Design of Controls

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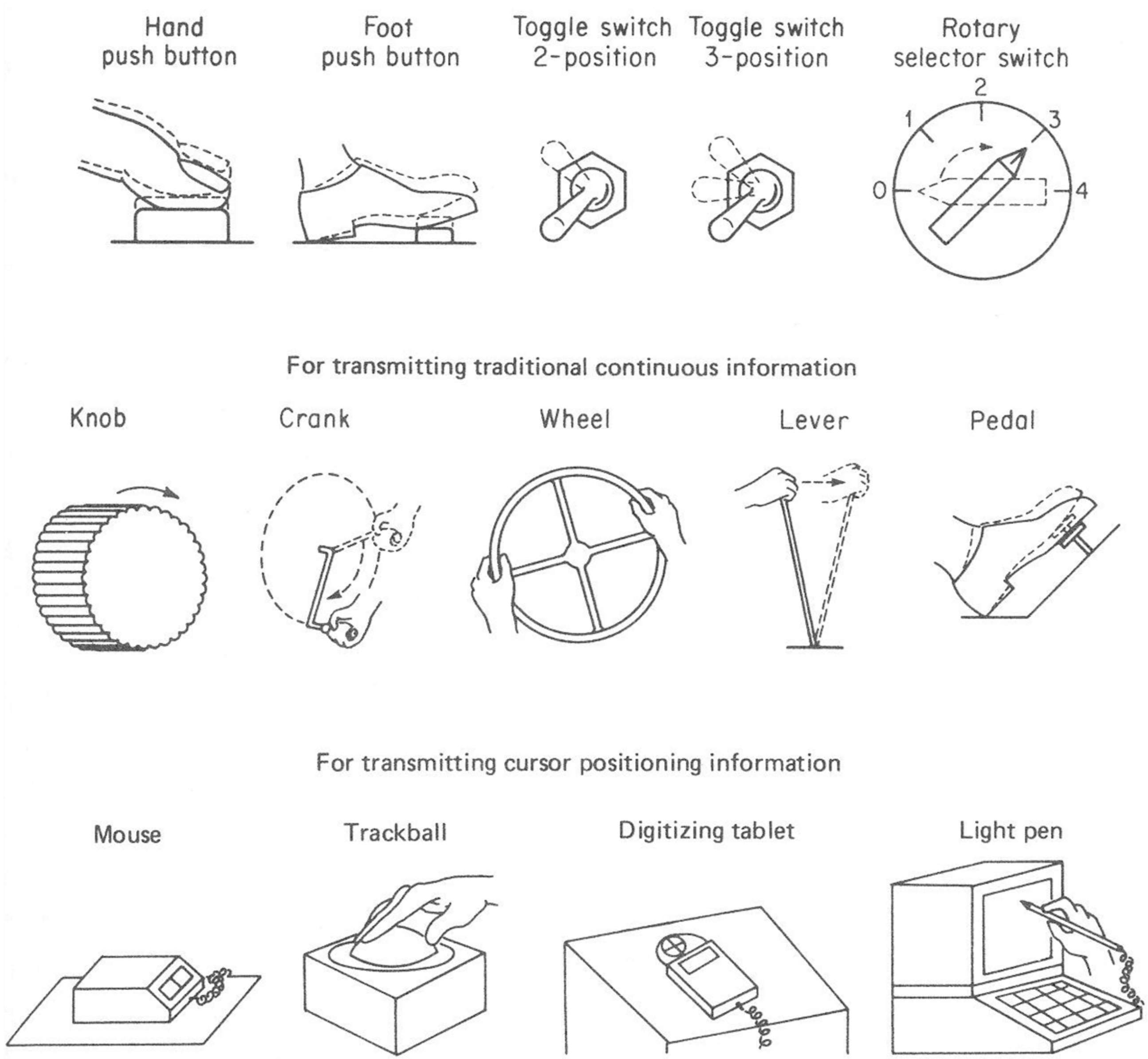
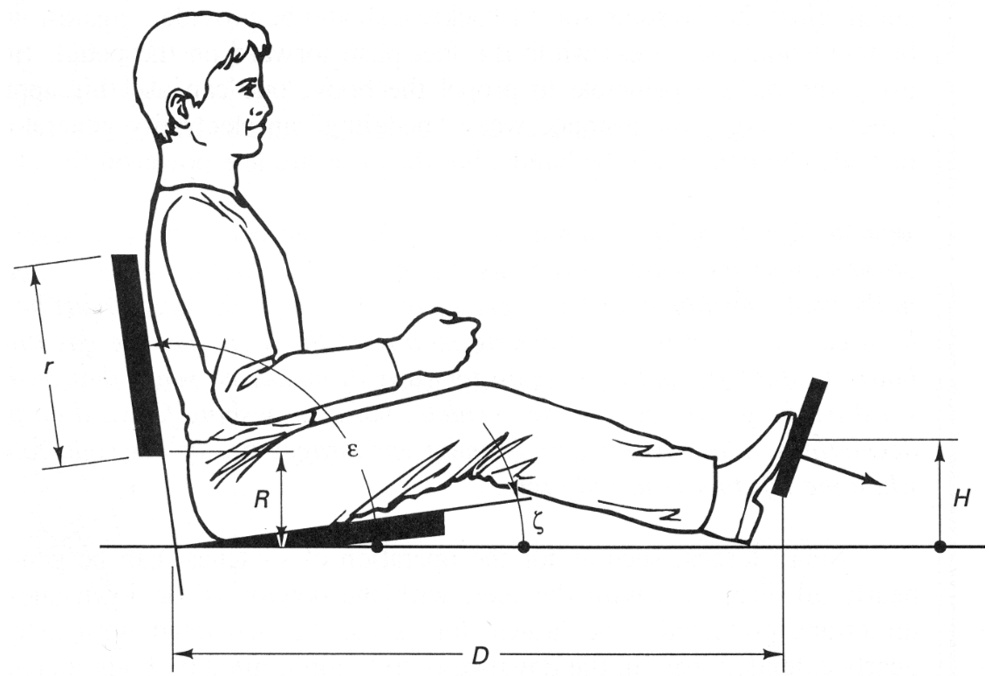
The Knobs and Dials Era

The 1940s and 1950s are often referred to as the “knobs and dials era”. At that time environments such as aircraft cockpits reached levels of complexity never before imagined, and it was difficult for humans to operate the new machines.

The Knobs and Dials Era



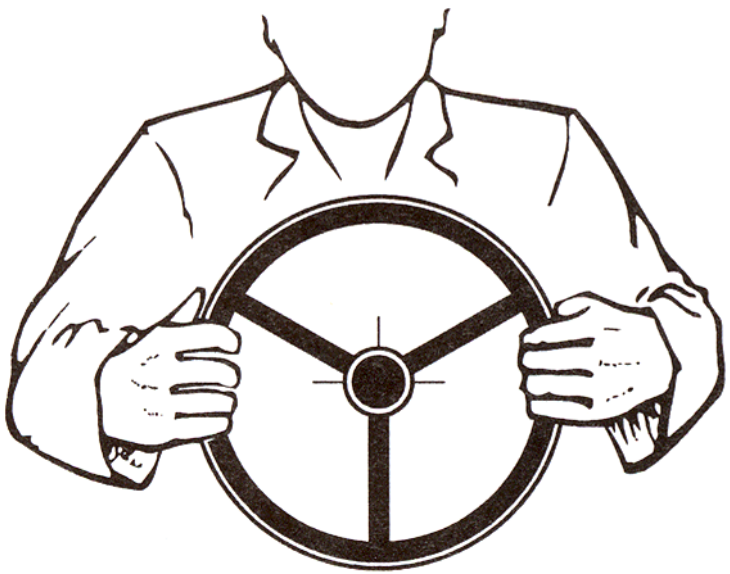
Control Selection Rules

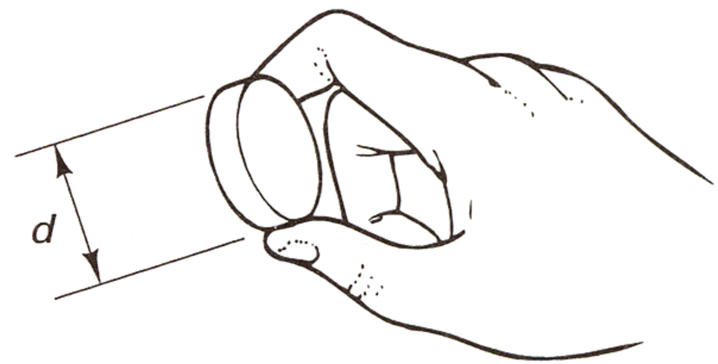


Fine movements and small forces should be performed using hand controls.

Gross adjustments and large forces should be achieved using foot controls.

Control Selection Rules



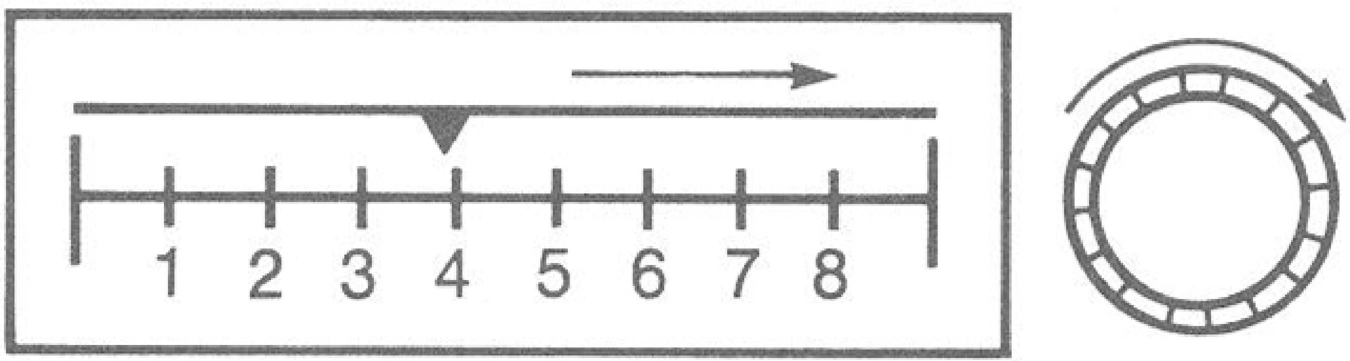


Control size should reflect stereotypes and past practice.

Control Selection Rules

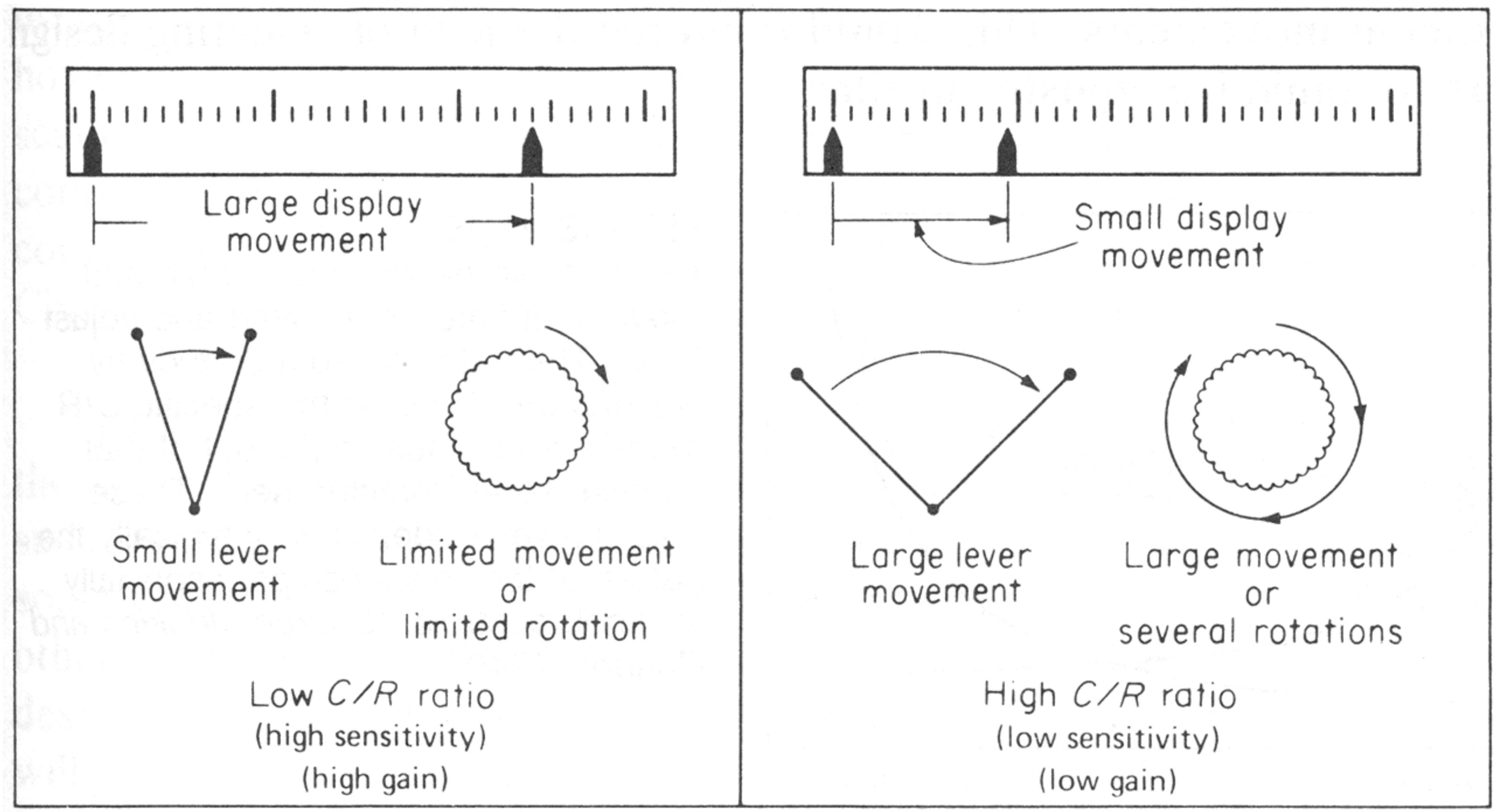
The force or torque required for the operation of a control should be kept as low as possible.

Control Selection Rules



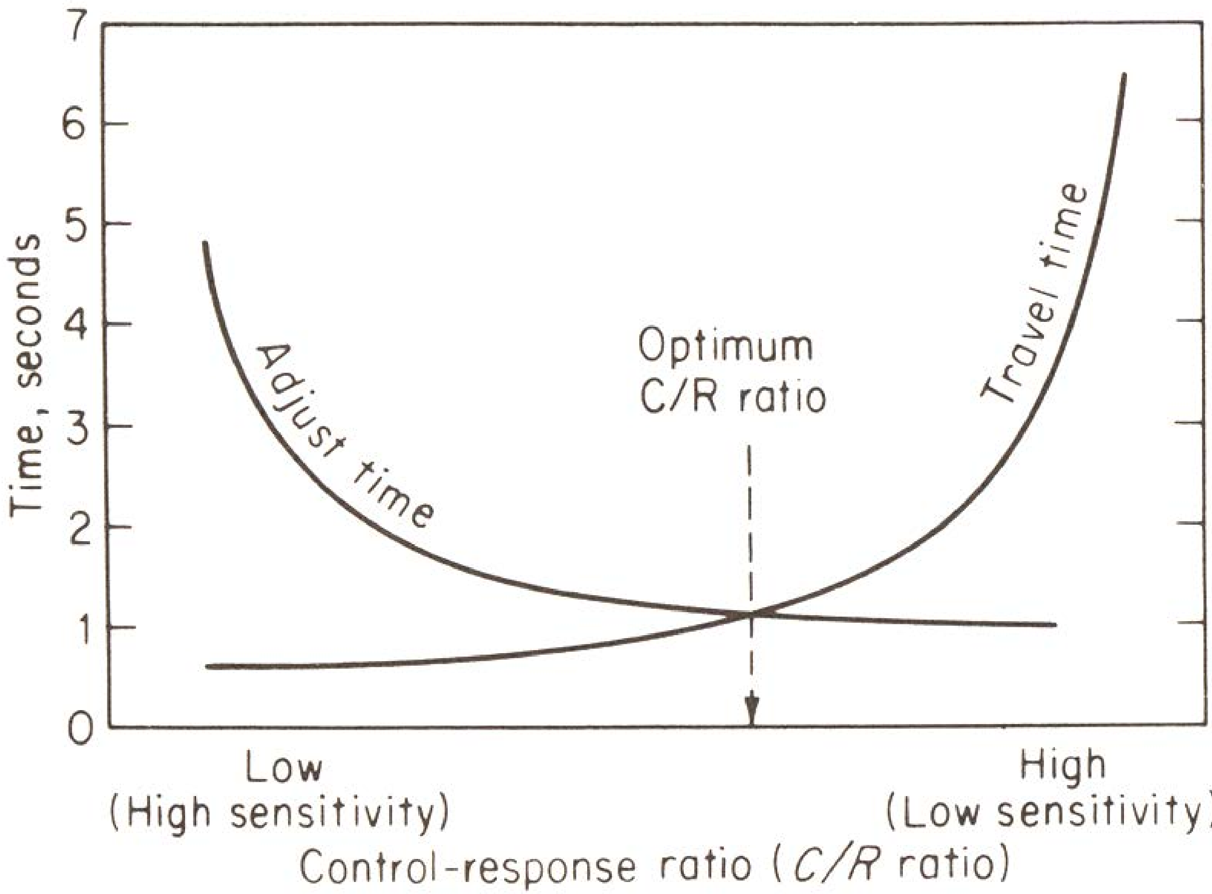
Control shape and motion should be compatible with any stereotypes or expectations regarding the situation in question.

Control Selection Rules



For continuous tasks the ratio of the movement of the control device to the movement of the system which is being controlled is called the control-response ratio (C/R ratio).

Control Selection Rules



An example of C/R ratio optimisation is a radio tuning dial. Low C/R ratios are fast for reaching a station frequency but slow to perform the fine tuning. High CR ratios make it easy to fine tune but require a long time to switch stations. The optimum is at the point of intersection of the travel time and adjustment time curves.

Feedback Resistance

All control devices provide some form of resistance which serves as a source of feedback to the operator. The four primary types of control resistance are:

- elastic resistance
- friction resistance
- viscous damping
- inertial

Feedback Resistance

Elastic resistance **such as the case of spring loaded devices varies with the displacement of the control. The relationship can be either linear or nonlinear.**

An advantage of elastic resistance is that it provides both force and displacement information, thus adding some redundancy.

Elastic controls are widely used for safety critical systems since they return to the off position when released.

Feedback Resistance

Static or coulomb friction resistance **causes time delays and movement irregularity when control movement is initiated or is reversed due to the switch in resistance direction.**

Since this resistance helps to hold controls fixed in place when not in use, it can be considered helpful from a safety point of view. In use, however, friction resistance has been found to degrade human performance due to the added complexity.

Feedback Resistance

Viscous damping resistance **provides a force which is proportional to the speed. It helps to achieve smooth movements. It also helps to prevent accidental activation.**

Since the force is proportional to the velocity, however, it is not easily interpreted by the operator.

Feedback Resistance

Inertial resistance **provides a force which is proportional to the mass of the mechanism and the acceleration imparted. By its nature inertial resistance makes it hard to perform quick and precise tasks such as tracking, but can be useful for maintaining smooth fixed speed. It also helps to reduce the risk of accidental activation.**

Standards

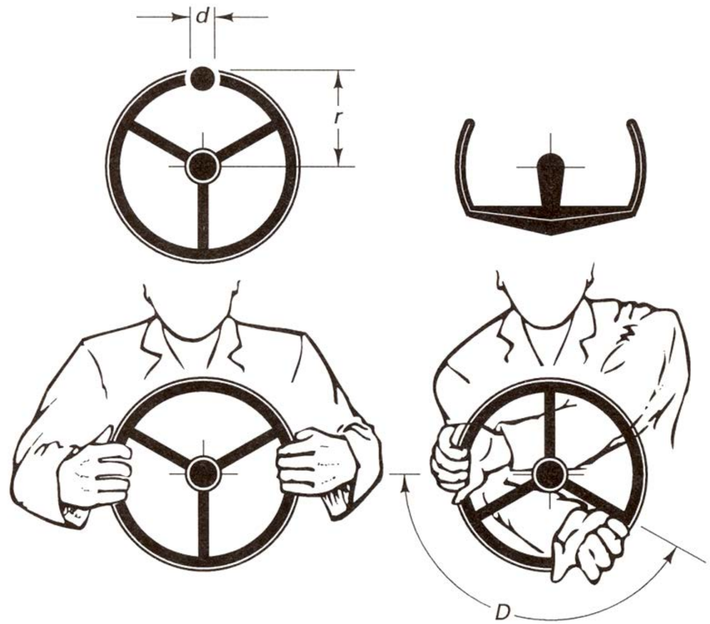


TABLE 11-14. DIMENSIONS OF A HANDWHEEL

	r, Wheel radius					
	With powersteering (mm)	Without powersteering (mm)	*d* Rim diameter (mm)	Tilt from vertical (degrees)	*R* Resistance (N)	*D* Displacement both hands on wheel (degrees)
Minimum	175	200	19	30 Light vehicle	20	—
Preferred	—	—	—	—	—	—
Maximum	200	255	32	45 Heavy vehicle	220	120

Standards

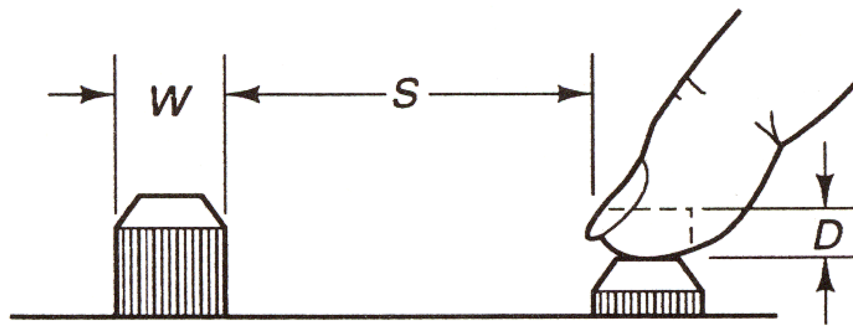
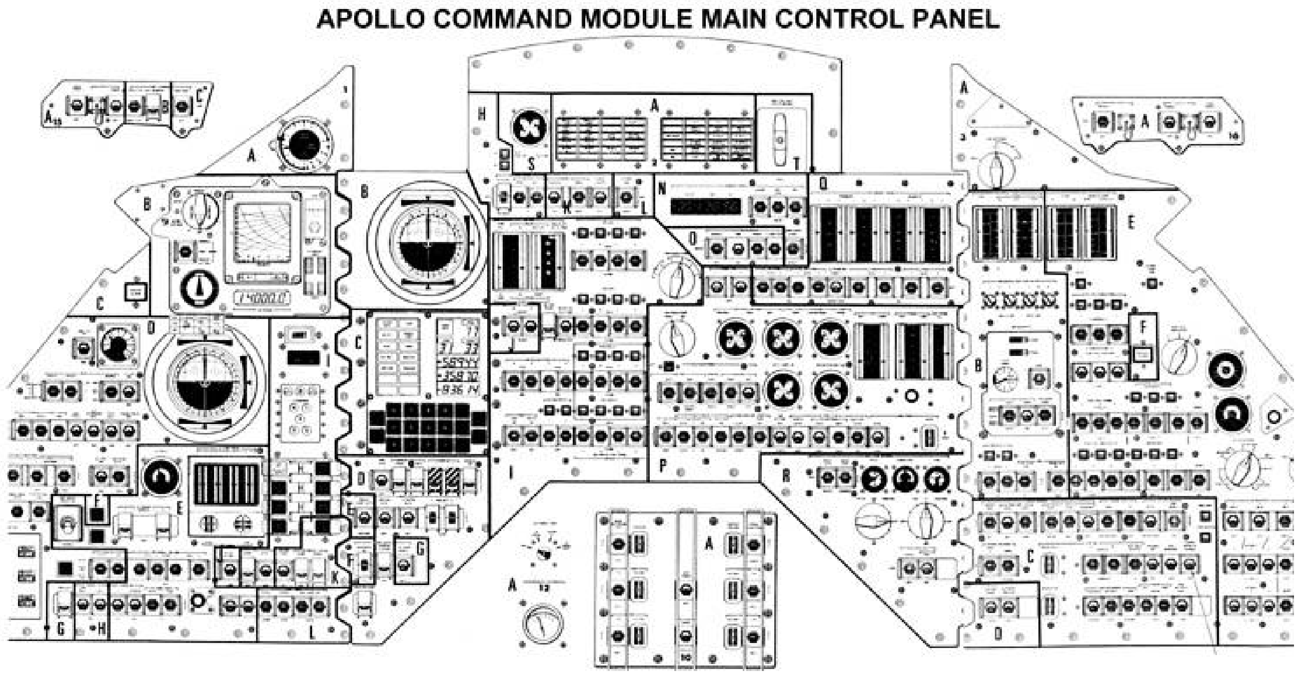
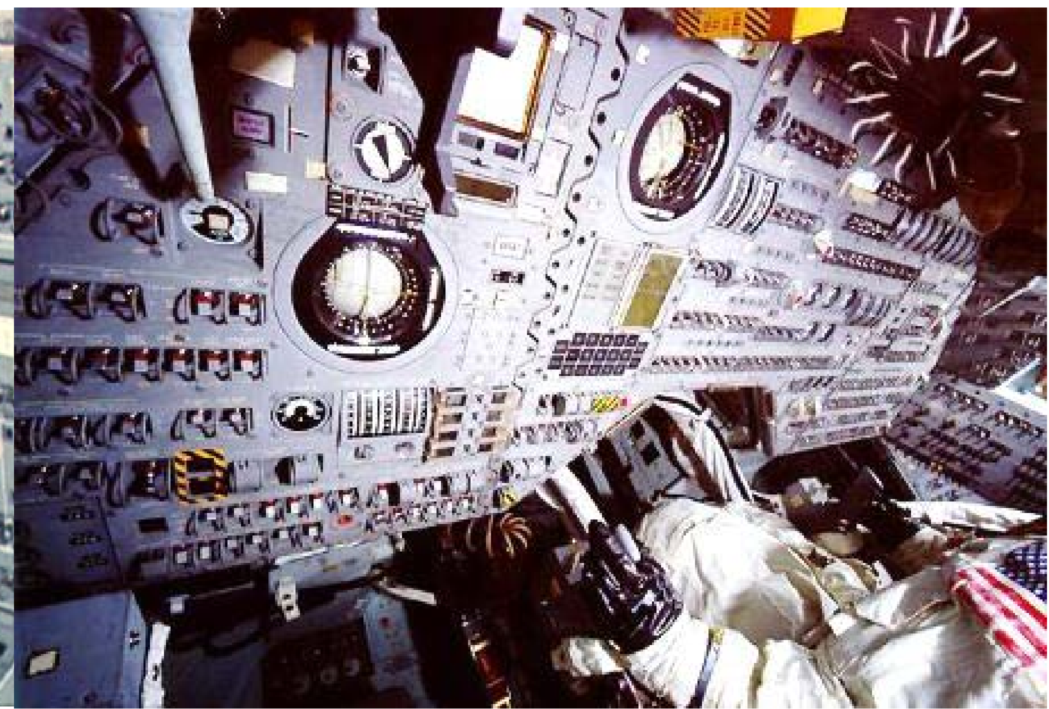


TABLE 11-8. DIMENSIONS OF A PUSHBUTTON

	W, Width of square or diameter			*R*, Resistance					*S*, Separation			
									Single finger			
Operation	Fingertip (mm)	Thumb (mm)	Palm of hand (mm)	Little finger (N)	Other finger (N)	Thumb (N)	Palm of hand (N)	*D*** Displacement (mm)	Single operation (mm)	Sequential operation (mm)	Different fingers (mm)	Palm or thumb (mm)
Minimum	10 13*	19	25	0.25	0.25	1.1	1.7	3.2 16	13 25*	6	6	25
Preferred	—	—	—	—	—	—	—	—	50	13	13	150
Maximum	19	—	—	1.5	11.1	16.7	22.2	6.5 20*	—	—	—	—

When there are many controls and displays errors can easily occur.





Control Coding

Location: **controls with similar functions are located together.**

Shape: **shapes are chosen depending on the control function.**

Size: **up to three different sizes are often used to subdivide different groups of controls.**

Mode of operation: **the movement and resistance is maintained the same for controls with similar functions.**

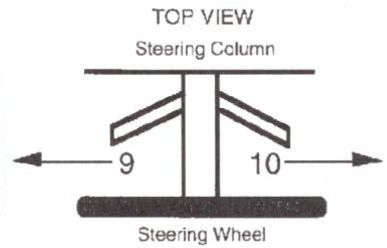
Labelling: **the same symbols are used to identify controls with the same function.**

Colour: **red, orange, yellow or white are often used to signify special or safety critical functions.**

Location Coding

Front Windshield Wiper

Zone:9 n=16 (30%)		
Switch	Motion	%
stalk	twist + & -y	28
stalk	multi-way t & p	2

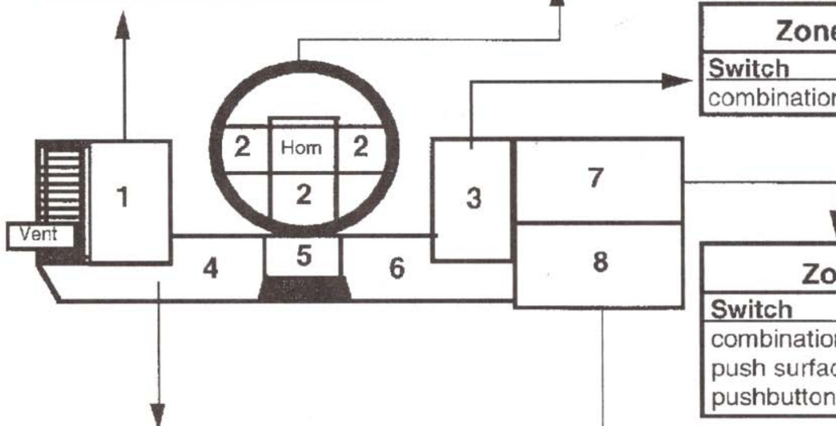


Zone:10 n=15 (28%)		
Switch	Motion	%
stalk	twist + & -y	19
stalk	push up & down	9

Zone:1 n=3 (6%)		
Switch	Motion	%
slide	push up & down	2
slide	push r & l	2
rocker	push in	2

Zone:2 n=3 (6%)		
Switch	Motion	%
combination	push in	4
combination	push r & l	2

Zone:3 n=3 (6%)		
Switch	Motion	%
combination	push up & down	6

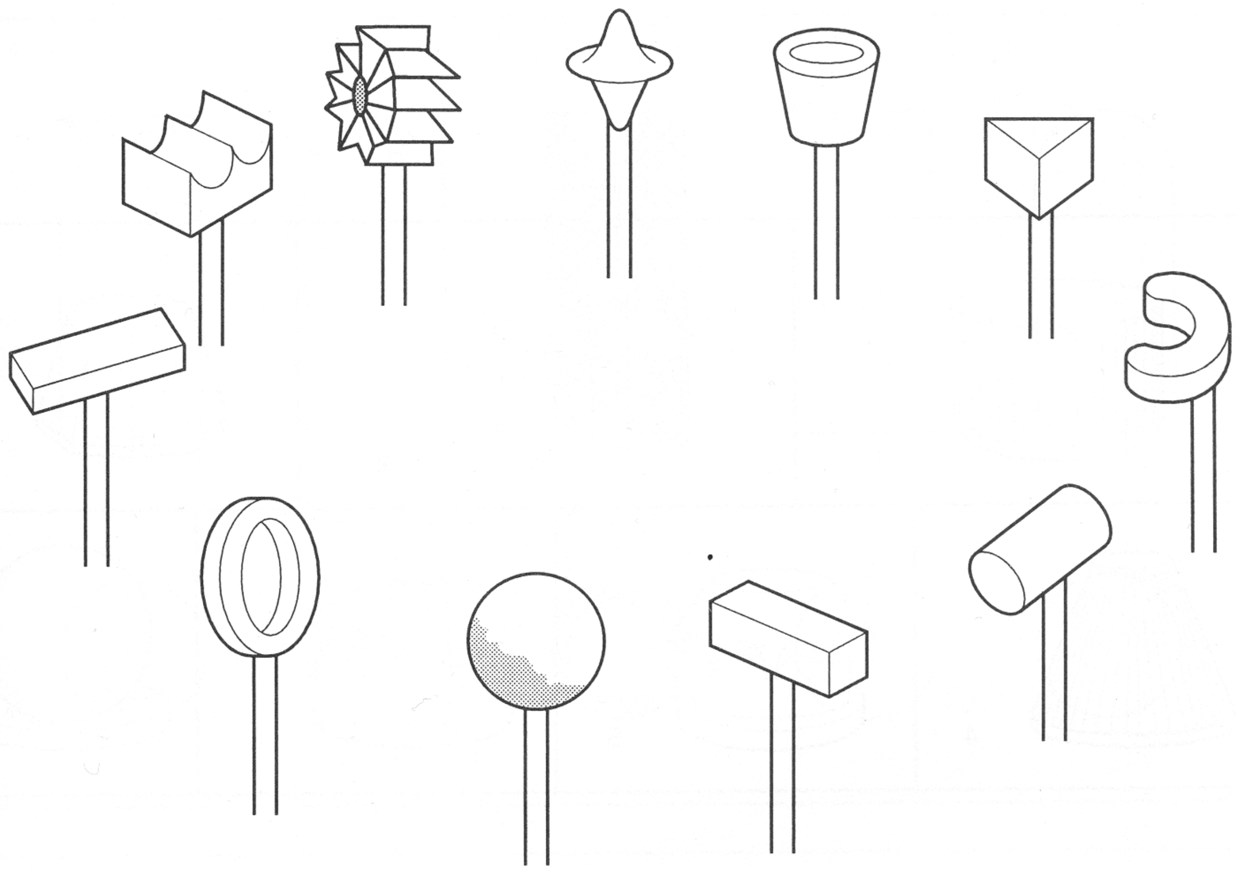


Zone:7 n=4 (7%)		
Switch	Motion	%
combination	push in	4
push surface*	push up & down	2
pushbutton	push in	2

Zone:4 n=5 (9%)		
Switch	Motion	%
knob	twist + & -x	4
knob	multi-way t & p	2
push-pull	twist + & -x	2
rocker	push in	2

Zone:8 n=5 (9%)		
Switch	Motion	%
combination	push up & down	6
lever	push up & down	2
push surface*	push in	2

Shape Coding

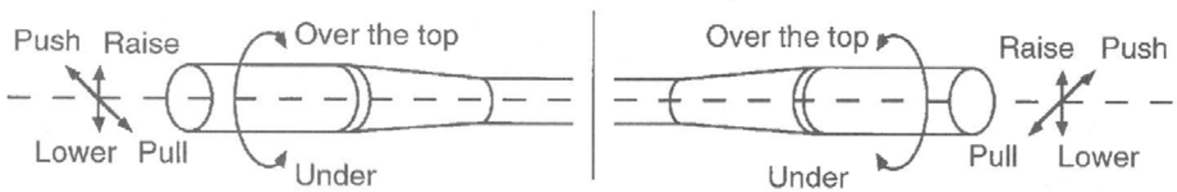


Some aircraft controls have been shape coded for easy recognition.

Size Coding

The controls which are more important or more frequently used are usually made larger.

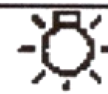
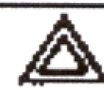
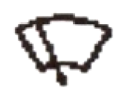
Mode of Operation Coding



Control location	Action	Desired Action	Movement Executed	% Complying
Nonspecific				
Left	Turn on	Raise or lower	Raise	96
Right	Turn on	Raise or lower	Raise	76
Left	Turn on	Push or pull	Pull	76
Right	Turn on	Push or pull	Pull	72
Left	Turn on	Rotate barrel	Over the top	82
Right	Turn on	Rotate barrel	Over the top	94
Specific Unconstrained				
Left	Turn on wipers	Unspecified	Over the top	50
Right	Turn on wipers	Unspecified	Over the top	50
Left	Turn on hi beam	Unspecified	Pull	76
Specific Constrained				
Left	Turn on wipers	Raise or lower	Raise	94
Right	Turn on wipers	Raise or lower	Raise	94
Left	Turn on wipers	Rotate barrel	Over the top	72
Right	Turn on wipers	Rotate barrel	Over the top	72
Left	Turn on hi beam	Push or pull	Pull	80
Left	Turn on headlight	Rotate barrel	Over the top	88

A control is usually easier to use if its shape and movement resemble that of the controlled device. An typical example is the stalk mounted windshield wiper control of an automobile.

Labelling Coding

Control	Identification
Clearance lamps, identification lamps and side marker lamps	
Master lighting switch	
Headlamp upper and lower beams	
Turn signals	
Hazard warning signal	
Windshield wiper	
Windshield washer	

ISO symbols are required by international safety standards.

Colour Coding

Numerous cockpit controls have been colour coded in the Piper Saratoga.

Design Classic: Honeywell T87 Thermostat

The T87 thermostat was first manufactured by Honeywell International in 1953. It was designed by Henry Dreyfuss, who based his design on a concept by Honeywell engineer Carl Kronmiller.

The T87 elegantly couples the rotary control motion of the human hand to a rotatory temperature display.

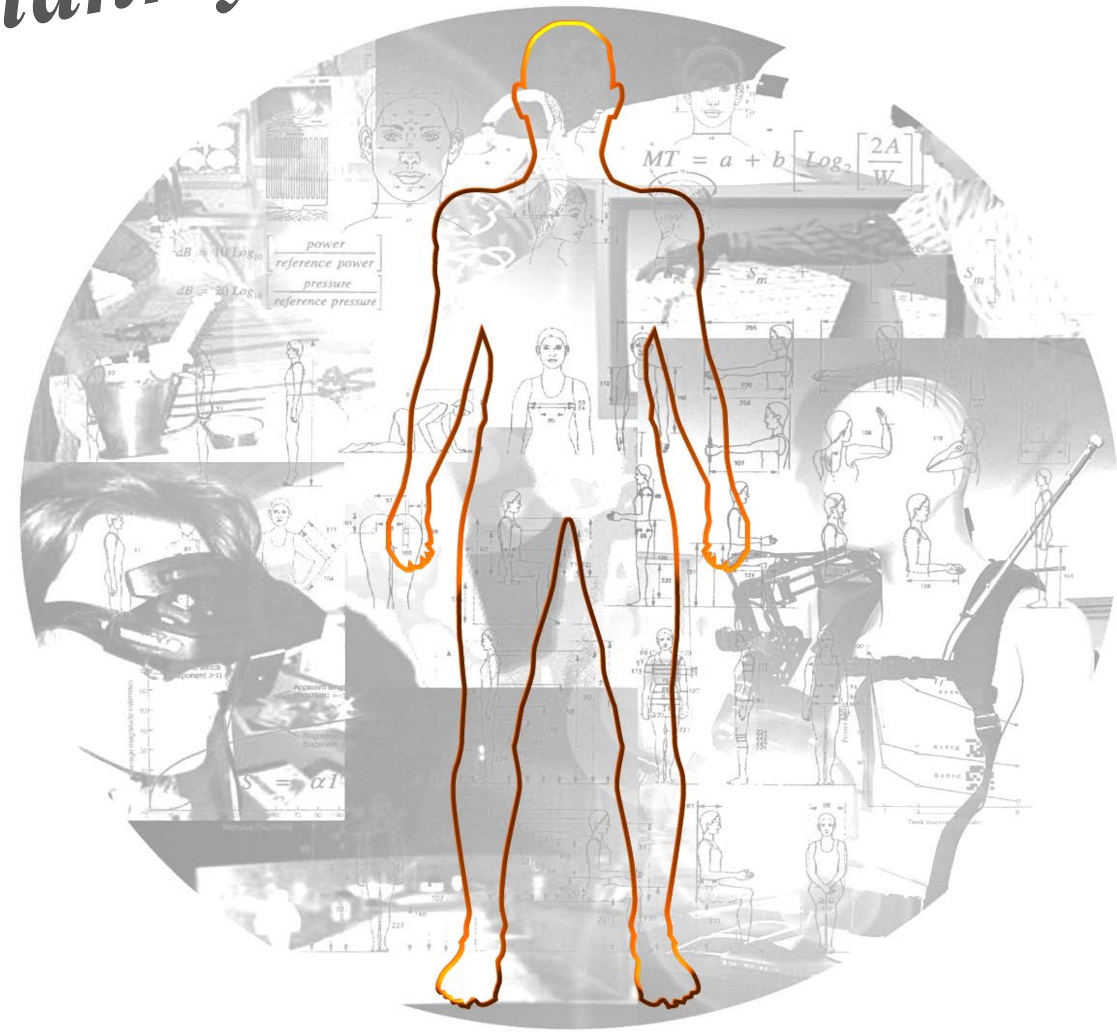
Design Classic: Sony PlayStation Controller

Introduced in 1994 the Sony PlayStation controller has withstood the test of time.

While the machine itself has been modified several times over the years, the triangle, circle, X and square-designed buttons have remained unchanged.

Each symbol has a purpose that applies to all the games. Other game controllers can feel complicated, causing frustration which kills the fun.

Thank you.



MT = a + b Log2 [2A/W]
power
reference power
pressure
reference pressure