Motion Stereotype for Material Handling Equipment.

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Motion Stereotype for Material Handling Equipment.

M.Des. Special project

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guided by Dr. G. G. Ray

Indian Institute of Technology, Bombay
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APPROVAL SHEET

The special project entitled **'Motion Stereotype for Material Handling Equipment'** by Atul A. Rajwade is approved in partial fulfillment of the requirements of the Masters of Design degree in Industrial Design.

Guide June 15 '98

Internal Examiner

Chairperson

ACKNOWLEDGMENT

I express my deepest gratitude towards my guide Prof. Dr. G. G. Ray for initiating this project and guiding me throughout the project.

I am also thankful to all the hundred people who became my subjects and for patiently allowing me to record their stereotype reactions, without which my project would not have been completed.

CONTENTS:

introduction

We humans in this world are in a situation where things are getting automated and new gadgets, machinery and equipments , computer software, are getting stuffed into are immediate environment.

It is not easy for the humans to learn new things and handle new equipments. Unless there is certain pattern and code applied while designing the equipment, it will be very difficult to operate a new machine. So one must take into consideration how the man will operate a vehicle or equipment which he hasn't seen at all. This is known as control motion expectancy and in ergonomic terms falls under the chapter of stereotype and compatibility.

In this special project I have carried out some research on this topic specially regarding material handling equipments. Also in this project I have carried out an experiment which will determine the stereotype reactions of the people controlling material handling equipment, (movements of which are taking place on the rear side of the operator).

It is postulated that, greater the degree of compatibility , less re-coding must be done to process the information. This in turn results in faster learning, faster response time, few errors and reduced mental work load.

Aims and Objectives:

The main aim of this project is to determine the stereotype reactions of the operators controlling material handling equipments, where the motion of the arm handling the material, is taking place on the rear side of the controller.

Up till now research has been carried out on the stereotype movements of the people, when control arms are placed in front of the operator but there is no available data on the stereotype reactions of the operator, with control motions of the arm on there rear side.

Thus the main objective of this special project is to carry an experiment to record the stereotype reactions for operating material handling arms on the rear side of the controller.

Theory of compatibility (Stereotype reactions)

Concept of compatibility:
Compatibility is a very generalized concept that has substantial applicability to human factors engineering. Compatibility refers to the spatial , movement , or conceptual relationship of stimuli and of responses individually or in combination, which are consistent with human expectations.
This concept of compatibility is also applicable where there is simply information transfer in absence of any corresponding physical response.
Compatibility can be broadly classified into three types:

1. Spatial compatibility : It is the compatibility of the physical feature or arrangement in space, of certain items, especially controls and displays.
There are many variations of spatial compatibility; most deal either with the *physical similarities* between displays and their corresponding controls or with the *arrangement* of displays and their controls.

2. Movement compatibility: The direction of movement of displays, controls and system responses.
Movement of a control device to follow the movement of a display (moving a level to the right to follow a right movement of a blip on a radarscope.
Movement of a control device to control the movement of a display.(tuning a radio to a particular wavelength)
Movement of a control device that produces a specific system response (turning a steering wheel right to turn right)
Movement of a display indication without any related response (the clockwise turn of the hands of a clock)
People's expectations regarding movement relationships are

often referred to as population stereotypes, with some stereotypes being stronger than others. Movement compatibility relationships depend in part on features of the controls and displays as well as their physical orientation to the user (such as whether they are in the same plane or different planes relative to the user).

3. Conceptual compatibility: The conceptual association people have . e.g.. Green - go, red - danger etc.

Degree of compatibility is at a maximum when the recoding process are at a minimum.

There are possibly two origins for the development of theory of compatibility relationships.

Certain compatible relationships are intrinsic in the situation. E.g.. When you want to turn right you turn the steering of the car to the right hand side .

Compatible relationships are culturally acquired, steaming from the habits and associations.

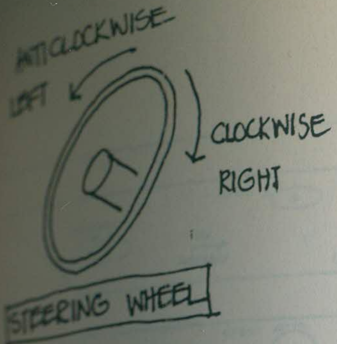
E.g.. In USA in order to turn the light 'on' one has to turn the switch up where as in the other countries it is the other way around.

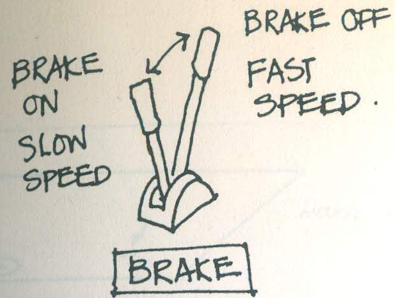
(Reference: Sanders and McCormick) .

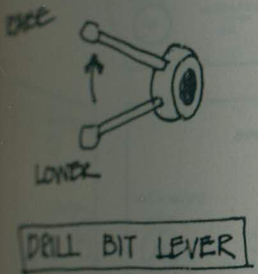
Motion control expectancy for common controls.

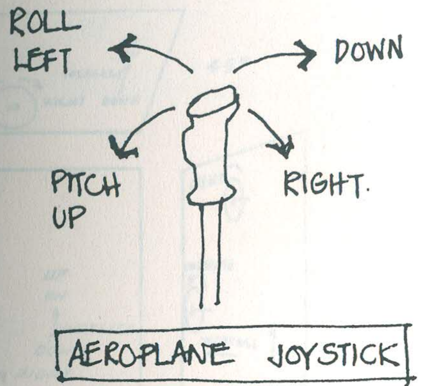
Some control motions seem more natural to people as a result of either innate characteristics (musculoskeletal configuration, handedness, etc.) or habit patterns that have been learned because most products are designed in a certain way.

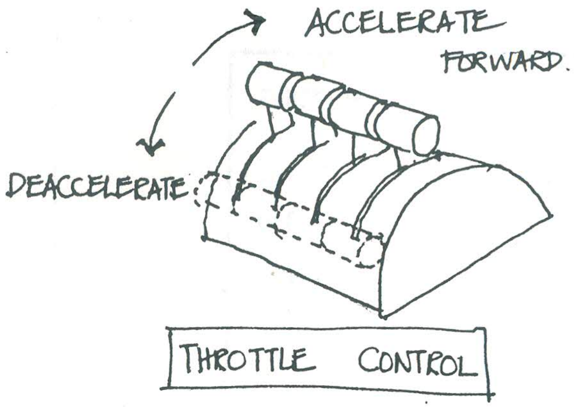
Here are some common examples concerning use of motion control expectancy. (Reference: Human Factors Design Handbook)

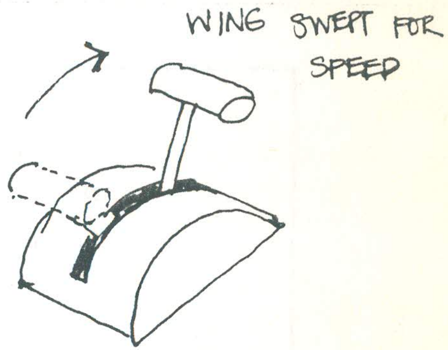


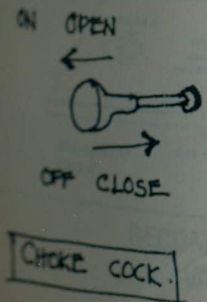


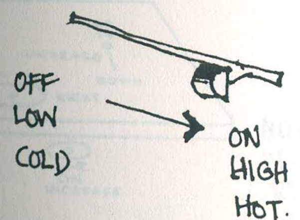


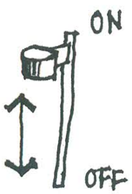


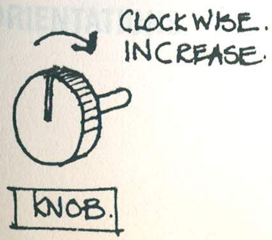


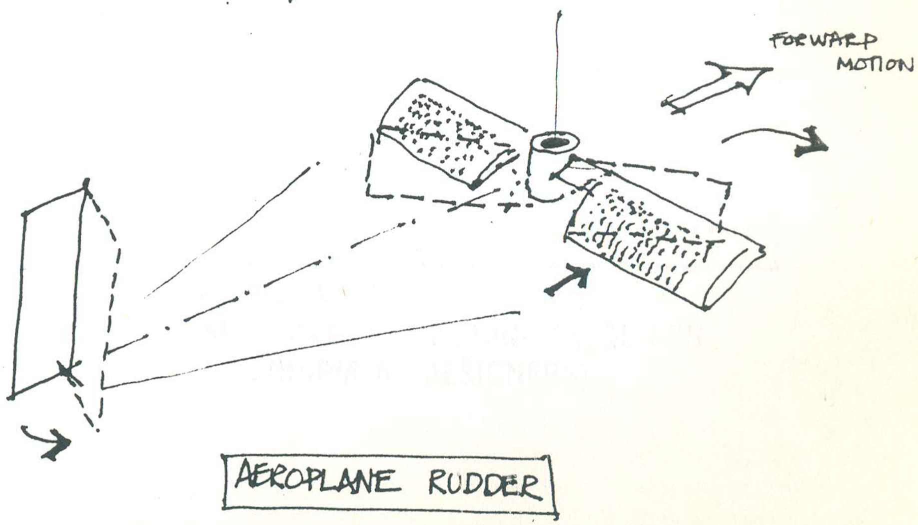








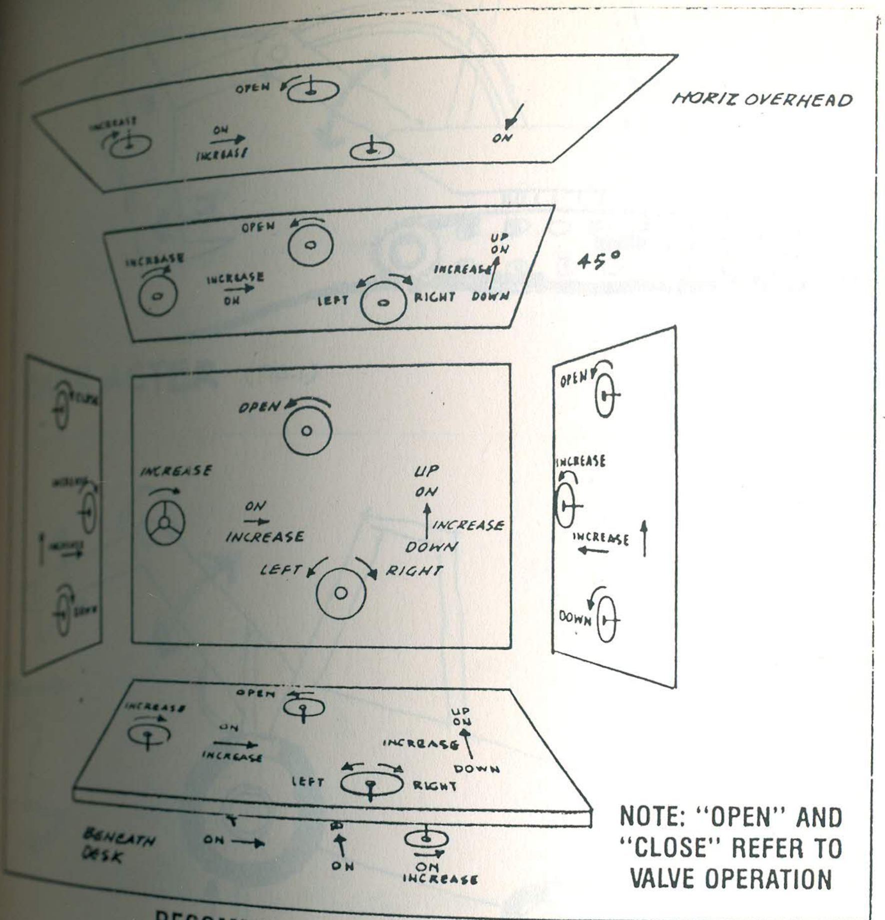




Control Motion Expectancy:

Control position - direction of motion relations may vary depending on the location of the control with respect to the operator.

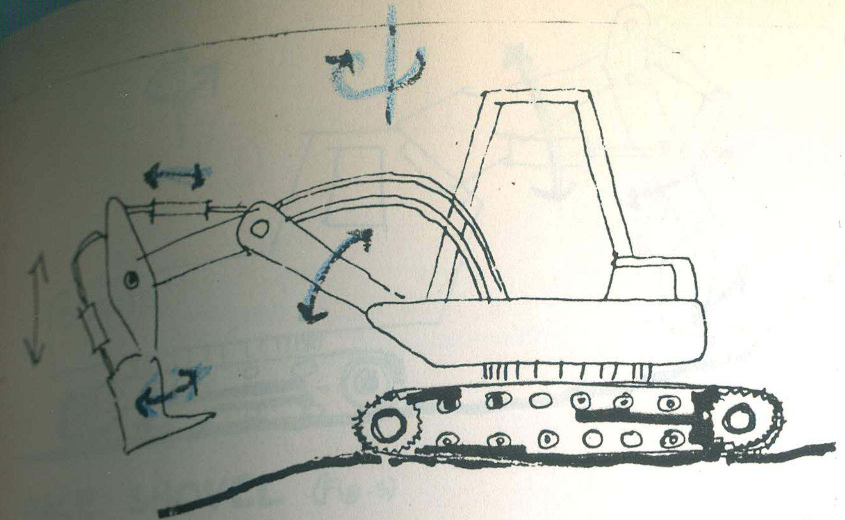
(Reference: Human Factors Design Handbook)



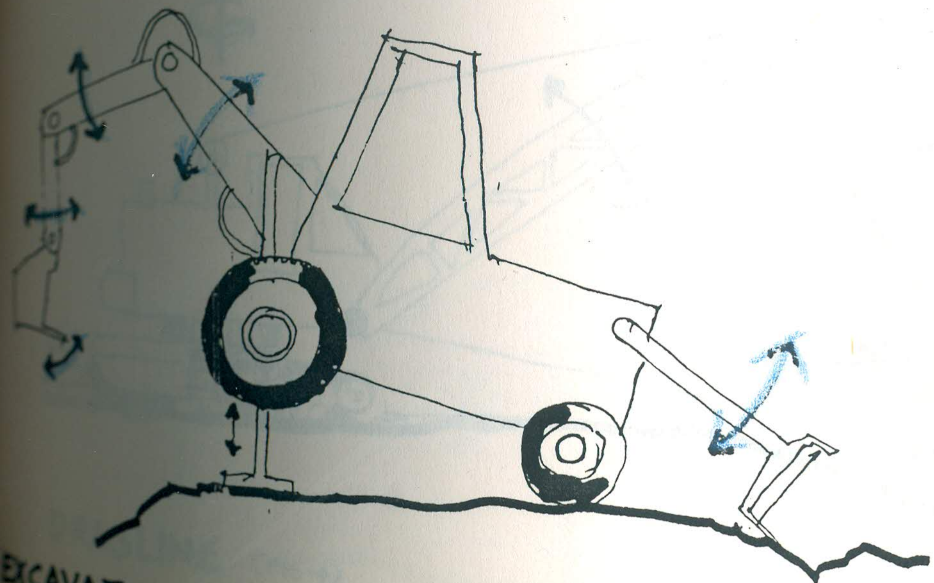
RECOMMENDED CONTROL MOTIONS FOR VARIOUS PANEL ORIENTATIONS

FUNCTION	CONTROL ACTION
On	Up, right, forward, press
Off	Down, left, rearward, pull
Right	Clockwise, right
Left	Counterclockwise, left
Up	Up, rearward
Down	Down, forward
Retract	Rearward, pull, counterclockwise, up
Extend	Forward, push, clockwise, down
Increase	Right, up, forward, clockwise
Decrease	Left, down, rearward, counterclockwise

RECOMMENDED CONTROL MOTIONS (FROM HUMAN ENGINEERING GUIDE FOR EQUIPMENT DESIGNERS)



BACK ACTER (FIG.1.)



EXCAVATOR LOADER (FIG.2)

Different types of earthmoving equipments :

Many different types of earth moving equipments are used for the purpose excavating, dumping and handling large volumes of earth.

Here they are given below along with the motion of its arms in the accompanying figure.

Backacter: Most popular machine for trenching, it also doubles as a crane and bucket used to press down trench supports and to consolidate backfills.(fig. 1)

Excavator Loader: Slews and maneuvers in tight spaces during loading when jacked. It is suitable for excavation of trenches etc.(fig. 2)

Face Shovel: For cutting or and for forming banks over 2m high. It can dig hard ground and soft rocks.(fig. 3)

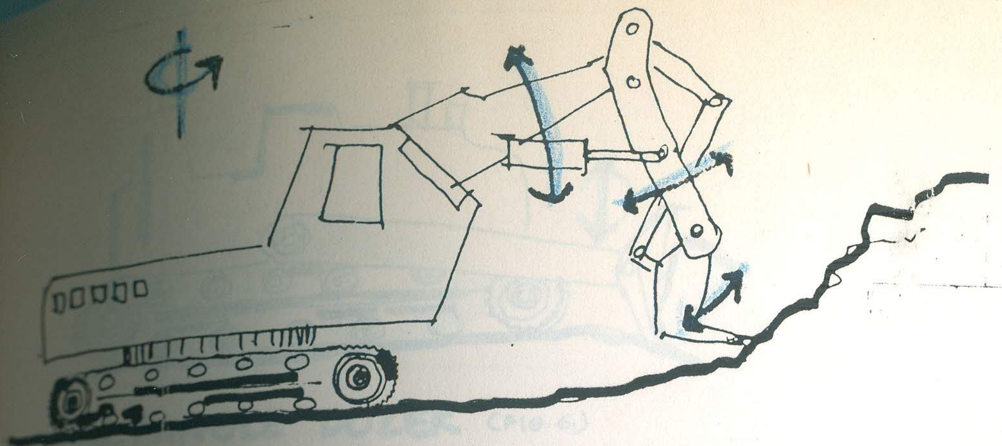
Dragline : For excavating below the level of its tracks. For clearing ditches and streams. Has a long dumping range and a long reach.(fig. 4)

Grab: For loading and unloading , digging loose materials and placing in heaps.(fig. 5)

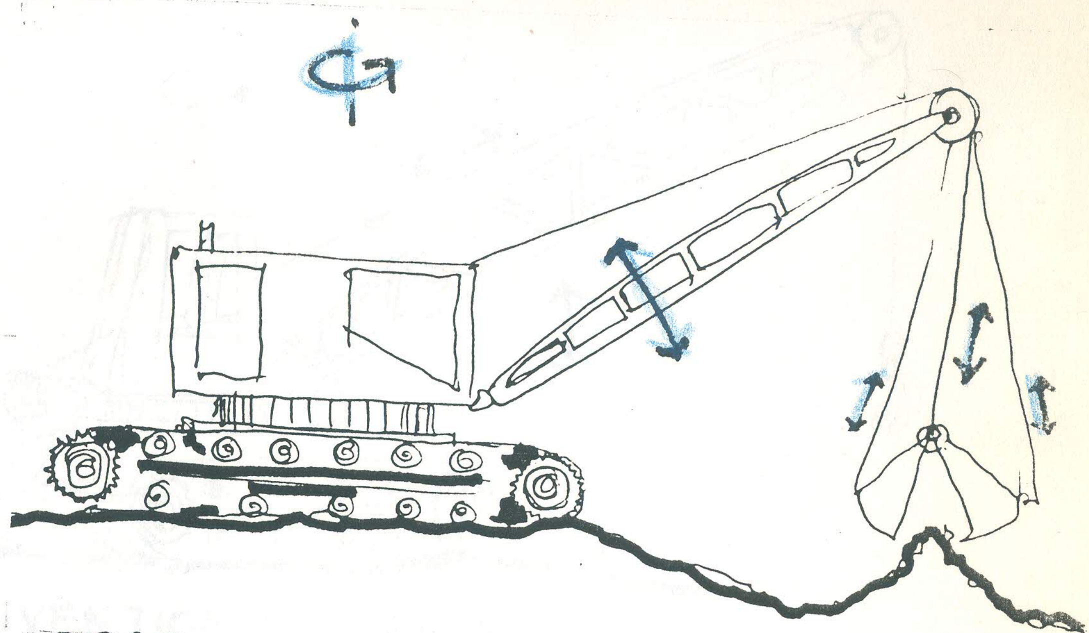
Bull / Angle Dozer : For filling and grading pushes up to 100 mts. (fig. 6)

Conventional crane : This is movable from one place to another while carrying its load. The operator is seated low as compared to the arm.(fig. 7)

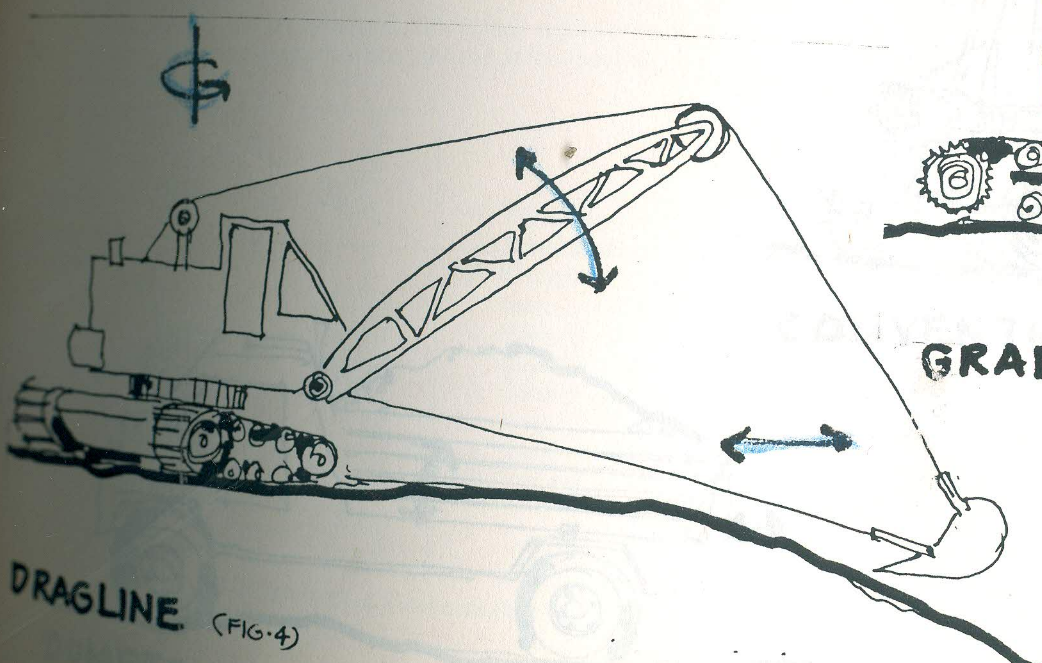
Dumper : For carrying and moving material over long distances and then dumping it at fixed locations.(fig. 8)



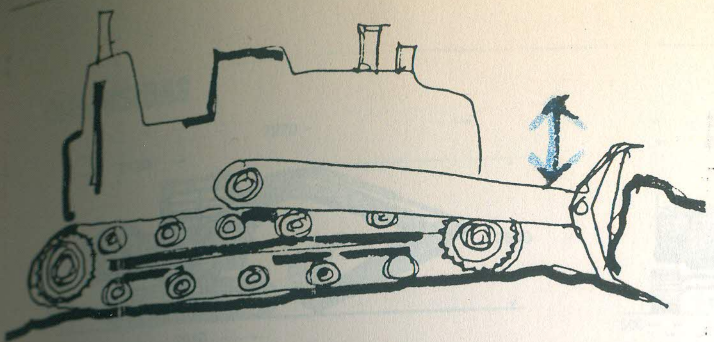
FACE SHOVEL (Fig. 3)



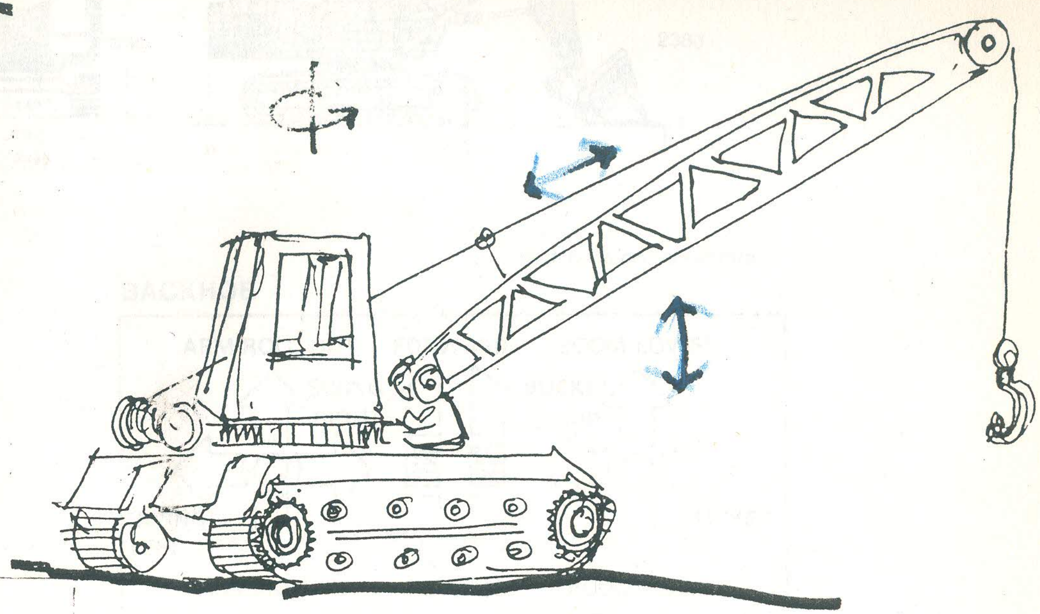
GRAB (FIG. 5)



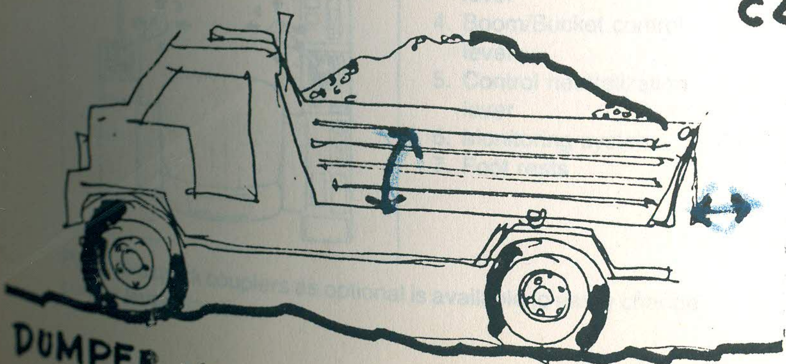
DRAGLINE (FIG. 4)



BULL/ANGLE DOZER (FIG. 6.)



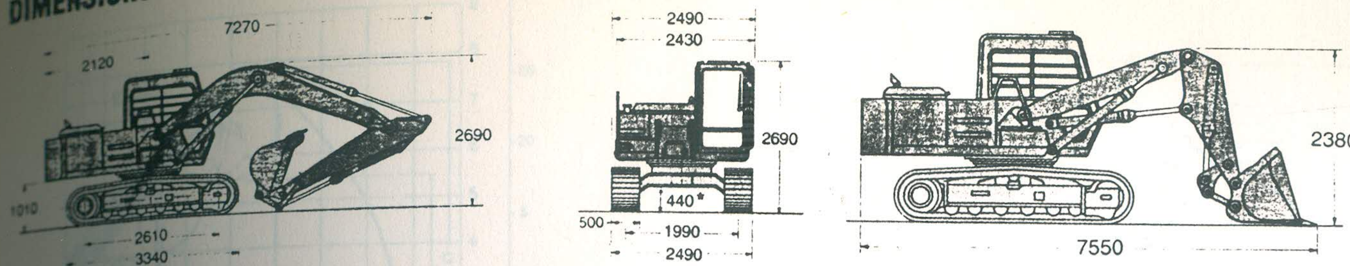
CONVENTIONAL CRANE (FIG. 7)



DUMPER (Fig 8.)

Tata Hitachi Hydraulic excavator:

DIMENSIONS

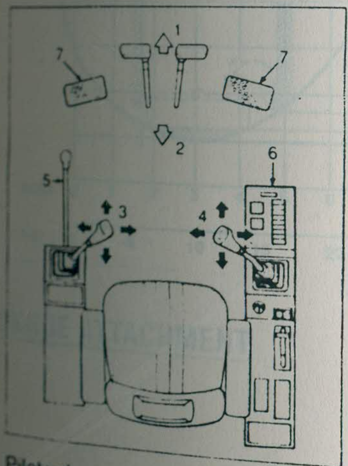


Rear-end swing radius 2130mm
* Track shoe lug height not included.

All dimensions are in mm

CONTROLS

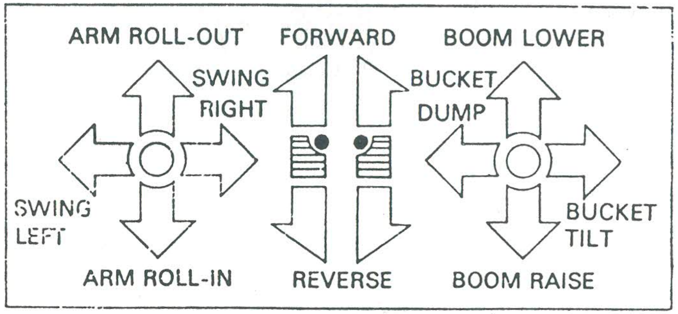
Pilot controls (for all functions). Shockless regulator and quick warm-up system are built in the pilot circuit for easy, fatigue-free operation.



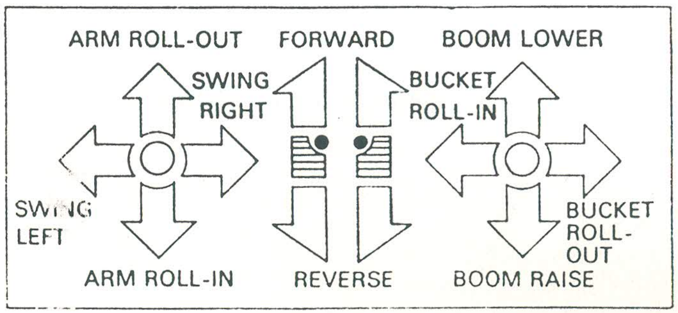
1. Travel forward
2. Travel reverse
3. Swing/Arm control lever
4. Boom/Bucket control lever
5. Control neutralization lever
6. Monitoring system
7. Foot rests

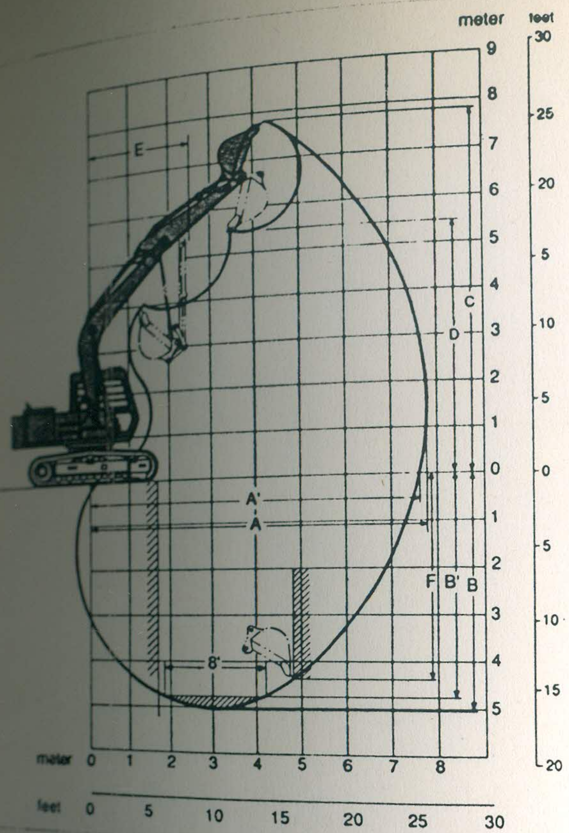
Pilot valve quick couplers as optional is available to easily change control lever direction.

BACKHOE

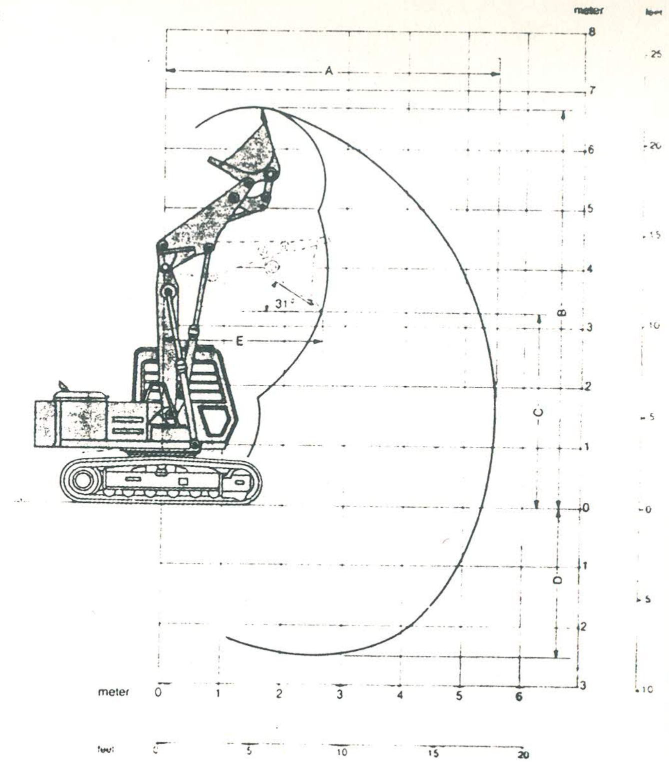


SHOVEL





BACKHOE ATTACHMENT



SHOVEL ATTACHMENT

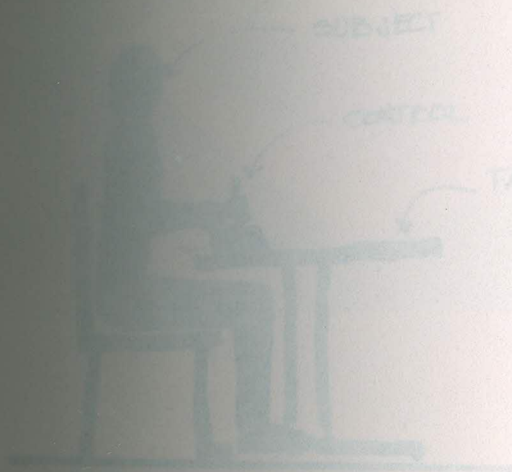
Experiment

Experimental setup:

This is an experiment to identify the stereotype reactions of an operator of a material handling equipment , where the lifting arm is placed on the rear side of the operator.

It was an experiment in which subjects was asked to carry out certain tasks under simulated conditions .There stereotype reac– tions was noted down and from the data which was collected, inferences were derived regarding the stereotype reactions of an operator. The experiment was carried out in two stages, first with 100 subjects and then with 50 subjects.

The subject was made to seat in a chair to which a joystick (or crank) was attached as shown in the figure.



POSITION OF THE SUBJECT WITH RESPECT TO THE CONTROL

Stage 1:

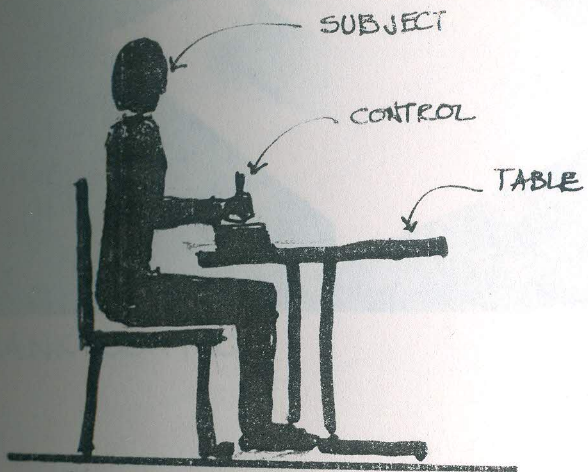
In this stage 100 subjects were asked to carry out the task .

The subjects were provided with cards on which the tasks they had to perform were given and accordingly carry them out with the help of the joystick and with the crank. The reactions of the subjects while performing the tasks were recorded and noted down in the table.

The subjects were allowed to take the most comfortable position they wanted to take, before they performed the task.

Stage 2:

In this stage 50 people performed the task. But during this stage there was a little difference in the manner in which the experi– ment was conducted. The tasks were shuffled for each control, sometimes opposite task than the one, which was given in the card, was asked to perform. Also care was taken so that no two subjects were near one another when readings of a subject were taken. In this stage subjects were from more varied background than the subjects in the first stage.

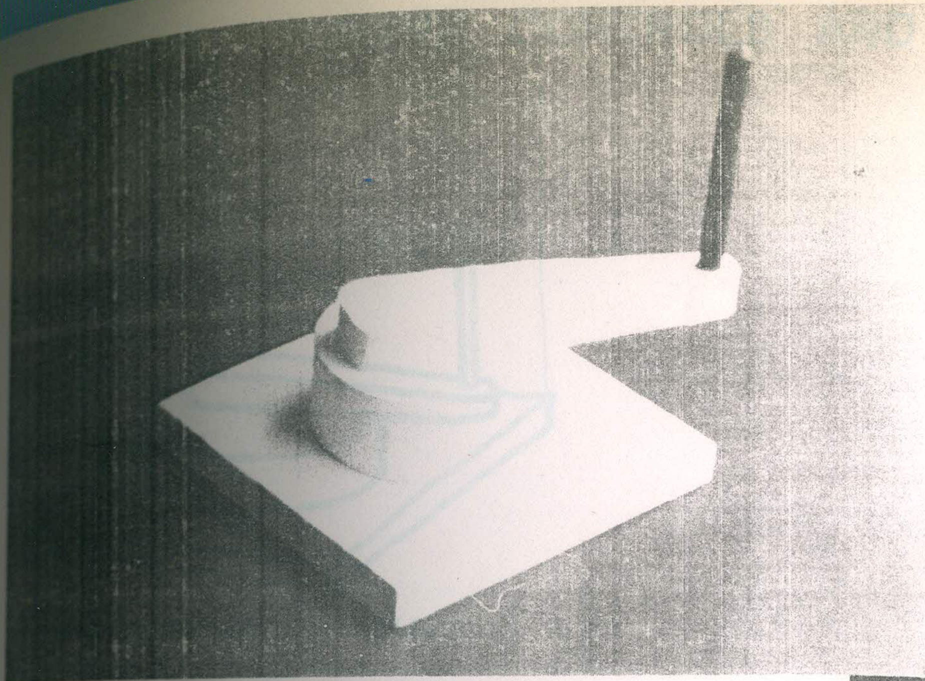


POSITION OF THE SUBJECT WITH RESPECT TO THE CONTROL

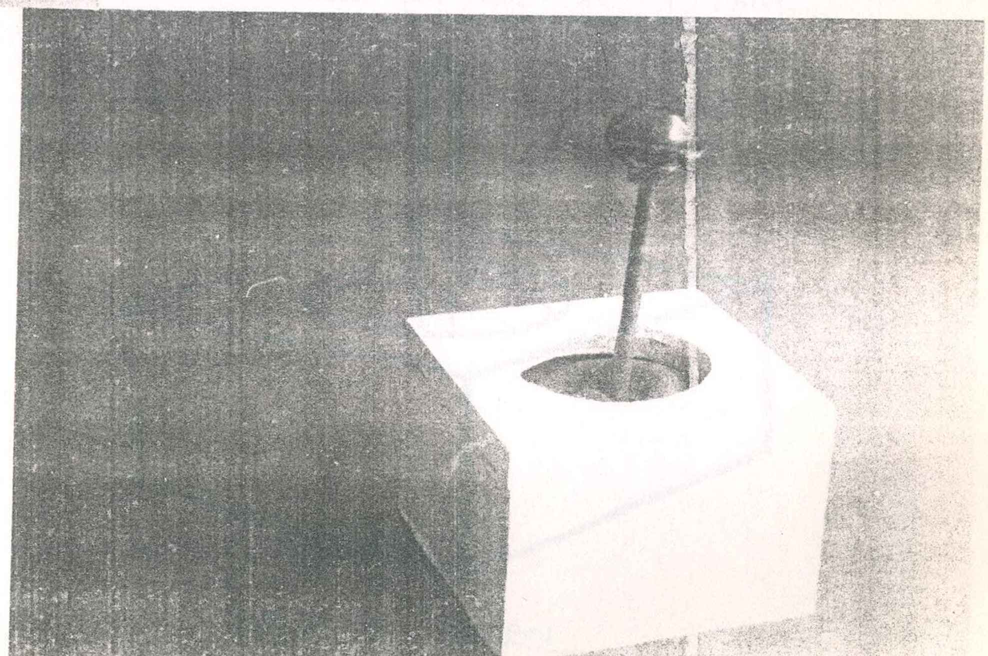
Methodology

1. Subjects were briefed about the nature and the objective of the experiment which was to be conducted.
2. Then they were made to sit in a chair with a table infront of it. The experiment control apparatus were placed on the table .
3. First the subjects were told just to handle the controls in order to get used to them, (not taking into consideration any tasks.)
4. Then they were shown the task sheet and each task was explained.
5. After this they were asked to perform the task with individual controls. [(a) Joystick control ,(b) Crank control in X plane, (c) Crank control in Y plane and (d) Crank control in the Z plane.] The 5 tasks which they had to perform for each control were shuffled.
6. Sometimes they were also asked to perform exactly the opposite tasks than those which were mentioned in the Task sheet .This step was for cross checking the earlier results of the stereotype reactions.
7. For last 50 readings each performed the task with no other subject standing near the experiment setup. This step was taken in order to ensure that the reactions of the other subjects were not affected by the on going experiment.
8. Also for the crank control tasks they were asked that 'Which of these tasks is best suited for that particular control?', and corresponding answers were noted down in the data sheet.
9. Once the subject had performed the task there reactions were noted down in the data sheet.
10. This was further analyzed and the results were noted down in form of percentage (%) of subjects which preferred to use the particular control for the task in a particular manner.

It was from this results sheet and the data sheet the inferences of the experiment were derived and observations noted down.

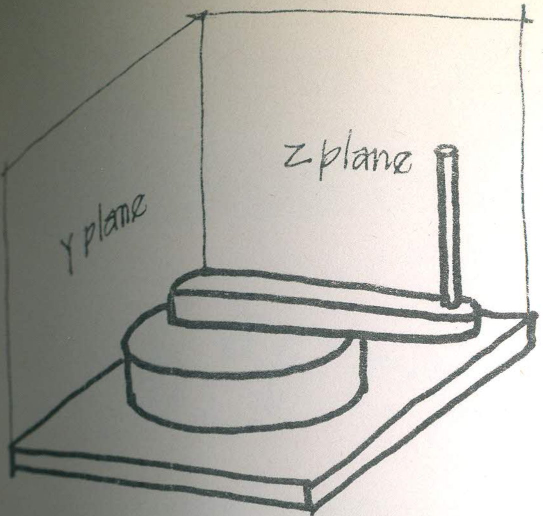


CRANK CONTROL

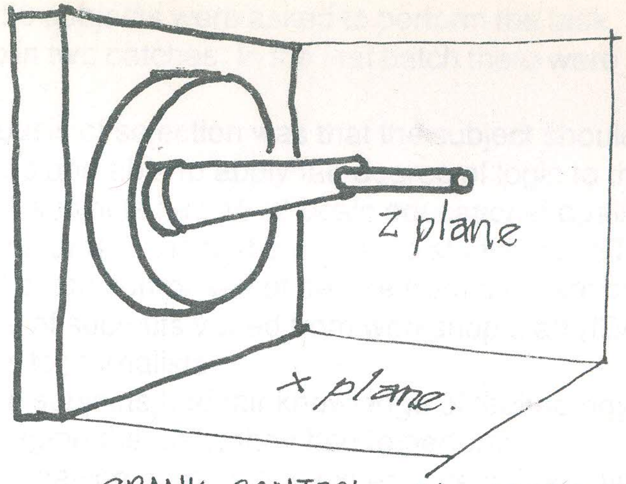


JOYSTICK CONTROL

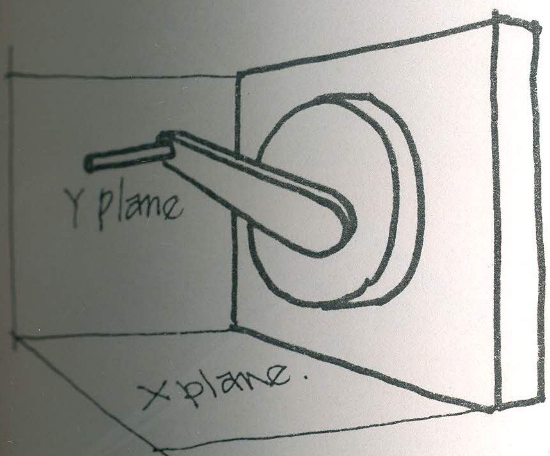
CRANK CONTROLS AND JOYSTICK CONTROL



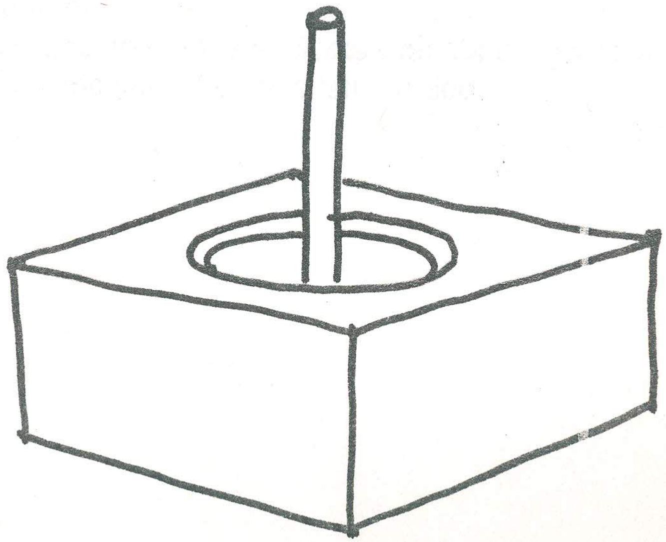
CRANK CONTROL IN X PLANE



CRANK CONTROL IN Y PLANE



CRANK CONTROL IN Z PLANE



JOYSTICK CONTROL

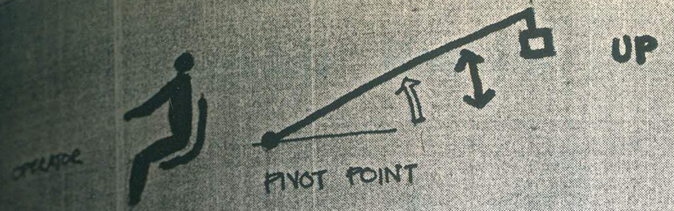
Subjects :

In all 150 subjects were asked to perform the task . They were split up in two batches. In the first batch there were 100 subjects.

The basis of selection was that the subject should be fairly educated and able to apply fair degree of logic to the task given.
All the subjects had 10+2 basic educational qualification. 92% of the subjects in the first batch were studying in IIT Bombay. The second batch comprised of people from different professions.
Range of subjects varied from workshop staff (IDC) to Phd. students to journalists.
All the subjects had fair knowledge of technology and could fairly imagine the tasks they had to perform.
People having no previous experience in operating material handling equipment were selected as subjects for this experiment .
Average age of the subjects was about 25 years.
6% of the subjects were left handed.

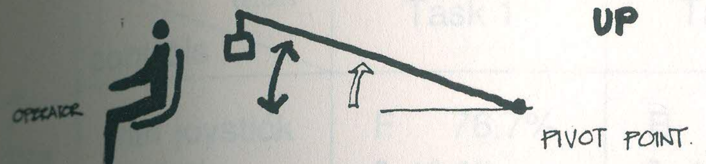
TASK SHEET

In all the cases the subject has to carry out the task in the simulated conditions, once by using a joystick and then by using a crank control.



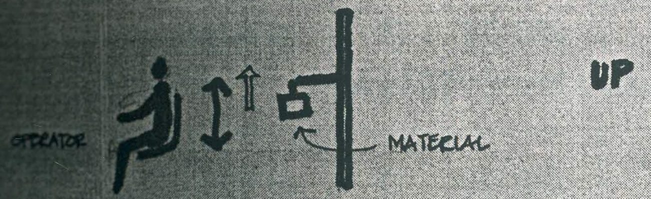
1. In the first task, the user has to lift the material, where the lifting arm is placed behind the subject .The pivot point of the lifting arm is directly behind the user. The material is lifted away from the operator.

LIFTING MOVEMENT IS ANGULAR



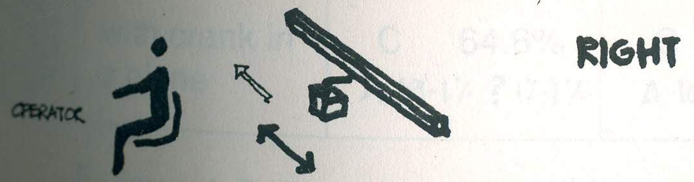
2. In this task , the pivot point of the lifting arm is placed away from the operator. The material handling arm is pointed towards the user and the motion of the lifting arm takes place in the same orientation as that of the operator.

LIFTING MOVEMENT IS ANGULAR.



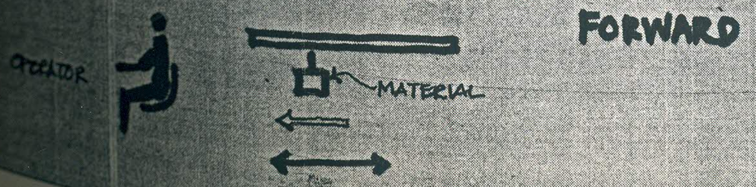
3. The material is lifted vertically behind the operator.

LIFTING MOVEMENT IS VERTICAL



4. The material is being transported from one point to another in the horizontal plane, in a straight line, behind the operator.

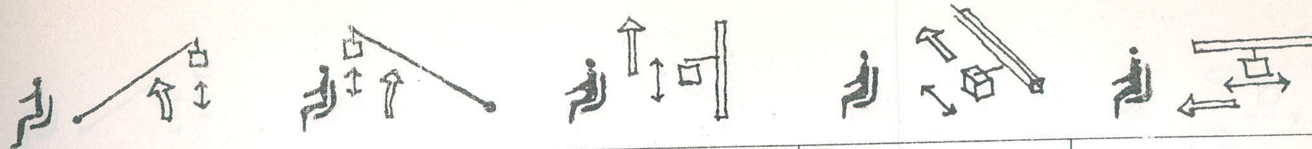
MOVEMENT OF THE LIFTING ARM IS HORIZONTAL AND PERPENDICULAR TO THE SUBJECT.



5. The material is moved forward and backward, i.e. towards and away from the subject.

MOVEMENT OF THE LIFTING ARM IS HORIZONTAL AND PARALLEL TO THE ORIENTATION OF THE SUBJECT.

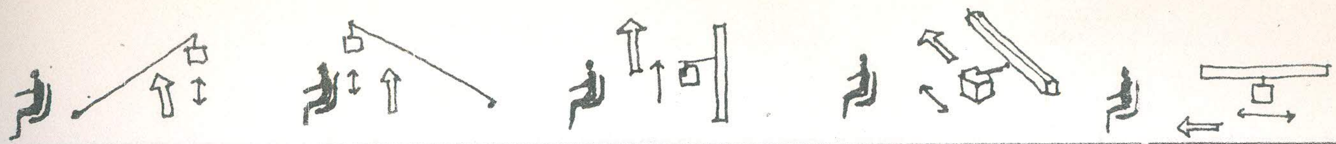
Experiment Results First batch



task / controls	Task 1	Task 2	Task 3	Task 4	Task 5
with joystick control	F 76.7% B 25.2%	B 77.7% F 27.2%	F 73.7% B 22.2%	R 92.9% L 9.09%	F 91.9% B 10.1%
with crank in x plane	C 60.6% A 37.3% ? 4.04%	C 66.6% A 30.3% ? 5.05%	C 71.7% A 23.2% ? 7.07%	C 76.7% A 24.2%	C 65.5% A 27.2% ? 11.1%
with crank in y plane	C 80.8% A · 21.2%	C 61.6% A 40.4%	C 79.7% A 22.2%	? C 35.5% A 11.1%	C 88.8% A 13.1%
with crank in z plane	C 64.6% A 19.1% ? 17.1%	C 65.6% A 16.1% ? 19.1%	C 72.7% A 17.1% ? 12.1%	C 90.9% A 11.1%	C 59.5% A 8.08% ? 35.5%

F– Forward , B– Backward , R– Right , C– Clockwise, A - Anticlockwise, ?-Undecided

Experiment Results Second batch



task / controls	Task 1	Task 2	Task 3	Task 4	Task 5
with joystick control	F 85.7% B 14.28%	B 71.4% F 28.5%	F 83.7% B 16.3%	R 93.8% L 6.1%	F 98% B 2.04%
with crank in x plane	C 63.2% A 36.73%	C 59.1% A 34.7% ? 6.1%	C 75.5% A 22.4% ? 2.04%	C 77.5% A 22.4%	C 69.4% A 16.3% ? 14.3%
with crank in y plane	C 83.7% A 16.32%	C 59.1% A 40.8%	C 89.8% A 10.20%	? C 36.73% A 18.3%	C 87.75% A 12.2%
with crank in z plane	C 85.7% A 12.24% ? 2.04%	C 73.46% A 24.5% ? 2.04%	C 77.55% A 18.36% ? 4.08%	C 87.75% A 12.24%	C 53.06% A 34.7% ? 28.6%

F- Forward , B- Backward , R- Right , C- Clockwise, A- Anticlockwise, ?- Undecided,

Experiment Results

Average of batch1 and batch2 results

task / controls	Task 1	Task 2	Task 3	Task 4	Task 5
with joystick control	F 81.2% B 19.74%	B 74.55% F 27.85%	F 78.7% B 19.25%	R 93.35% L 7.6%	F 94.95% B 6.03%
with crank in x plane	C 61.9% A 37.01% ? 2.01%	C 62.85% A 32.5% ? 5.5%	C 73.6% A 22.8% ? 4.55%	C 77.1% A 23.3%	C 67.45% A 21.75% ? 12.7%
with crank in y plane	C 82.25% A 18.76%	C 60.35% A 40.6%	C 84.75% A 16.2%	? C 36.11% A 14.7%	C 88.25% A 12.65%
with crank in z plane	C 75.15% A 15.67% ? 9.57%	C 69.53% A 20.3% ? 10.6%	C 75.12% A 17.13% ? 8.09%	C 89.32% A 11.67%	C 56.28% A 21.38% ? 31.95%

F- Forward , B- Backward , R- Right , C- Clockwise, A- Anticlockwise, ?- Undecided

Experiment Results First batch

CRANK CONTROLS BEST SUITED FOR

1. CRANK in X PLANE	**TASK 4**
2. CRANK in Y PLANE	**TASK 5**
3. CRANK in Z PLANE	**TASK 4**

Experiment Results   Second batch

CRANK CONTROLS BEST SUITED FOR

1. CRANK in X PLANE	**TASK 4**
2. CRANK in Y PLANE	**TASK 5**
3. CRANK in Z PLANE	**TASK 4**

Observations :

Overall thinking pattern of the subjects was that anything which is positive is connected with clockwise motion.

Lifting up , moving to the right , getting material forward are all positive motions from the point of view of the subjects, hence in all the cases clockwise motion is predominant.

In cases where the percentage of clockwise motion was less, there people either followed the motion of the material handling arm or applied the convention of unscrewing - anticlockwise for lifting an object.

In many cases ,especially in TASK 4 with CRANK in Y PLANE, subjects were unable to decide because the direction of motion was perpendicular and horizontal to the plane and orientation of crank .

Crank controls are preferred by subjects for moving the objects laterally rather than for lifting.

Limitations of this Experiment and the Next Step :

The subjects were asked to imagine the tasks they had to perform and their reactions were noted down with assumption that they had understood the task exactly which was told. There was no motion of material handling arm actually taking place, it was only imagined by the individual subjects while performing the task.

The next step will be to device some kind of mechanical devices which simulates the motion of the material handling arm while the experiment is being conducted. This will give much clearer picture to the subjects who are performing the task. This might also affect the result to a certain extent.

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