operations, when necessary). This electronic amplifier can be furnished with different executions which are offered in many different types. Select one which enables a later coupling with a computer (EDP system). A computer system is part of the basic equipment yet it becomes only necessary when the test compass is getting so large that a shortage of staff occurs. Then the code system described in paragraph 1 becomes very useful by running the tests automatically. A definition of the piece of furniture is fed to the computer that controls the testing machinery and records the measured values and keeps it registered. The computer can also handle administrative work.

3.2 Special Equipment

The special equipment consists of the individual test units equipped with the probe. The test units should be designed for multi-application in lab testing as to decrease set-up time. The following are needed for such laboratories:

1) Test storage units:
   - pivot door test unit changeable to flap testing
   - drawer test unit (2x)

- test bench to measure the deflection of shelves (6 to 8 if possible) probably with potentiometer
- carcase test unit (also applicable to tables)

2) Test chairs:
   - testing machine for upright chairs (3x)
   - testing machine for easy chairs
3) Test beds and couches:
   - an appliance as shown in Figure 3 and Picture 6
4) Probably a Universal test bench for research work
5) Surface laboratory

Furthermore, a series of individual devices are needed for special test runs only which have to be revised.

The pneumatic equipment will be expected to cover:

2 - 3 cylinders ø 60 mm
15 - 20 cylinders ø 40 mm of different lengths.

Valves for the control small material.

That mainly cylinders with a ø of 40 mm are used results from the fact that most loads are under 750 N which can be reached with a pressure of about 6 bar, and air consumption remains at a minimum.

3.3 Personal Prerequisites

As mentioned earlier in this report, the field of furniture teasing is still a new one. Because of this, many rules concerning the staffing of a furniture testing plant are made and either broken or supported by others in an effort to find the most reasonable working solution. In view of production costs, such an institute carries a considerable cost factor and therefore must hire only specialists in the various fields involved. The work to be done, however, varies ranging from general administration to electronic data processing (including info-technology). Also, there is the handicraft work to be done. In short, a wide range of knowledge of furniture making from each staff member is essential to the success of the industry.

In light of these facts, the personnel structure could be the following:

1 co-ordinating engineer (and also the manager of the institute)
1 technical manager (also an engineer)
1 testing engineer
2 testing technicians (skilled in joinery or cabinet making)
1 out-door specialist (service technician)
1 administrative employee

which is a total of 8 employees.

3.4 Estimated costs:

3.4.1 Capital Cost (in DM)

Buildings (planning and maintenance)	DM 25,000
Administrative department	DM 20,000
Testing equipment (purchased)	DM 40,000
Testing equipment (self-made)	DM 30,000
Measuring equipment (without EDP)	DM 60,000
EDP (also for administration)	DM 50,000
Comprssed air supply	DM 35,000
Workshop	DM 20,000
Total	DM 280,000.-

These costs are spread over a time period of 2 years. Employment costs are not included during this period of time. Furthermore, it is porvided that the planning of the testing machines is done by members of the staff and that they are manufactured in the institute. (** All costs relate to the suggested outline of an institute).

3.4.2 Current Costs (estimate)

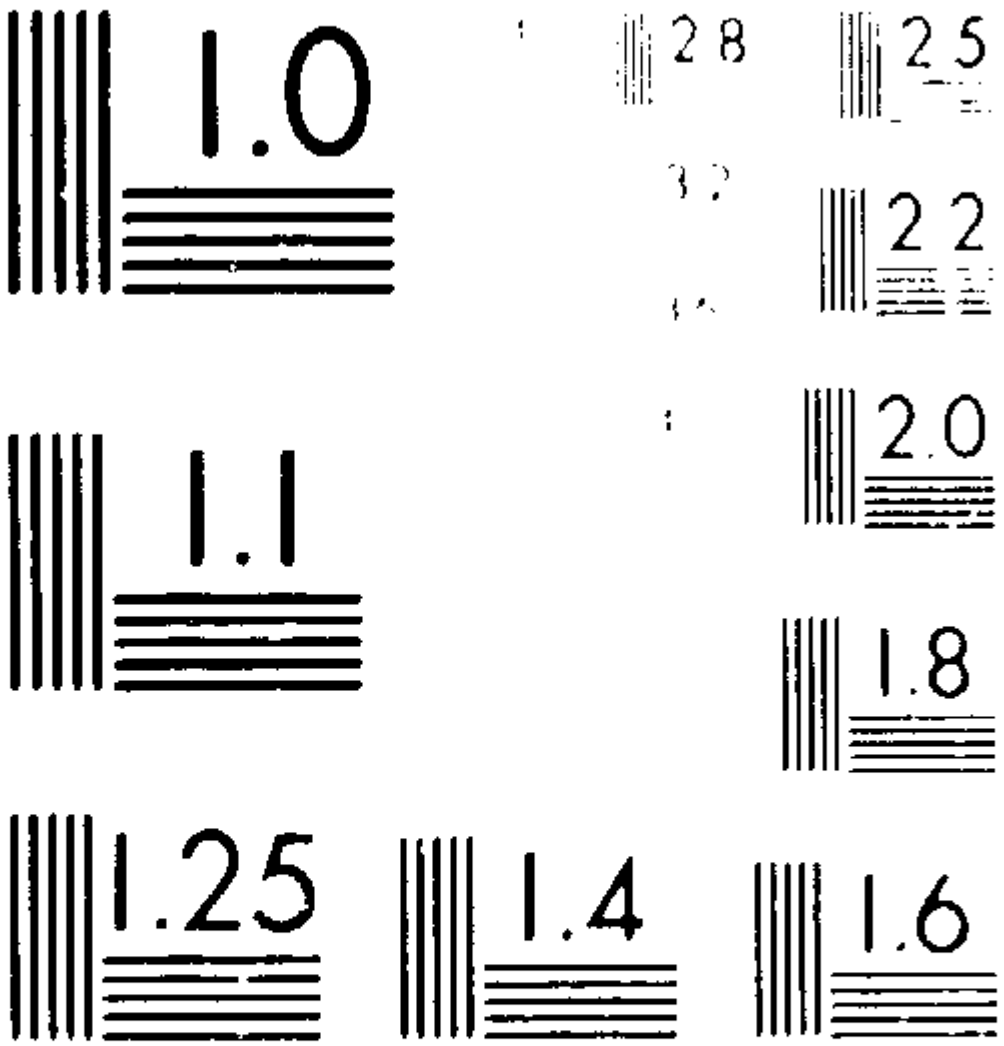
Rental about 350 m^2	monthly	DM 3,500
Energy	monthly	DM 2,000
Administration	monthly	DM 800
Maintenance, repair	monthly	DM 500
Material	monthly	DM 1,500
Employment costs	monthly	DM 25,000
		DM 33,800 **

4. Co-operation between industry and institute

An intensive co-operation is coercive. An institute for furniture testing must act as a focal point for all those interested in an aspect of furniture manufacture. One of its main duties should be to adivse producers on design problems. It should also act as the controlling authority for the consumer to ensure that his interests are protected. Another important function of the furniture testing institute is that it is expected to intervene between the furniture industry and the ancillary industry on occassion, when necessary. What better place for the newest ancillary materials and hardware components to be discussed and debated than within the specialized institute. Hardly any producer is able to carry out such thorough tests alone.

For the entire range of inter-firm quality control furniture laboratories techniques have been developed which enable the manufacturer by aid of uncomplicated appliances to test production quality on their own without pruchasing the complicated equipment. The long-reaching goal, then, of furniture testers is to discover the quality determinative factors thus enabling the strict standard to be set and so "calculate" the quality of the piece in advance.

For quite awhile now, the metal workin, industry has employed a tolerance system and it is well accepted by everyone. For the furniture industry this has not yet happened. To achieve this, an intensive co-operation with all parties concerned is necessary. One must remember, however, that despite all of the work involved in creating a piece of furniture, the testing of it should be quick, efficient, and exact. The function of the furniture testing institute is a practical one and should never be confused with that of the manufacturer.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MACHINES AND EQUIPMENT FOR QUALITY CONTROL OF FURNITURE *

by

Alfred Fink **

CORRIGENDUM

On page 18, point 3: Planning of an Institute for Furniture Testing, (c):

> Instead of State-controlled institute operating on research orders (FIRA Stevenage)

please read:

> Industry and member-controlled institute operating on a combination of contracted research and services basis (FIRA Stevenage)

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