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ABSTRACT

The curricula of industrial arts courses in the Asian Region are changing to a more general approach to arouse interest in, and simple understanding of, industry and industrial processes. Spaces for industrial arts should be less tightly tailored to the needs of specific subject fields than was the case in the past. In secondary general schools, the trend should be toward general purpose spaces for all industrial arts teaching and learning. Some multipurpose workshops are illustrated and described including work-flow patterns and space requirements. (Author/MLF)

SCHOOL BUILDING DIGEST 13.

Asian Regional Institute for School Building Research
(sponsored by Unesco)
P. O. Box 1368, Colombo, Ceylon.

THE DESIGN OF INDUSTRIAL ARTS WORKSHOPS FOR SECONDARY GENERAL SCHOOLS IN THE ASIAN REGION

1. Industrial Arts.

The object of industrial arts as an area of Secondary General Education is to help the child to develop basic practical skills through the use of common tools and to arouse interest in and simple understanding of industry and industrial processes. The experience gained by the child in this area of education may be either of very general use after leaving school or sometimes, through the interest aroused and the aptitudes revealed, may lead on to further, purely vocational studies.

As at present conceived in many countries of the Region, Industrial Arts, although part of general education has a frankly vocational flavour: Syllabuses usually include the common crafts subjects such as wood or metal work and emphasis in teaching is on acquiring skills with tools and materials through the construction of personal projects. It is for this situation that the modern workshop has to be designed.

The designer should, however, be aware of developments in Industrial Arts teaching and learning so that new laboratories, whilst suitable for present teaching schemes, can readily be adapted to respond to future changes in curricula.

2. Changing curricula in Industrial Arts.

At present Industrial Arts in most countries of the Asian Region include two or more of the following fields of activity :

Woodwork	Technical drawing
Metalwork	Ceramics
Electricity/Electronics	Textiles
Cane and Bamboo work	Motor mechanics
Leather work	

In some countries new activity fields have been introduced such as:

Aerospace industry	General power technology
Industrial technology	Technology
Soft materials technology	Transportation power technology

The approach to learning in these new fields is through directed "discovery". In many ways the new schemes reflect the current changes in Science teaching and will demand similar changes in industrial arts workshop design as those already made in laboratory design, furniture and equipment, if and when they are adopted in the Region.

Perhaps the most important conclusion to be drawn by the reader from a study of this situation is that spaces for industrial arts should be much less tightly tailored to the needs of specific subject fields than was the case in the past. Just as in design for industry, the trend is towards "general purpose" factories, so, in secondary general schools, the trend should be towards general purpose spaces for all industrial arts teaching and learning.

3. Accommodation Needs of the Region.

A typical allocation of time for Industrial Arts in the secondary general school's curricula in the Asian Region is as follows:

Class	8	4 periods
	9	5 periods
	10	5 periods
Total		14 periods

The students are required to study two subjects, often metal work and wood work. The resulting Industrial Arts timetable is arranged as follows:-

Class	Metal	Wood	Theory	Total
8	2	2	–	4
9	2	2	1	5
10	2	2	1	5
TOTAL	6	6	2	14

There are usually 40 periods in a week and thus if there is only one stream or section in each grade then the use of the metal or wood-work shops is :-

$$\frac{6}{40} \times 100 \quad 15\%$$

That is to say the workshops are empty and unused for 85% of the week. The specialist teacher has also to be given other duties for he too has only a 15% utilization factor in his own speciality.

This unsatisfactory situation can be resolved in several ways:

(a) By providing only *one*, multi-purpose workshop for both metal *and* wood. Its utilization will be

$$\frac{12}{40} \times 100 = 30\%$$

(b) By reducing the size of the workshop to take only half of a full class. When half of the class is in the reduced multi-purpose workshop, the other half might be in a reduced science laboratory. The utilization of the workshop and specialist teacher would then be:

half class-section,	(a) $\frac{12}{40} \times 100$	30%
half class-section,	(b) $\frac{12}{40} \times 100$	30%
Total utilization		60%

Whilst economising in building, this alternative has the disadvantage that the teacher is working with less than the optimum number of students.

(c) By locating industrial arts workshops only in schools having multi-form entry, that is a number of classes or sections to each grade.

If there were 3 sections or streams to each of grades 8, 9 and 10, then the utilization of the multi-purpose wood *and* metal workshop and teacher would be:

$$\frac{12 \text{ periods} \times 3 \text{ streams}}{40} \times 100 = 90\%$$

Table 1 indicates the size of school needed to make economic use of *one, multi-purpose workshop* in the Secondary General Schools of some of the countries of the Region.

TABLE 1 – MINIMUM SIZE OF SECONDARY GENERAL SCHOOL TO MAKE ECONOMICAL USE OF ONE, MULTI-PURPOSE WORKSHOP

Country	*Size of Secondary General School in streams or sections per Grade (see Note.)*
Cambodia	Two form entry*
Ceylon	Two form entry
China	Two form entry
India	Three form entry
Indonesia	One form entry
Iran	One form entry
Japan	Three form entry
Korea	Three form entry
Laos	Three form entry
Mongolia	Three form entry
Pakistan	Two form entry
Philippines	One form entry
Singapore	Three form entry
Thailand	Three form entry
Viet-nam	Three form entry

Note: The table has been calculated from the latest curricula available in the Institute.

* Two form entry means that there are two streams, classes or sections in each grade.

4 **Resistance to the Introduction and use of Multi-Purpose Workshops:**

The idea of combining in one workshop such diverse subjects as wood and metal working and possibly ceramics and electricity is one which is likely to meet with stiff resistance from educators who have been trained to work in unit workshops.

In one Asian country in which only 5 % of the second-level general schools had workshop facilities, it was said that "educators felt that, in view of different objectives and physical maturity of the pupils, separate workshops should be maintained." In many countries, policy makers have to decide on whether to give more children education in multi-purpose workshops or provide far fewer children with separate workshops for each craft. The designer can, in estimating the accommodation needs and calculating utilization factors for each element of accommodation, draw the attention of education authorities to requests for designs for workshops which are demonstrably to be underutilized and explain some of the alternatives that might lead to more economic investment.

Teacher training is, of course, also linked with the problem of better workshop utilization. There is a need in multi-purpose shops for teachers trained in both of the subject areas for which the shop provides facilities.

5. **Course Content and Physical Facilities**

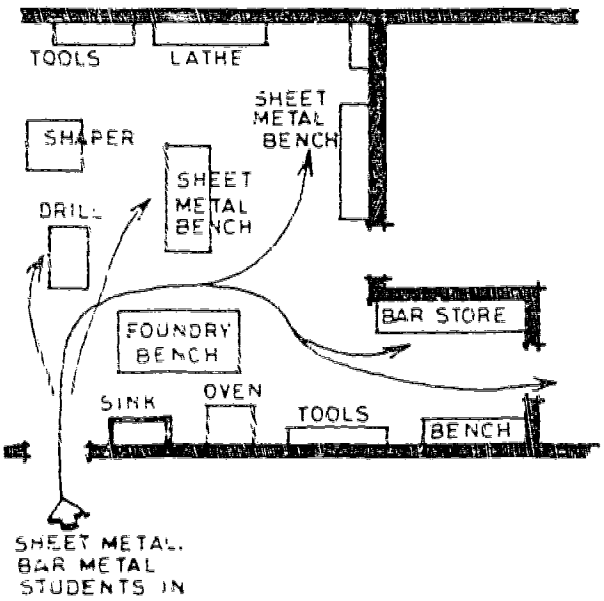
Most units of work for industrial arts take the following general form:

(a) Planning
(b) Obtain materials and set out
(c) Process (cut, joint, fasten)
(d) Finish
(e) Evaluate and store

Thus in most workshops there are common needs for accommodation, namely:–

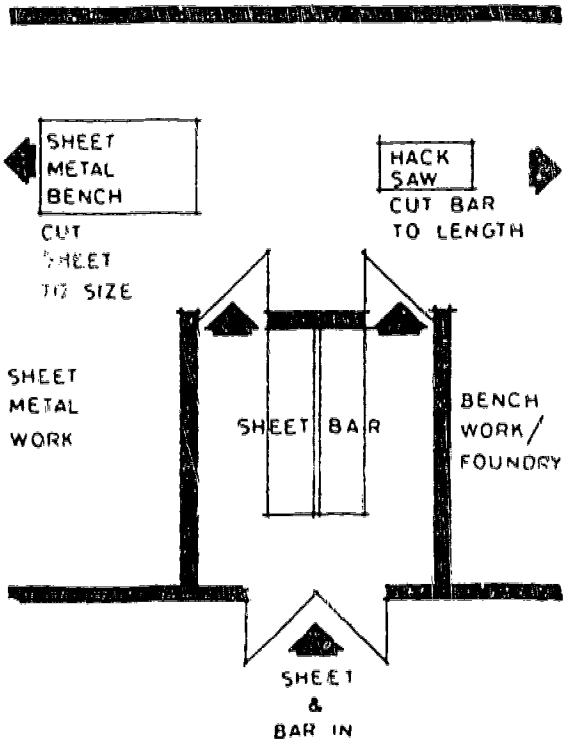
(i) Storage – for raw material
for tools
for finished work
(ii) Space for individual work (not at machinery)
(iii) Space for fixed machinery
(iv) Common work spaces (such as a glue bench)
(v) Space for planning work
(vi) Work room for teacher
(vii) Demonstration area for teacher
(viii) Space for changing to working clothes and for washing at the end of the period.

As one of the desired outcomes of industrial arts learning is an understanding of industrial processes, it is important that the workshop, through the inherent quality of its design, should, both descriptively and prescriptively, assist in the achievement of this aim. Where production of finished models is the main objective, such as in wood, metal and ceramics workshops, there should be a carefully arranged flow sequence into and out of the material store, to the workbench/machine, to the finished work store and out. A teacher will find it much more difficult to explain and illustrate processes in an ill-considered workshop such as in Figure 1 than in a carefully designed space as in Figure 2.



CONFUSED MOVEMENT OF MATERIALS

FIGURE 1



LOGICAL "FLOW" OF MATERIALS FROM VEHICLE TO STORE TO LABORATORY.

FIGURE 2

If the aim of education in Industrial Arts is an understanding of industry and its methods, then it is most likely to succeed in surroundings which, whilst not duplicating, at least reflect the atmosphere of a good, modern industrial plant.

6. Design of Multi-purpose Industrial Arts Laboratories

The desired capacity of workshops varies from country to country in the Region from as few as 16 up to as many as 40 student places. What is needed for general planning purposes is thus a *per place area* which will form a sound basis for the design of the work areas for laboratories of any capacity. The area should of course be such as to meet present *and* future needs. To it will be added other areas for storage, washing and teacher.

Table II suggests the gross per place area needed for different fields in a multi-purpose workshop.

TABLE II– GROSS PER PLACE AREAS FOR DIFFERENT FIELDS IN INDUSTRIAL ARTS MULTI-PURPOSE WORKSHOPS *(see note)*

Field of Activity	*Gross area per place in sq. metres*
Woodworking	6.1
Metal working (fitting and sheet metal)	6.1
Electricity/Electronics	4.25
Spinning and weaving	8.75
Ceramics (pottery and clay craft)	6.25
Rattan and bamboo work	5.0
Leather work	4.0
Masonry	4.25
Power mechanics (motor mechanics)	9.5

Note: The method by which these areas have been calculated is very fully explained in Study no. 5. The Design of Workshop for Asian Second Level Schools, ARISBR, Colombo. 1970.

The use of this data can be examplified with reference to a particular scheme of work in which children are required to study metal, wood, ceramics and weaving. There are 40 children in the class or section and they divide thus into 4 groups of 10, one group for each activity. The area of the multi-purpose workshop would be calculated as shown in Table III.

TABLE III – CALCULATING GROSS AREA MULTI-PURPOSE WORKSHOP

No. of students working in field	*Field*	*Per place area from Table II*	*Total area for field*
10	Woodwork	6.1	61m²
10	Metalwork	6.5	65m²
10	Ceramics	6.25	62m²
10	Weaving	8.75	88m²
TOTAL AREA OF WORKSHOP			276m²

It should be noted that the area calculated includes for a reasonable amount of machinery such as saws, lathes, drills in woodwork and lathes and drills in metal work. In ceramics a kiln is allowed for and in weaving a variety of looms. Where, at present neither equipment nor power are available it is still wise to provide adequate space for it rather than face elaborate and expensive additions and alterations to the workshop at some future date.

To provide less than adequate space will almost certainly create future difficulties "Once a building is built, it stands firmly for at least two or three generations to thwart any serious changes in the traditional deployment of space, time and students."

As far as storage areas are concerned, these should range from 15 to 24% of the floor area of the multipurpose workshop. A teacher's room of about 9 sq.m. and a hand washing area of about 7 sq.m. are also needed. For example given in Table III, the total covered area of the workshop would comprise:

Gross work area (from Table III)	276m²
Storage area	60m²
Teacher's room	9m²
Washing space	7m²
Total:	352m²

Ways of arranging this total covered space are shown in Figures 3 and 4.

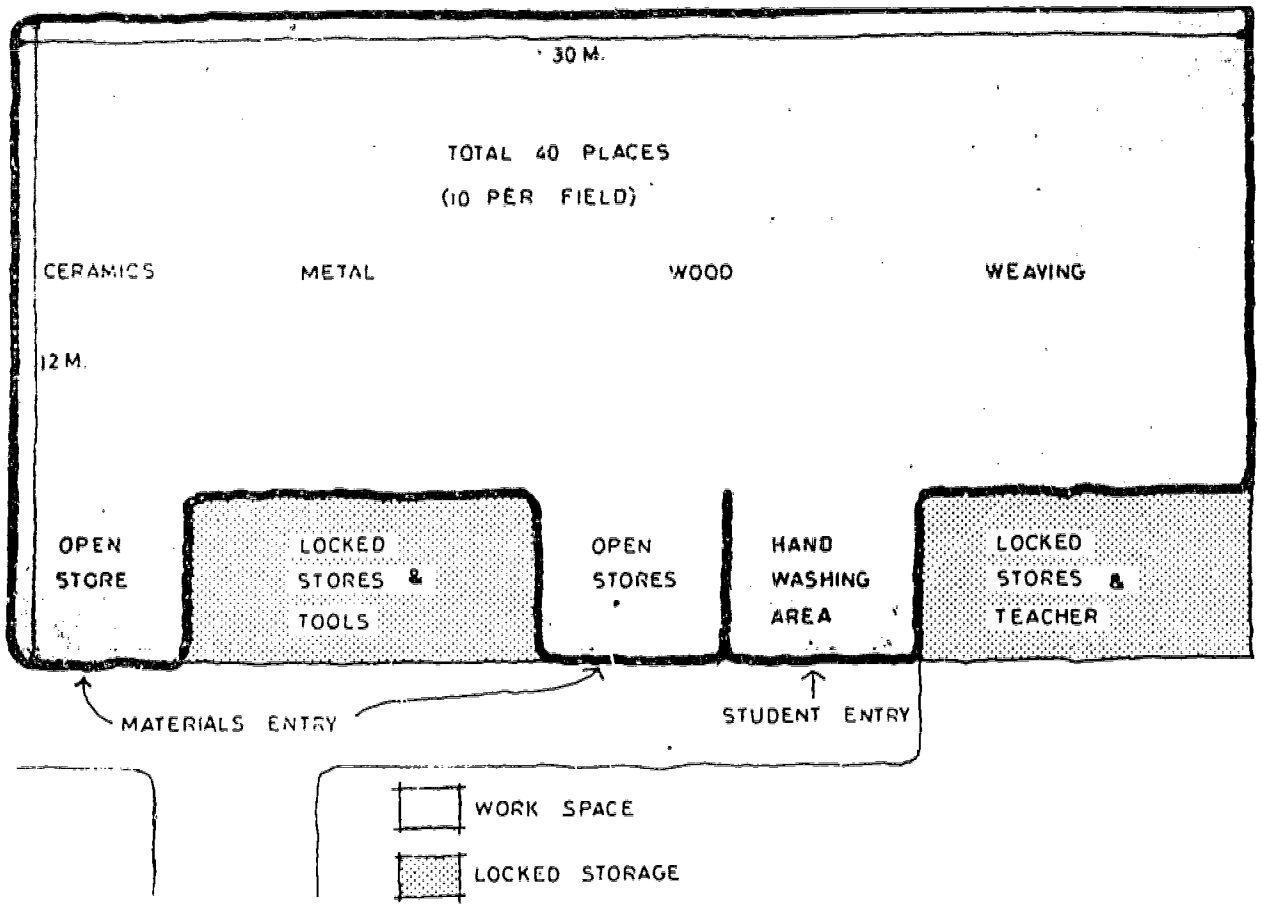
The detailed layout of work stations and equipment in the multipurpose workshop provide both a challenge and opportunity to the teacher. One alternative is to treat the subject fields as water tight compartments and to assign areas of the available floor space separately to each of woodwork, metalwork, electricity etc. This in fact would be creating a series of single field workshops but without dividing walls between them. Other and perhaps more exciting possibilities break away from this concept of separate activity fields and emphasise the similarities rather than the division between processes. One can think, for example of cutting, jointing and finishing and arrange the shop to show how these processes are undertaken in soft and hard materials.

The workshop designer is perhaps less concerned with which of these alternatives are selected than with ensuring that, as teachers and as curricula change, satisfactory accommodation is available to meet the needs, whatever they may be.

7. Ergonomics and Workshop Design.

Ergonomics is concerned with ways of improving the performance of tasks through detailed attention to the design of the environment.

This involves consideration of layout for optimum performance, an understanding of children's body sizes so that benches can be designed for convenient working, the provision of illumination levels that permit the execution of the task having regard to its degree of fineness and of the creation of a suitable thermal environment – an important point in the warm tropics where manual work results in the more rapid onset of heat stress than in temperate climates.

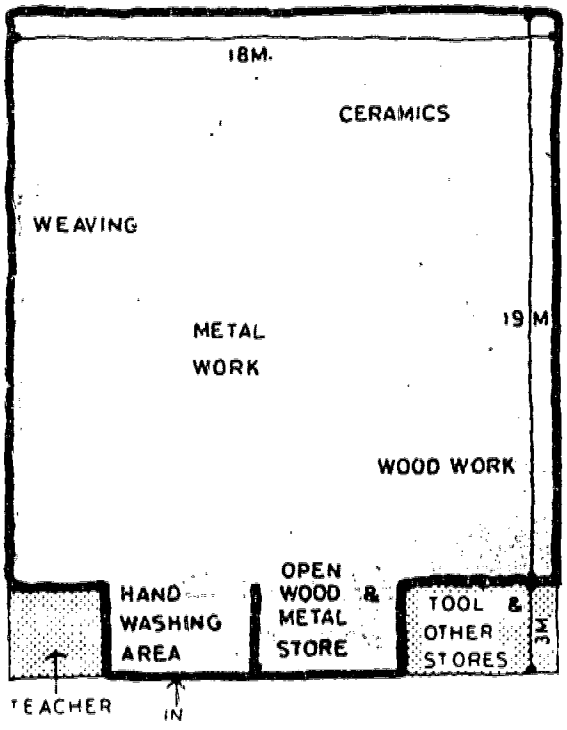


MULTIFIELD LABORATORY
SUITABLE FOR CEYLON INDUSTRIAL ARTS CURRICULUM

FIGURE 3

Detailed layout can best be determined by the analysis of the movements resulting from the operation of the teaching and learning activities through association charts. Figure 5 indicates how this analysis can be undertaken for a simple woodworking area of a multi-purpose workshop. It shows that the point to which most movement takes place is the teacher's bench and thus, to save the time associated with movement and to make the best use of the time available for the lesson, the teacher's bench should be placed in the centre of the workshop. This is the sort of unconventional solution that emerges through analysis and, by itself, indicates the need to study all workshop design situations afresh. Around the teacher's bench, movement criteria demand the placement of the students' work benches, whilst the less frequently used elements of equipment and accommodation are arranged logically around the circumference of the workshop. Indeed the work "circumference" itself suggests that the best form for this workshop might be circular rather than square. In most countries of the Region, however, building technology is such that a square solution will be preferred.

Where machines are involved, the criterion for arrangement might be flow of processes and Figure 6 illustrates the results of acceptance of this need.



MULTIFIELD LABORATORY
SUITABLE FOR CEYLON
INDUSTRIAL ARTS CURRICULUM

FIGURE 4

ORDER OF IMPORTANCE	NO. OF JOURNEYS	ELEMENT OF ACCOMMODATION
3	16	BOOK & BAG STORAGE RACK
2	31	UNFINISHED WORK STORE
1	73	WORK BENCH
3	16	TOOL BOARD
7	4	GLUEING BENCH
5	8	FINISHING AREA
3	16	GRINDER
6	6	BAND SAW
7	4	THICKNESSER
4	12	SANDER

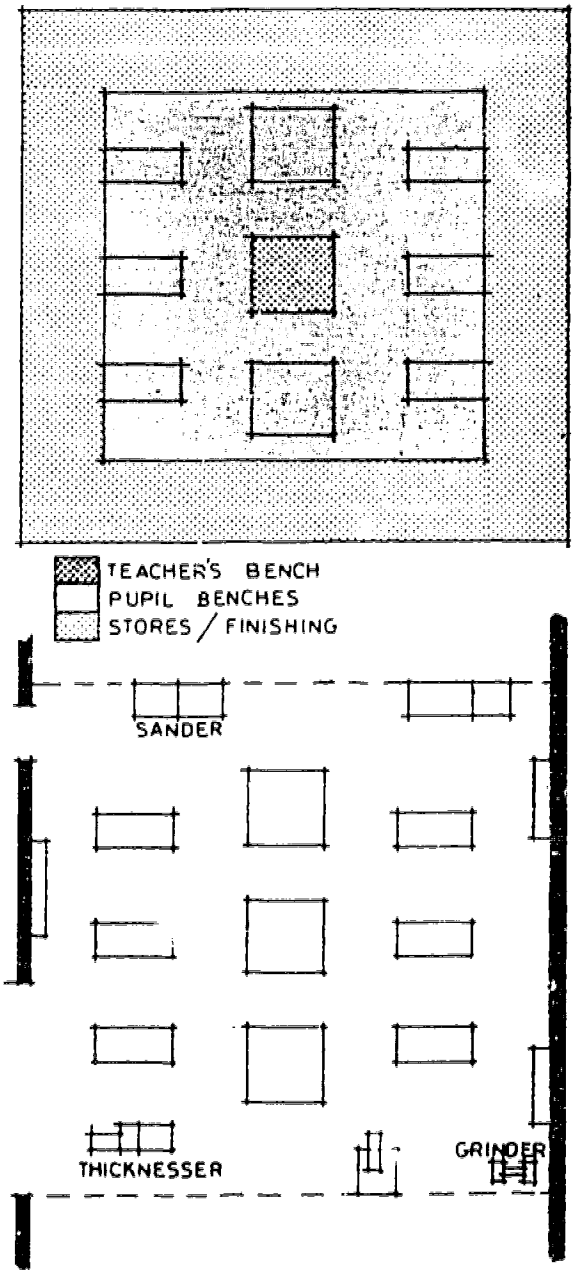


FIGURE 5

With the future in mind, it will be important to fix as little of the furniture and machinery as possible. The flexibility of the workshop will depend on this. Likewise, the provision of services for machines can best flow at ceiling level rather than in ducts in the floor. Connecti can then be dropped to any point when changes a needed thus avoiding the alterations of the structure-often a reason given against change and a cause of expense when change occurs.

The heights and other dimensions for convenient working are illustrated in Figures 7, 8, 9, and 10.

Illumination is an important aspect as, in most workshops, a variety of levels of lighting are needed. Fine work requires much higher levels than coarse and where the source of illumination is daylight, then workstations for the finer tasks can best be located near windows where levels are higher and coarser work arranged in less favourable situations away from the windows. These illumination needs have to be reconciled with the layouts resulting from study of association charts as mentioned above.

The quality of illumination is also important and glare should be avoided. When a student raises his head having worked on a fine task and looks out of a window at a bright wall or at the sky, he will suffer discomfort. Windows in workshops might thus well be placed at somewhat higher levels than is the case in ordinary classrooms where, in general the children are not sat to face the light.

High level windows however, pose a thermal comfort problem for, when opened, they will not, in hot-humid situations, provide the flow of air over the student's

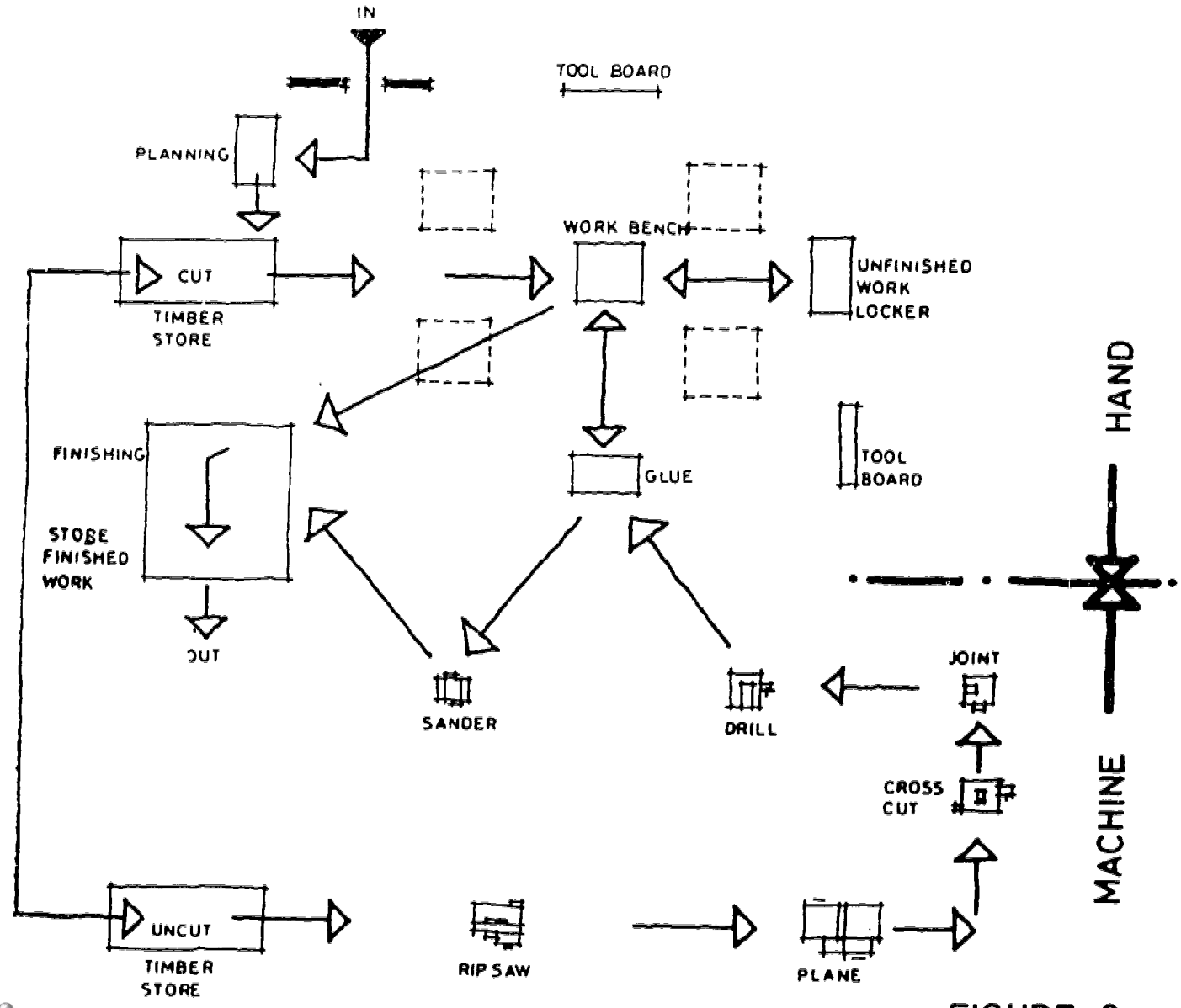


FIGURE 6

skin which is so essential if cooling is to be achieved. This problem can be overcome by the provision of pierced brick or blockwork at low level in the external walls. In hot dry climates, windows will normally be closed and walls shaded from the sun or, alternatively, made thick enough to retard the penetration of conducted heat.

Finally, it should be remembered that workshops are usually a noise source. They also need supplies that are delivered by lorry. There is a strong case to be made, where site conditions permit, for locating them at ground floor level and well away from teaching accommodation where quiet is needed.

METAL WORK
basic activities and heights of working surfaces

AGE IN YEARS	MEAN HEIGHT	ELBOW & VICE TOP HEIGHT	WAIST HEIGHT	BENCH HEIGHT*
	S H (cms)	E (cms)	W (cms)	B (cms)
12	136	81	74	64
13	141	89	77	72
14	146	92	80	75
15	152	96	83	79
16	157	99	85	82
17	161	101	87	84

* ASSUMING DISTANCE FROM TOP OF VICE JAWS TO BENCH TOP IS 17 Cms FOR OTHER VICE SIZES AN ADJUSTMENT WILL BE NEEDED IN BENCH HEIGHT

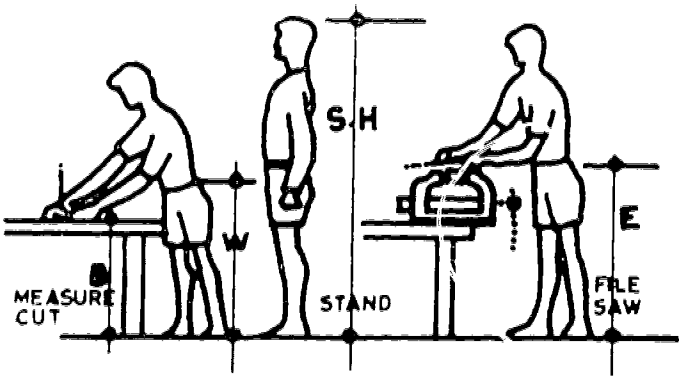


FIGURE 7

WOODWORK BENCH
basic activities and heights of working surfaces

AGE IN YEARS	MEAN HEIGHT	ELBOW HEIGHT	BENCH HEIGHT
	S.H(cms)	E.(cms)	B.(cms)
12	136	81	71
13	141	89	79
14	146	92	82
15	152	96	86
16	157	99	89
17	161	101	91

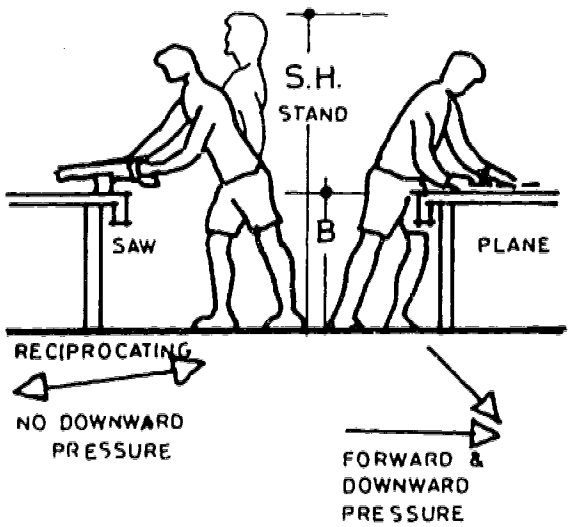


FIGURE 8

ELECTRICITY

JASIC ACTIVITIES AND HEIGHTS OF WORKING SURFACES

AGE IN YEARS	MEAN HEIGHT	BENCH HEIGHT SITTING	BENCH HT SITTING / STANDING	SEAT HEIGHT	
	S H.(cms)	B (cms)	BS (cms)	A	C
12	136	60	77	38	55
13	141	63	80	39	56
14	146	65	83	41	59
15	152	68	86	42	60
16	157	70	89	44	63
17	161	72	92	45	65

NOTE

THERE SHOULD BE NO DRAWER OR OTHER OBSTRUCTION UNDER A SURFACE CORRECTLY LOCATED FOR SITTING

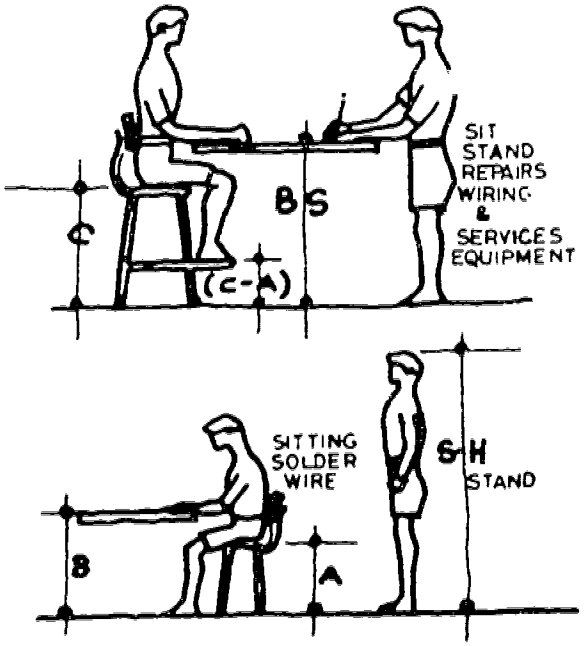


FIG. 9

GENERAL CRAFTS

HEIGHTS OF WORKING SURFACES

AGE IN YEARS	MEAN HEIGHT	BENCH HEIGHT SITTING	BENCH HT SITTING STANDING	SEAT HEIGHT	
	SH cms	B cms	BS cms	A	C
12	136	60	77	38	55
13	141	63	80	39	56
14	146	65	83	41	59
15	152	68	86	42	60
16	157	70	89	44	63
17	161	72	92	45	65

NOTE

THERE SHOULD BE NO DRAWER OR OTHER OBSTRUCTION UNDER A SURFACE CORRECTLY LOCATED FOR SITTING

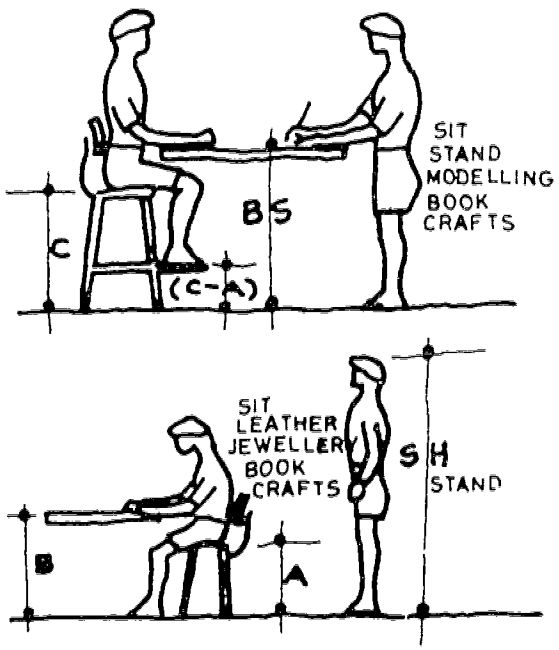


FIG. 10

Prepared by D. J. Vickery

May 1970

Kularatne & Co. Ltd., Colombo 10. 1784-6-70.