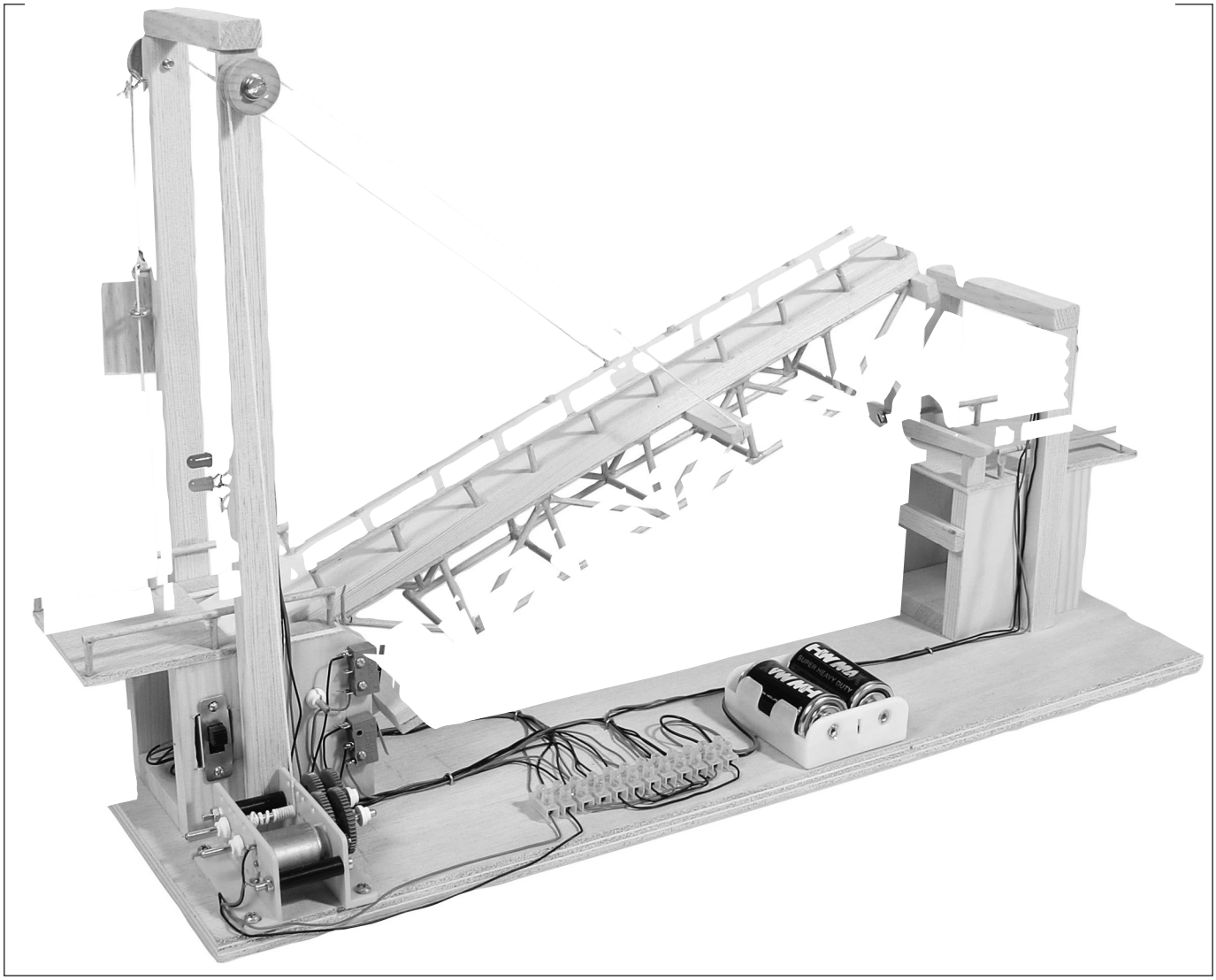
OPITEC

105.456
Drawbridge

An opening bridge with light signal system (Electro-mechanical)



Please Note

The OPITEC range of projects is not intended as play toys for young children.They are teaching aids for young people learning the skills of Craft, Design and Technology.These projects should only be undertaken and tested with the guidance of a fully qualified adult.
The finished projects are not suitable to give to children under 3 years old. Some parts can be swallowed. Danger of suffocation!

1. General

Teaching aims

- Drawing plans and wiring diagrams.
- Making a bridge construction.
- Assembling a motor and gearbox.
- Combining simple electronic circuits (Light diodes and resistors)
- Recognising components (Joiners, switches, motors etc)
- Mechanics (Pulley, gear assembly, barriers, counter balance weights)

Necessary tools (Not included))

- Set square
- Saw
- Wood file
- Sandpaper
- Drills 3 and 4mm diameter
- Screwdriver
- Spanners M3 and M4
- Scissors
- Pliers
- Soldering iron and flux
- PVA Wood glue
- 1.5 Volt Batteries (R14 x 2)

Size

600 x 320 x 150 mm

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Team work

If this is undertaken as a team project, one person needs to oversee the task , to ensure all the separate parts are constructed properly and that nothing is missed out or made twice. They must also organise the progress and how to avoid any problems or conflicts that may arise.

Designing the construction

In this phase of the project, the team should try to understand how the bridge is made and what the materials are, and what it will look like when it is finished. Plans and sketches for the mechanical and electrical layout also need to be undertaken. Drawings and records should be made of all the components and systems that are used.

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Construction challenge

When making this project you should be able to describe and recognise all the necessary materials and how to use them.
Describe and use all the tools that may be needed, especially the workshop machines and safety issues involved.
Assemble all the various parts in the correct way.

Test phase

You should be able to test the bridge function and find any faults.
Make a progress report and show how to overcome any problems and improve the working of the finished project. Make notes of all the changes..

Analysis of the main construction points

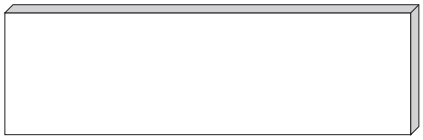
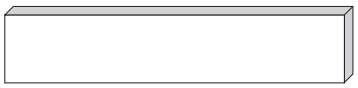
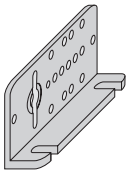
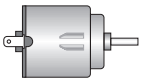
- Function
- Reliability
- Ease of use
- Looks
- Strength
- Accuracy
- Costs
- Etc.

Goal

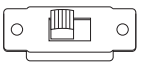
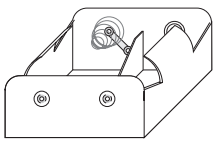
To build a gear operated working model of an opening draw bridge with in built electronic safety system.

To learn about the basics of structures, mechanics and electronics.
To solve two problems a) to allow a person or vehicle to cross a bridge, whilst
b) allowing the passage of large ships that are taller than the bridge.

2. Materials

Nr.	Name	Quantity	Size	Part	Diagram
1	Plywood sheet	1	10 x 140 x 495 mm	Base	
2	Wood strip	1	10 x 50 x 300 mm	**2x** 10 x 50 x 100 **2x** 10 x 50 x 50	
3	Wood strip	1	10 x 75 x 80 mm	**4x** 10 x 80 x 100	
4	Wood strip	1	10 x 50 x 350 mm	Zugbrücke	
5	Plywood sheet	1	5 x 70 x 250 mm	**1x** 2,5 x 70 x 150 **1x** 2,5 x 70 x 100 **2x** 2,5 x 50 x 10	
6	Wood strips	4	10 x 15 x 325 mm	**1x** 10 x 15 x 310 **1x** 10 x 15 x 300 **1x** 10 x 15 x 160 **1x** 10 x 15 x 150 **2x** 10 x 15 x 90 **3x** 10 x 15 x 40	
7	Pulley	2	20 dia x 10mm		
8	Wood strip	3	5 x 10 x 250	**1x** 5 x 10 x 115 **1x** 5 x 10 x 90 **3x** 5 x 10 x 80 **1x** 5 x 10 x 70 **1x** 5 x 10 x 20 **3x** 5 x 10 x 15	
9	Dowel	12	3dia x 500mm	Supports / rails	
10	Thread	1	2 metres	Rope / Counterweight	
11	Metal axle	1	3dia x 95mm	Middle shaft	
12	Spacers	6	3 dia	Shaft holder	
13	Metal axle	2	3dia x 70mm	Gearbox	
14	Mounting brackets	2	30 x 53 mm	Gearbox	
15	PVC Spacer tube	2	7dia x 25mm	Gearbox	
16	Brass sleeve	1	4dia x 5mm	Gearbox	
17	motor		21 dia x 25mm	Drive	
18	Double gear	4	Module 0.5 50 / 10 teeth	Gearbox 3 x white / 1 red	

2. Materials

Nr.	Name	Quantity	Size	Part	Diagram
19	Small gear	1	Module 0,5/10 Teeth	Motor drive	
20	Connector block	2	12 pole	Electrical connection	
21	LED	2	5mm dia / Red	Signal	
22	LED	2	5mm dia /Green	Signal	
23	Resistors	2	130 Ohm	Protection for LED	
24	Micro switch	2	250V/5A	Switch for bridge	
25	slide switch	1	23 x 14 x 12 mm (6 contacts)	Circuit switch	
26					
27	Insulated wire	4 or 1	2,0m 10,0m	Circuit switch Circuit switch	
28	Machine screws	2	M4 x 30 mm	Shaft	
29	Nuts	4	M4		
30	Washers	6	M4	Shaft	
31	Machine screws	2	M3 x 35 mm	Gearbox	
32	Machine screws	1	M3 x 20 mm	Barrier	
33	Nuts	4	M3	Barrier / gearbox	
34	Washers	8	M3	Barrier / gearbox	
35	Screw eyes	4	3dia x 10mm	Guide / counter	
36	Screws	6	DIN 7971/2,9 x 9,5 mm	**2x** Battery cover **4x** Gearbox	
37	Screws	8	DIN 96/2 x 12 mm	**4x** Strip **4x** Switch	
38	Screws	2	DIN 7971/ 2,2 x 6,5 mm	Slide switch	
39	Battery holder	1	2 batteries 1,5V (R14)	Supply	
40	Battery clip	1		Battery connection	

3. Construction

Before starting this project we recommend that you study the plans on page 29 and 30 of the bridge and the electronic cable layout in diagram 28. These plans should help throughout all the stages in constructing this project.

Overview

3.1 Constructing the moving parts of the bridge

3.2 Making the bridge supports

3.3 Making the barrier

3.4 Bau des Getriebes mit Elektromotor

3.5 Assembling all the separate elements

3.6 Installing the circuitry.

3.1 Constructing the moving parts of the bridge

3.1.1 Mark out and saw from the plywood 350 x 50 x 10mm (2) 2 pieces 80x50 x 10mm and 2 pieces ca. 50 x 50 x 10mm. The two pieces 80 x 50 x 10mm are for the bridge supports

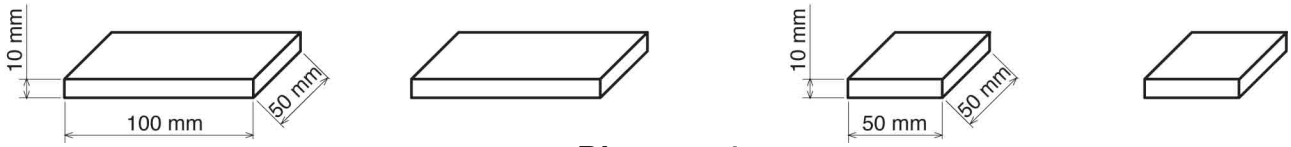


Diagram: 1

3.1.2 Mark out the middle of the pieces 50 x 50 x 10 from step 3.1.1 and radius the corner as shown in diagram 2. These pieces are for the moving parts

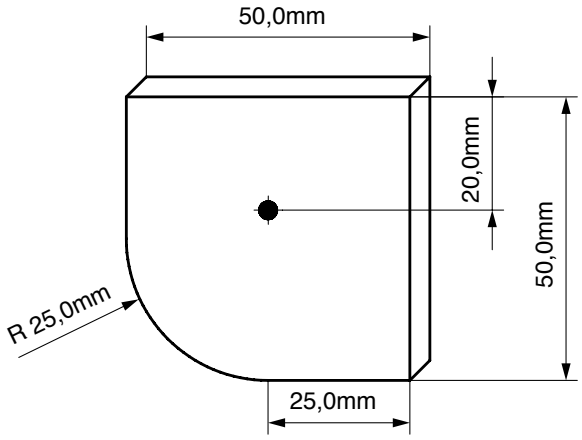


Diagram: 2

3.1.3 Drill the 3mm diameter holes in the pieces as shown (Diagram 2)

Note: Sellotape the two pieces together and drill them in one go

The metal shaft 3dia x 95mm (11) should pass through these holes

3.1.4 The bridge deck (4) 350 x 50 x 10mm is made smaller at one end
Ca. 55 mm long, depth 2.5mm. Saw out as shown (Diagram 3).

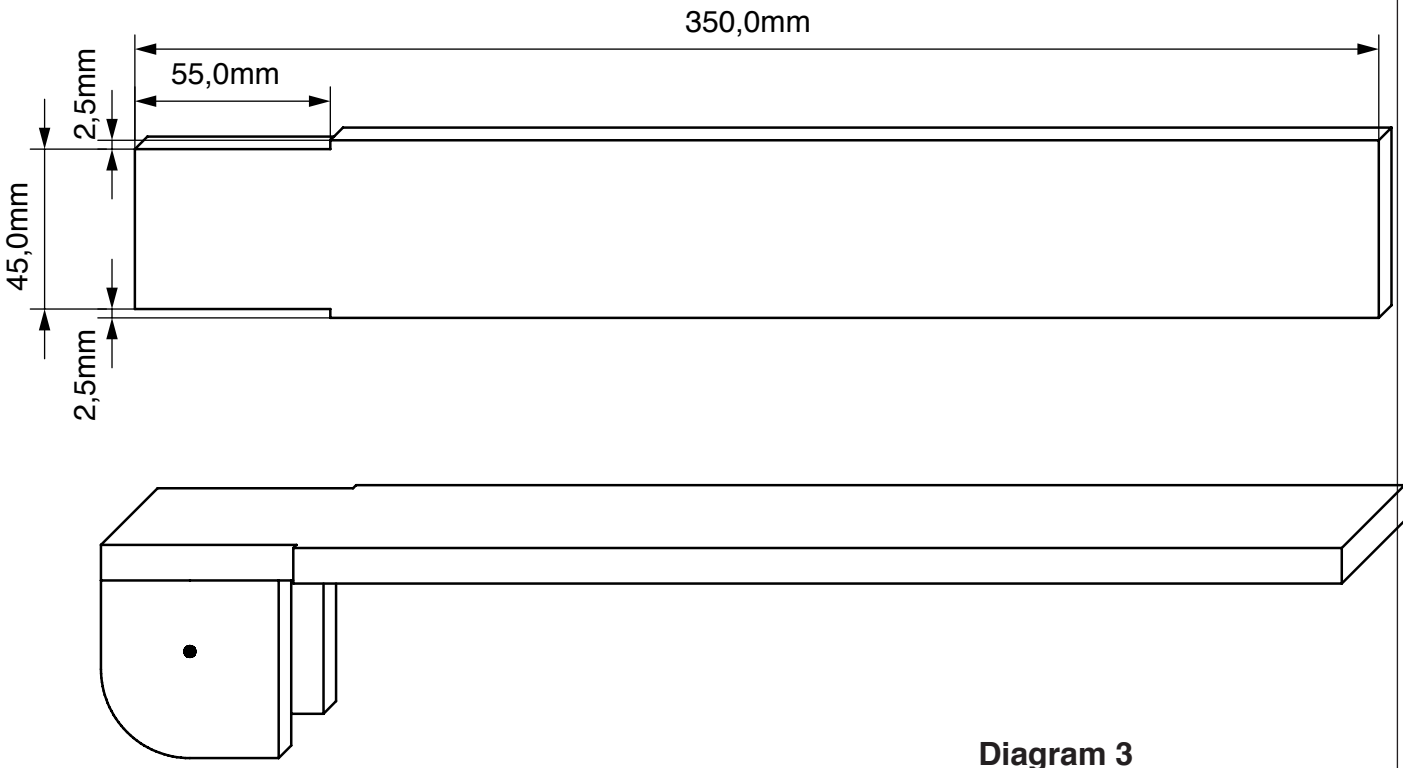


Diagram 3

3.1.5 GGlue the two drilled piece 50 x 50 x 10 to the smaller end of the bridge deck (Diagram 3)
This completes the basic moving bridge platform e.

3.1.6 From the two large wood strips 500 x 10 x 5mm saw the following lengths (Diagram 4)

1 Length 115 x 10 x 5 mm
1 Length 90 x 10 x 5 mm
3 Lengths 80 x 10 x 5 mm
1 Length 70 x 10 x 5 mm
1 Length 20 x 10 x 5 mm
3 Lengths 15 x 10 x 5 mm

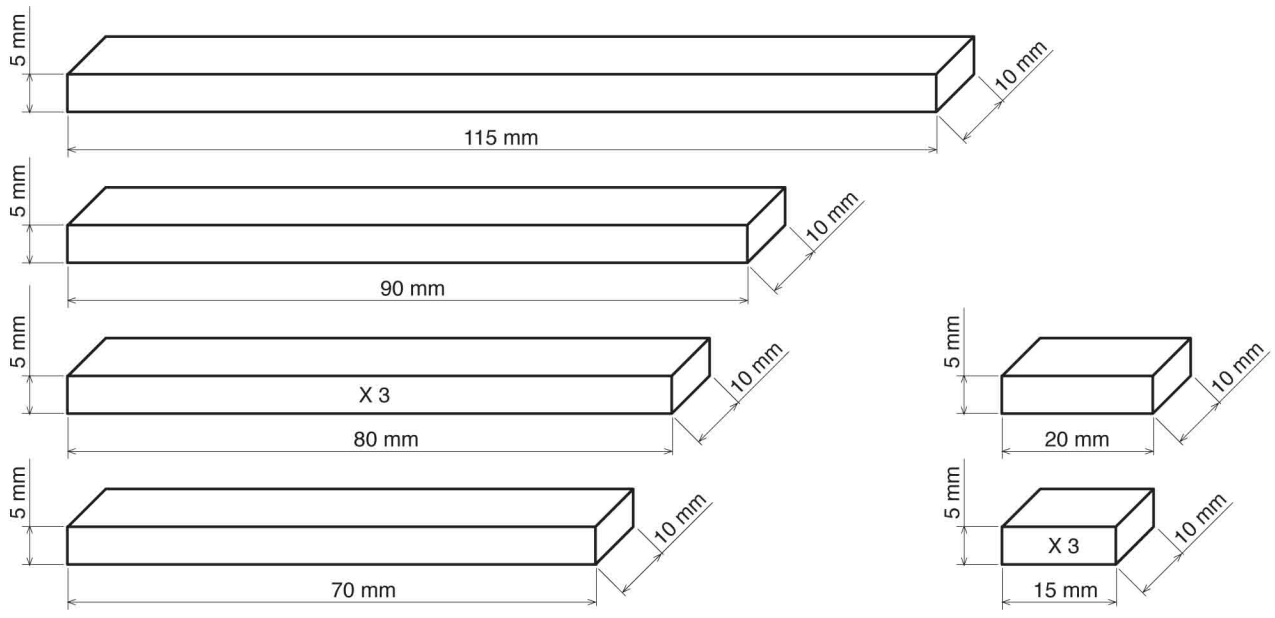


Diagram 4

3.1.7 Mark out and saw a groove in both ends of the pine strip 115 x10 x 5mm (Step 3.1.6)
As shown in diagram 5
These strips are supports for the bridge and counterweight .

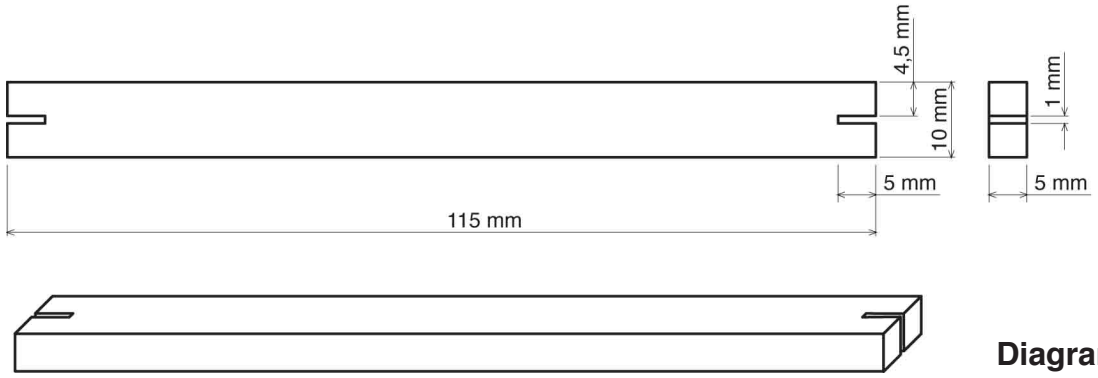


Diagram 5

3.1.8 From the piece 15 x 10 x 5mm (Step 3.1.6) shape on side to make a claw
Glue it as shown on the end of the wood strip 80 x 10x 5mm (Step 3.1.7)

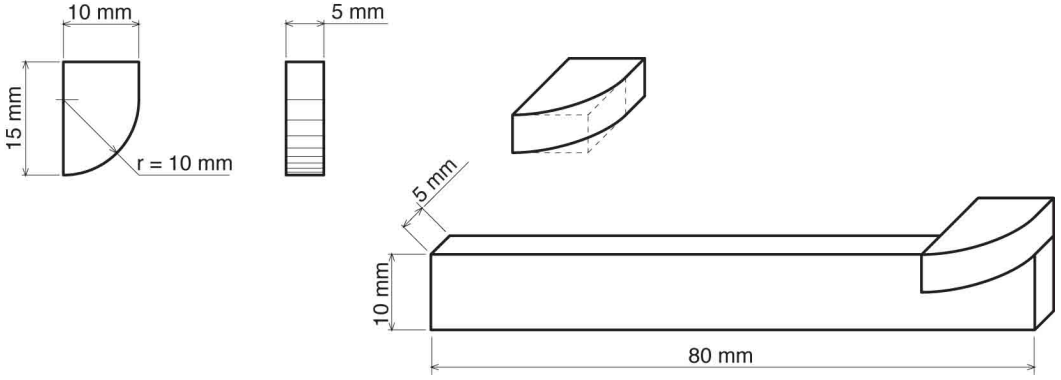
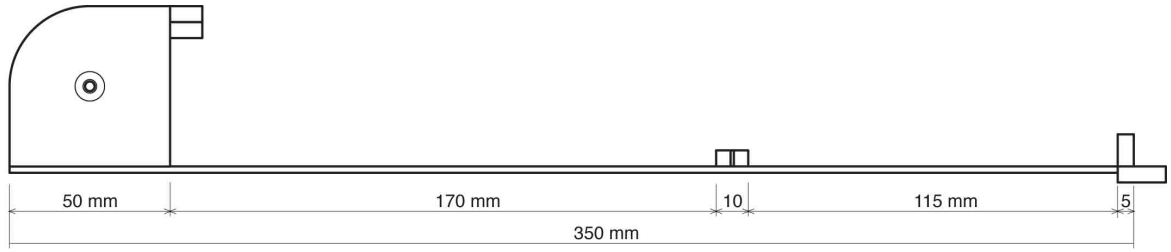
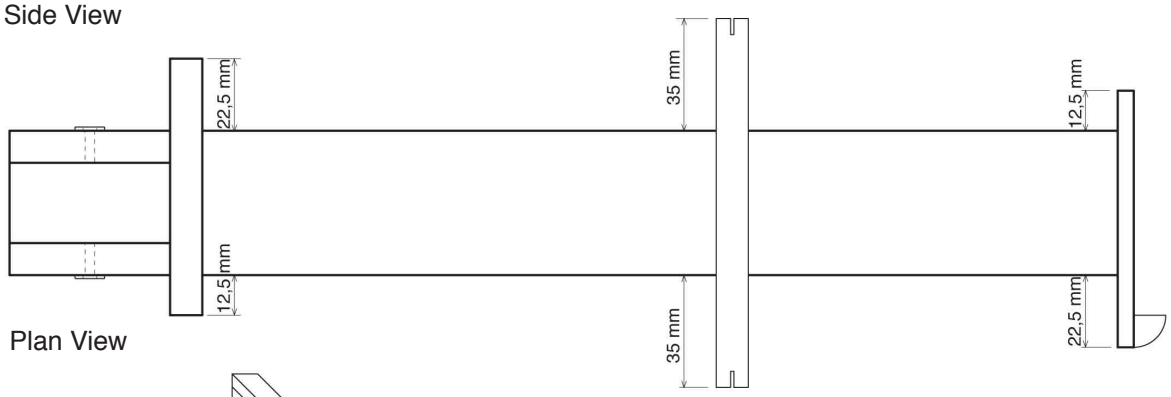


Diagram 6

3.1.9 Glue the wood strips 115 x 10 x 5mm and the strip 80 x 10 x 5mm (Step 3.1.8) complete with claw , and the two strips 80 x 10 x 5 mm on to the bridge deck (See diagram 7)
Glue a washer M4 (30) over the holes in the end as shown in diagram 7



Side View



Plan View

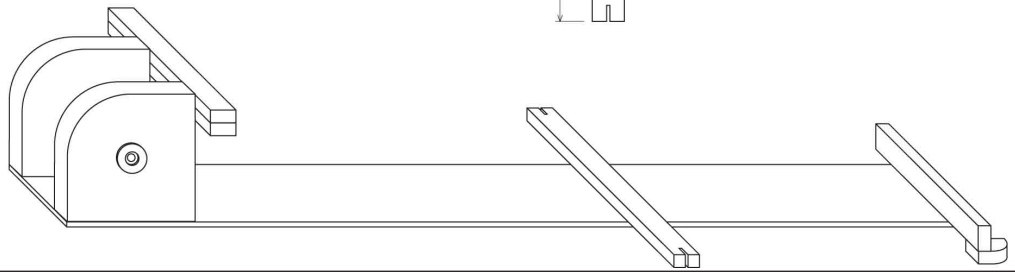


Diagram 7

3.1.10 Now construct the bridge support framework from the dowel (9) using the scale 1:1 plan on page 29

Construct one side then the other and connect them with the cross members as shown in diagram 8. Do not forget to add extra diagonal supports “a” and “b” which form a strong triangulation

3.1.11 Constructing the railing

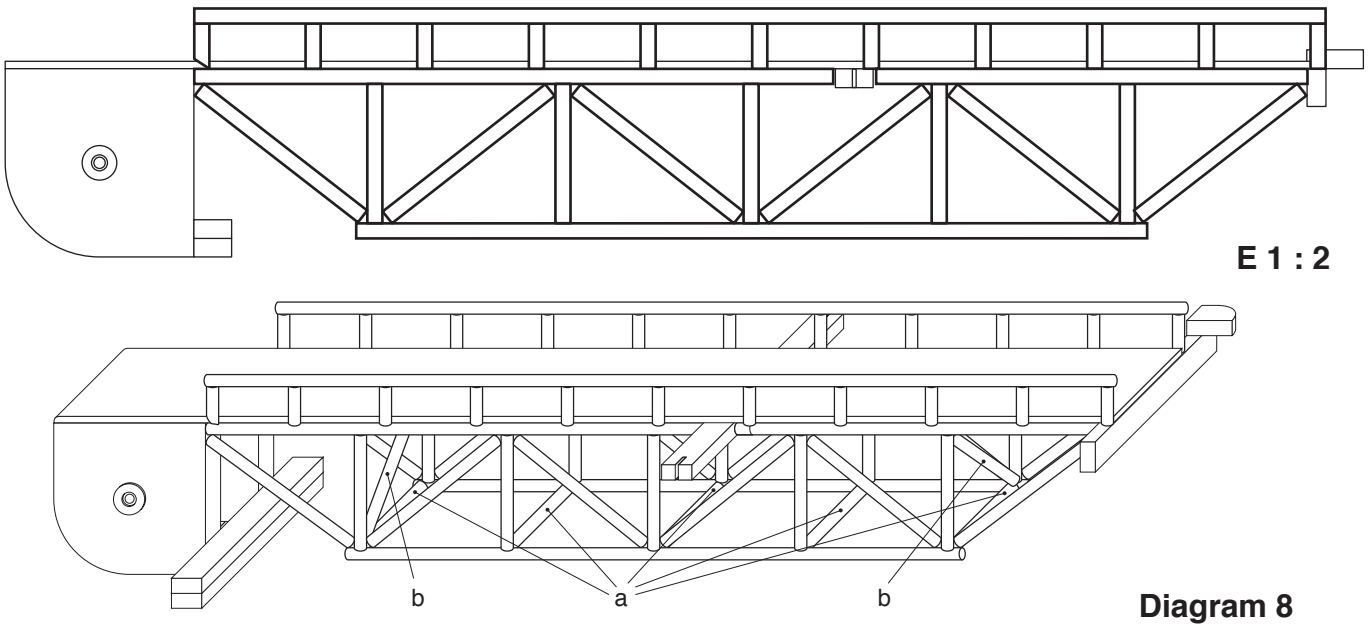


Diagram 8

The railing is made up of 11 uprights , made from the dowel (9) equally spaced as shown in diagram 8 . Once the uprights are in place add the top rail and glue it in position .

Note:

Neither the railing or the supporting framework must protrude from the bridge , otherwise it will foul the lifting mechanism (See diagram 8)

3.2 Bridge supports

3.2.1 Mark out and saw a hole in one of the four bridge supports 80x75x10mm (4) as shown (Drill then shape)
This is for the on/off switch (25) at a later stage
Drill a 3mm dia. hole in two of the supports (One with rectangular hole and one without)
Finally cut away a corner on each support as shown .

Note:

To ensure accuracy place one support over the other when drilling and make the hole in both at the same time.

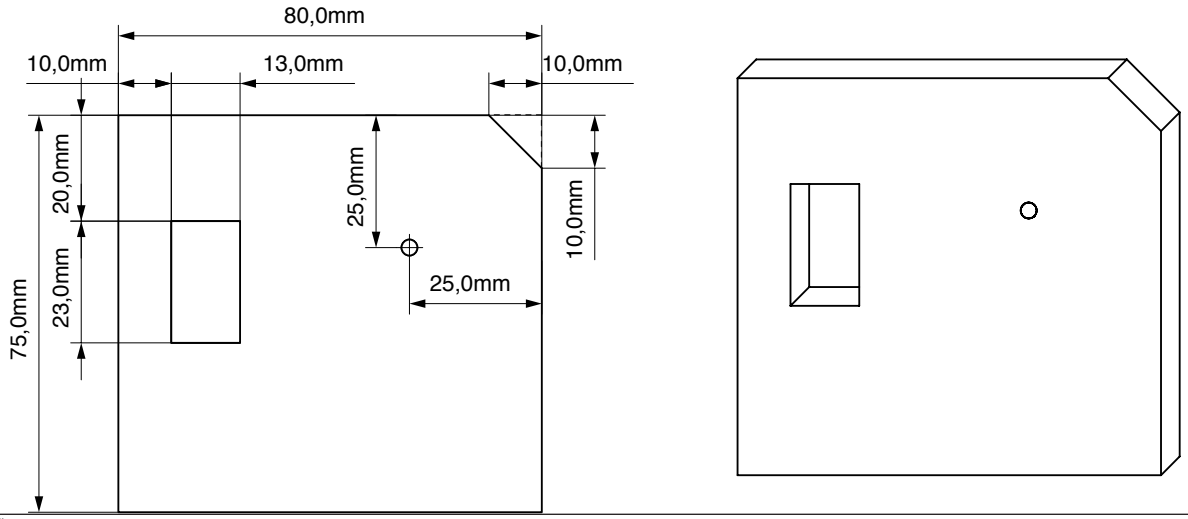


Diagram 9

3.2.2 Glue the two supports 80 x 75 x 10mm with the 3 mm hole lining up on to the base 75 x 50 x 40 (Step 3.1).
See diagram 10
Repeat this step with the two 80 x 75 x 10mm supports (without hole) joining them to the remaining piece 75 x 50 10 mm.

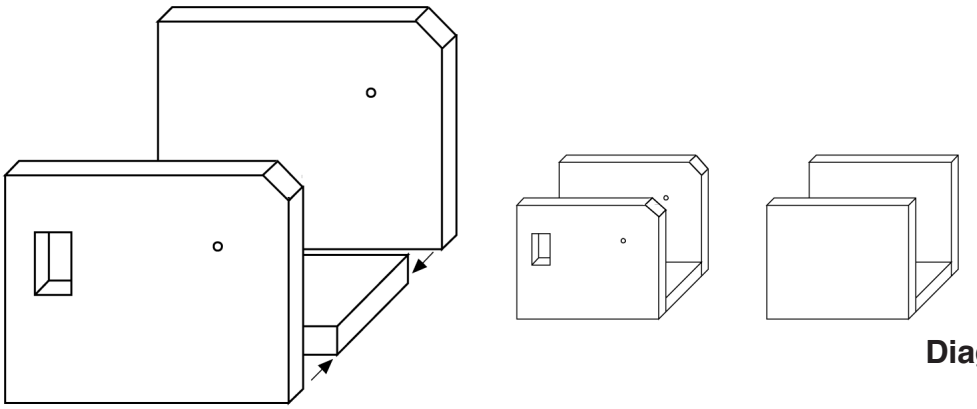


Diagram 10

3.2.3 Glue the supports (step 3.2.2) with holes on to the base (1) 495 x 140 x 10mm as shown in diagram 11
3.2.4 Once this is dry mount the moving part of the bridge (from set 3) between the bridge support , inserting the

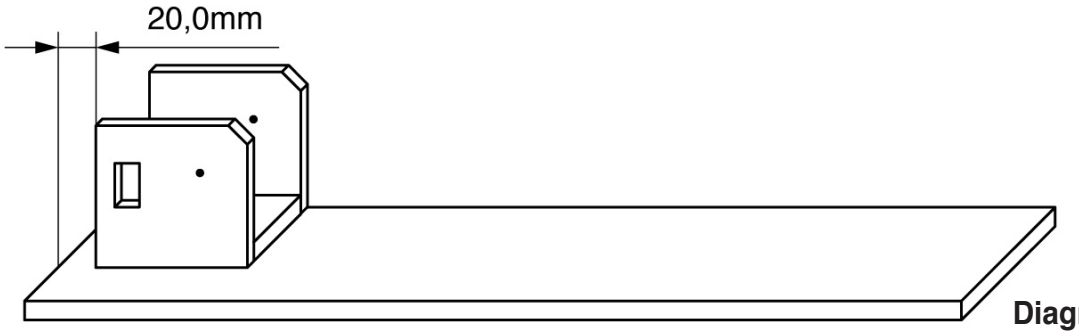


Diagram 11

metal shaft 3mm dia. x 95mm (11) so that it hinges.
The end of the deck should lie a little under horizontal. If its too high the stop point on the support must be filed (Dia. 12)
Secure the shaft with two distance pieces (12) on the support (Dia 12)
Place the second support. Step 3.2.2 (without holes) at the other end of the bridge
Please keep a gap of 0.5 -1mm between the deck and the support

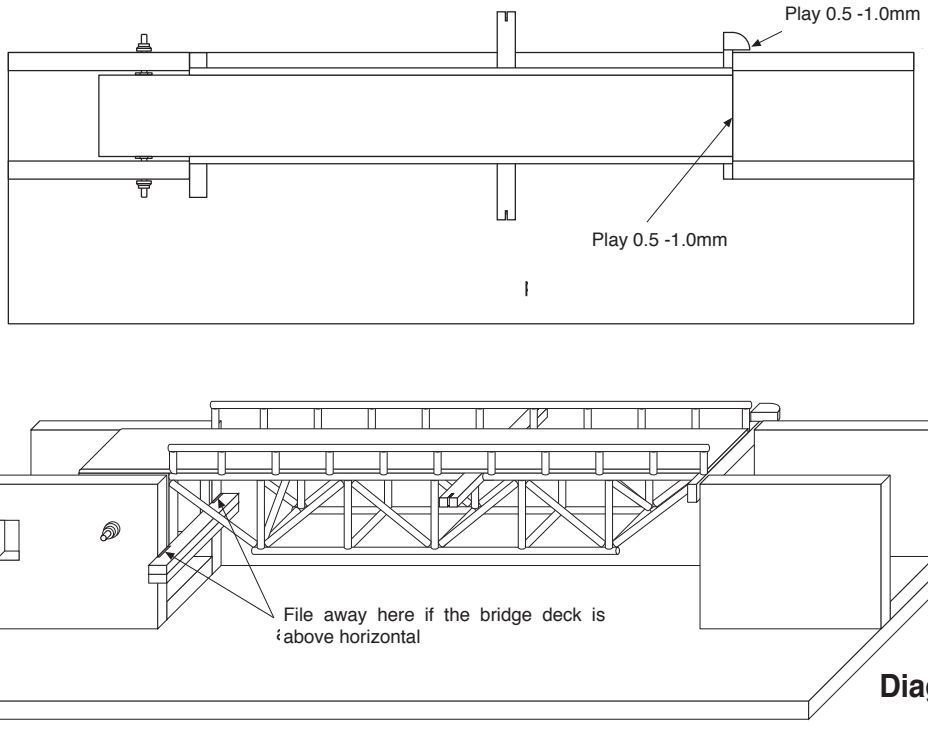


Diagram.: 12

3.2.5 Mark out and saw from the plywood 250 x 70 x5mm the following parts (Dia.13)

1 Piece 150 x 70 x 2,5mm
1 Piece 100 x 70 x 2,5mm
2 Piece 10 x 50 x 2,5mm

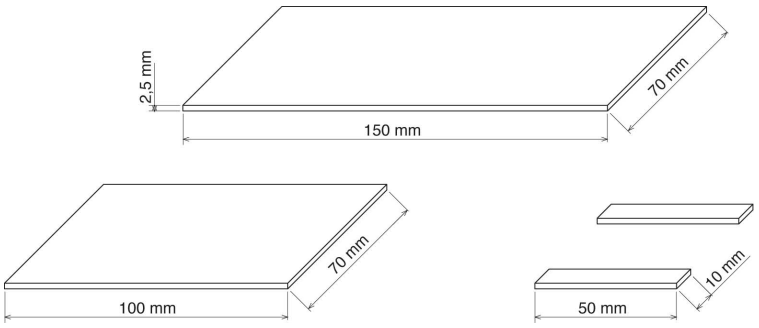


Diagram 13

3.2.6 Glue the parts in place as shown in diagram 14

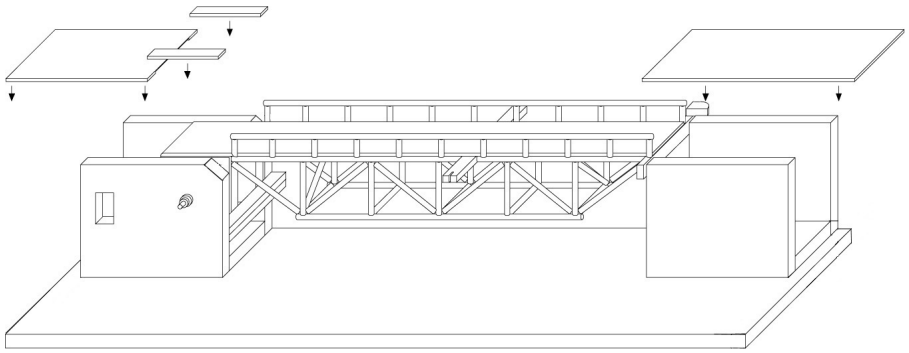


Diagram 14

3.2.7 Sand to fit – especially the area between the part 110 x 70 x 5mm

3.2.8 Take the wood strip 70 x 10 5mm (from Step 3.17) and glue it in place as shown

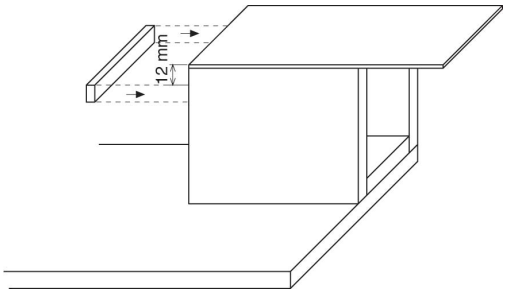


Diagram 15

Check that the deck of the bridge works correctly (See diagram 15)

3.2.9. Saw from the wood strips 500 x 15 x 10mm (6) the following pieces

1 length 310 x 15 x 10mm
1 length 300 x 15 x 10mm
1 length 150 x 15 x 10mm
2 lengths 90 x 15 x 10mm

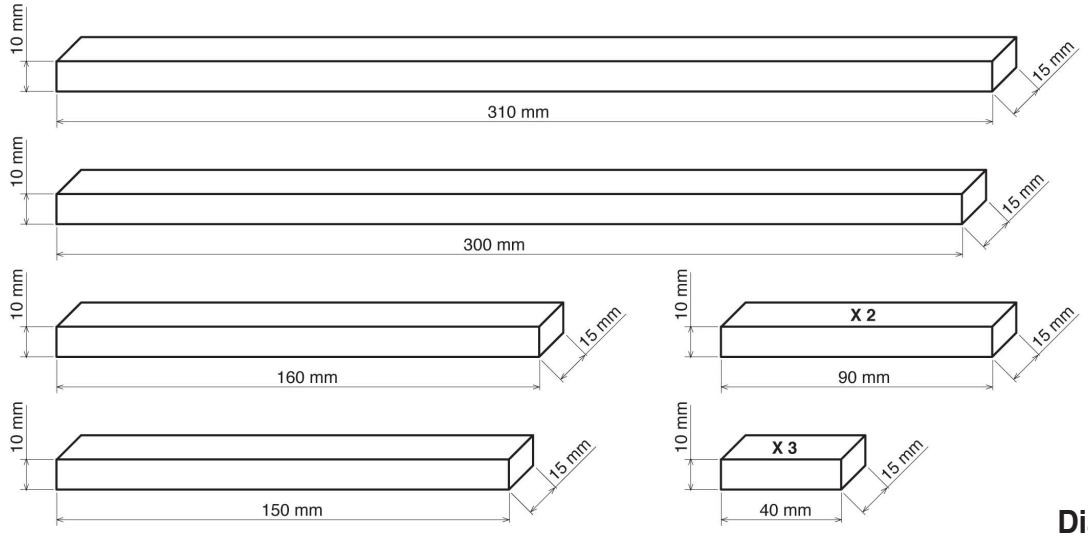
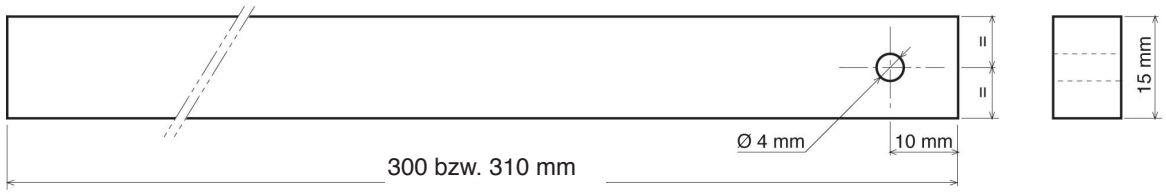


Diagram 16

3.2.10 Mark out and drill the wood strips 310 x 15 x 10 and the strip 300 x 15 x 10

These are the holes for the M4 x 30mm (28) machine screws to mount the pulleys on.



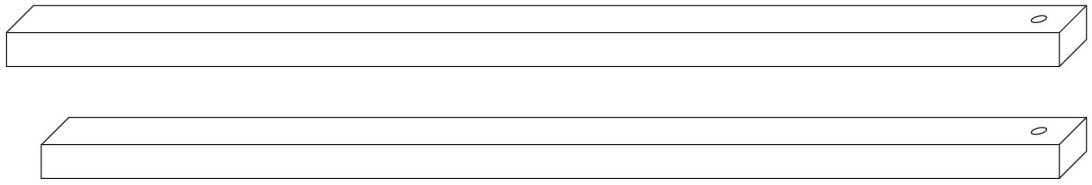
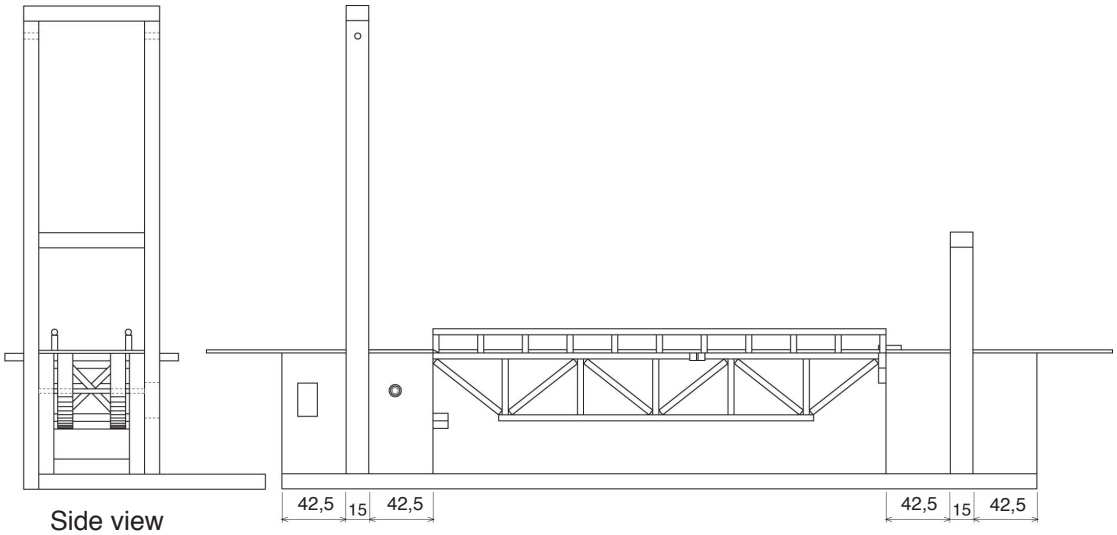


Diagram 17

3.2.11. Glue the parts from step 3.2.10 across the top as shown in Dia: 18

The larger uprights are made from the strips 310 x 15 x 10 and one 300 x 15 x 10mm
The holes must be at the top. The cross member is 90 x 15 x 10mm
The lower bridge bridge uprights are made from the wood strip 160 x 15 x 10mm and 150 x 15 x 10mm
The cross member is from 90 x 15 x 10mm



Side view

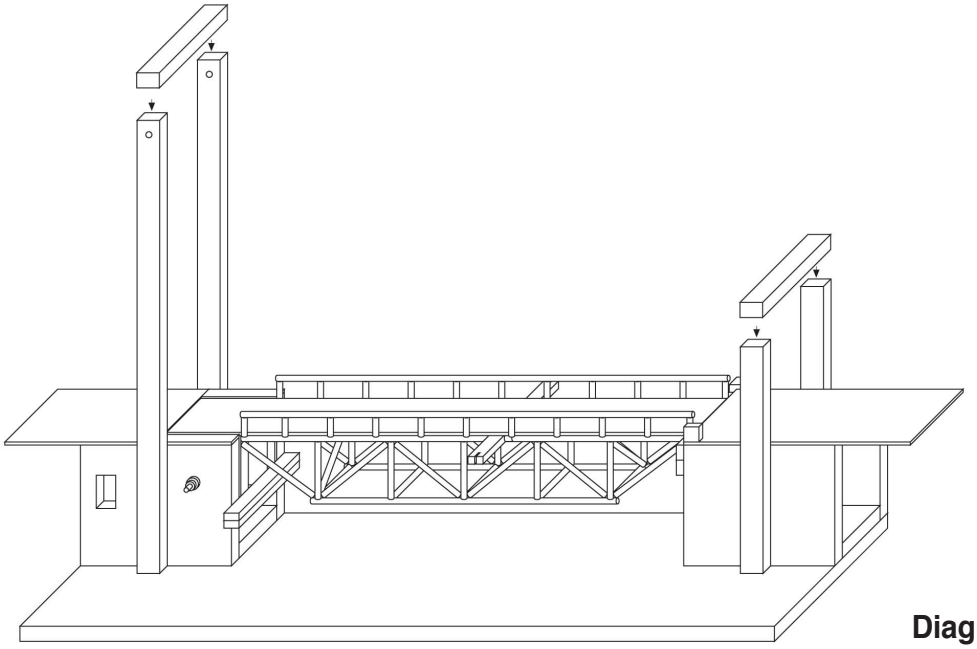


Diagram 18

3.2.12 Fix the pulleys with the M4 (28) machine screws , four washers M4 (30) and four nuts M4 (29) as shown in dia. 19

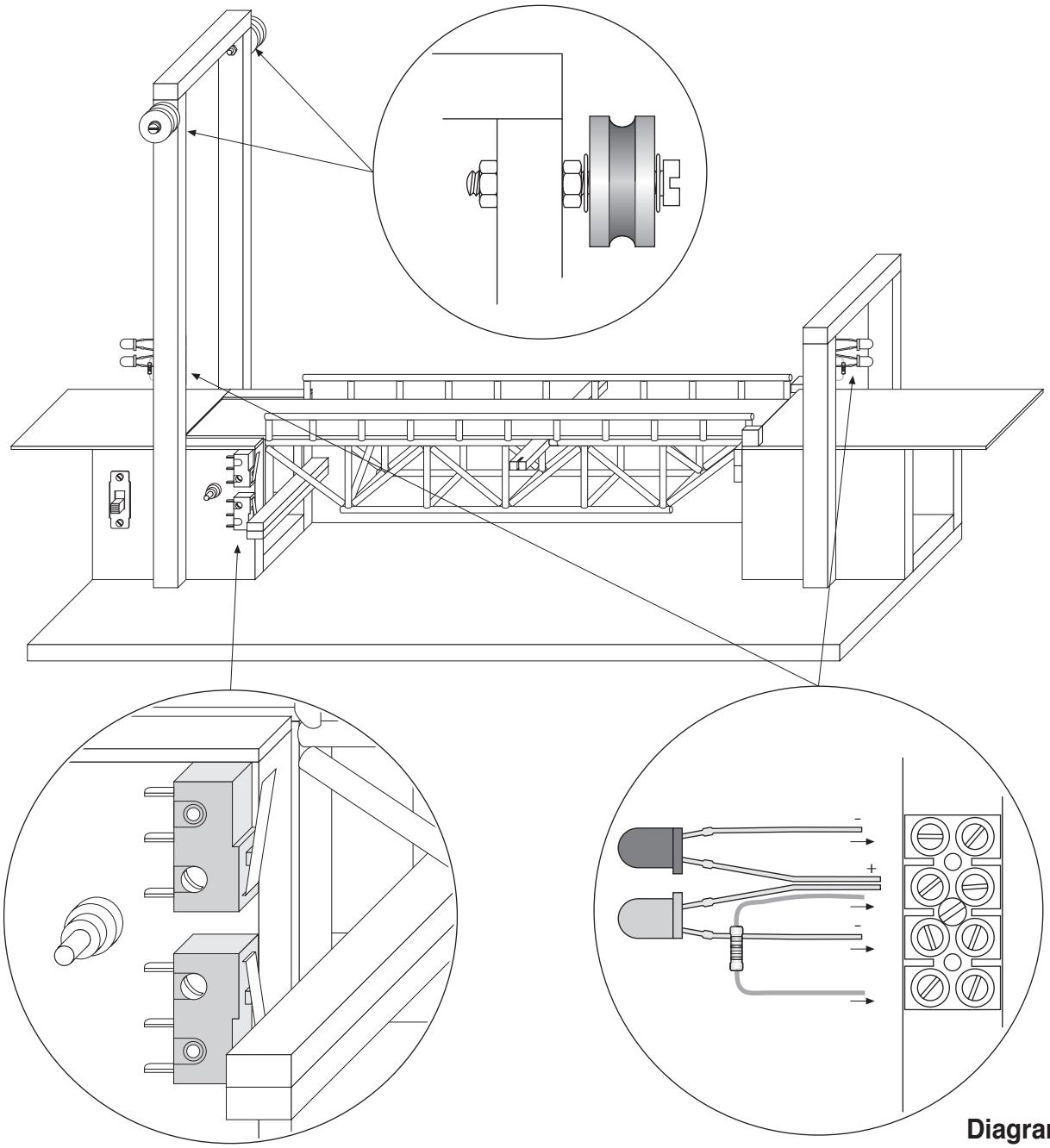


Diagram 19

3.2.13 Screw the switch (25) in the rectangular hole in the bridge support using the screws 2.2 x 6.5mm (38) and the two end switches (24) with the screws 2 x 12 (37) as shown in diagram

Note:
The end switches should be tried in place with just one screw so that the ideal place for fitting can be found.

3.2.14 Mount the leds (21 & 22) and the resistor (23) in the connector block as shown in diagram 19

Note:
The shorter leg on the light diodes is the minus pole the resistor can go either way around

Note: The leg of the resistor must only touch one leg (-) of a diode and not make a short circuit

Glue the connector blocks , LEDs and resistors in position as shown in the diagram 19

3.3 Constructing the barrier

3.3.1 Draw out the shape of the barrier on the wood strip 90 x 10 x 5mm (Step 3.17) and saw and sand to shape as shown. Finally drill the 3mm dia hole

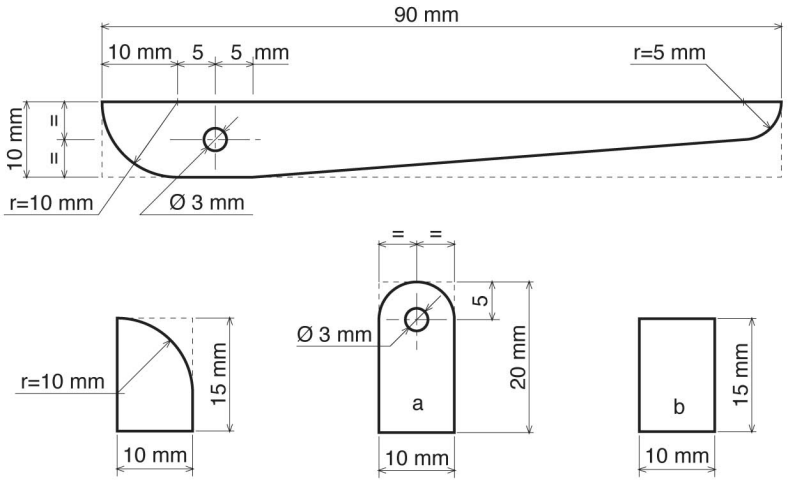


Diagram 20

3.3.2 aw out and shape the blocks as shown 20 x 10 x 5mm, round the end and drill 3mm. Radius piece 15 x 10 x 5mm as shown. The remaining block 15 x 10 x 5mm serves as the rest for the barrier

3.3.3 Assemble the 3 parts from step 3.31 and 3.3.2 as shown in diagram 21. Use the machine screw M3 x20 (32) two washers M3 (34) and two nuts M3 (33) to make up the barrier . The remaining block " b" as the rest block for the barrier.
When correctly adjusted the barrier should move up and down smoothly with the least possible resistance .

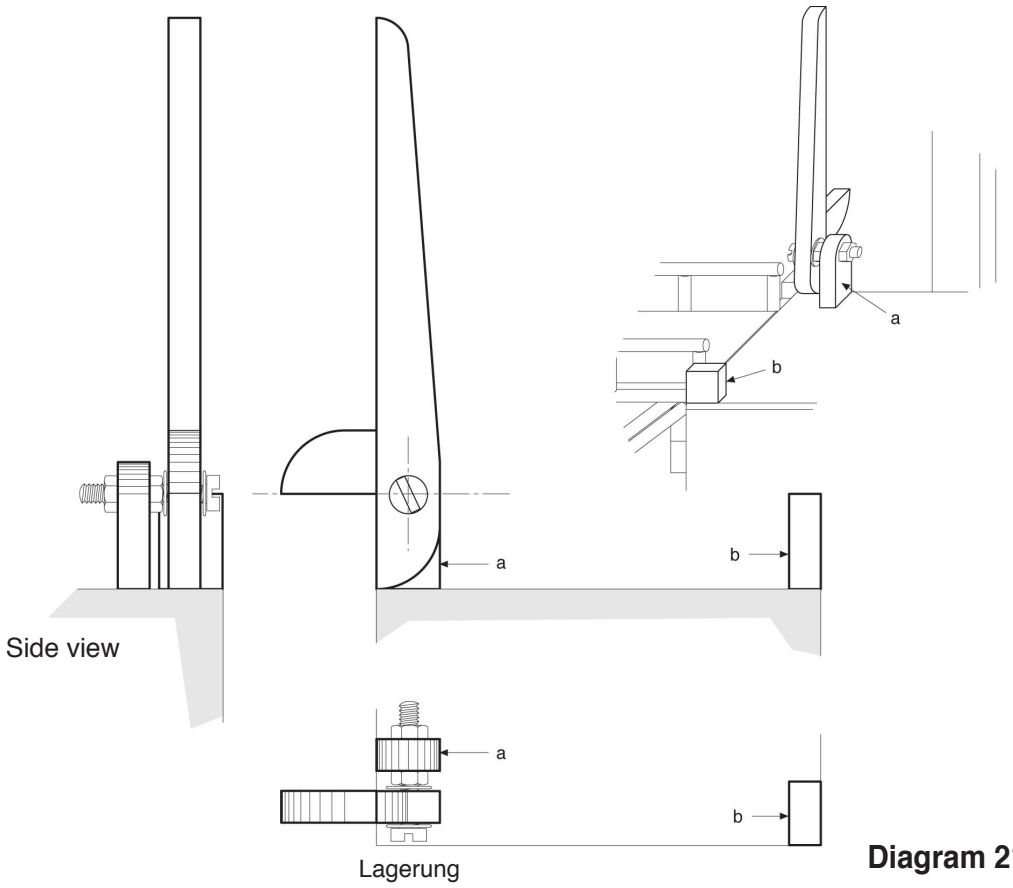
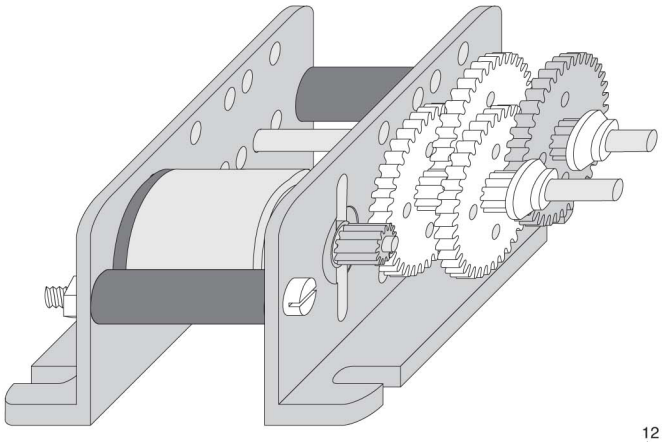


Diagram 21

3.3.4 Carefully try out the function of the barrier, checking the up and down movement .

3.3.5 Construct the remaining end railings from the remaining dowel (See diagram 27 and 28)

3.4. Assembling the motor and gearbox



1 Angled mounting brackets (14)
2 Set screws M3 x 35mm (31)
3 Distance tubes (15)
4 Nuts M3 (33)
5 Electric motor 1.5-4.5 Volt (17)
6 Metal shaft (13)
7 Motor worm drive. Module 0.5 (19)
8 Double gear, module 0.5 (18)
9 Distance spacer (12)
10 Washers M4 (30)
11 3 washers M3 (34)
12 Spacer tube 5mm (Brass /16)

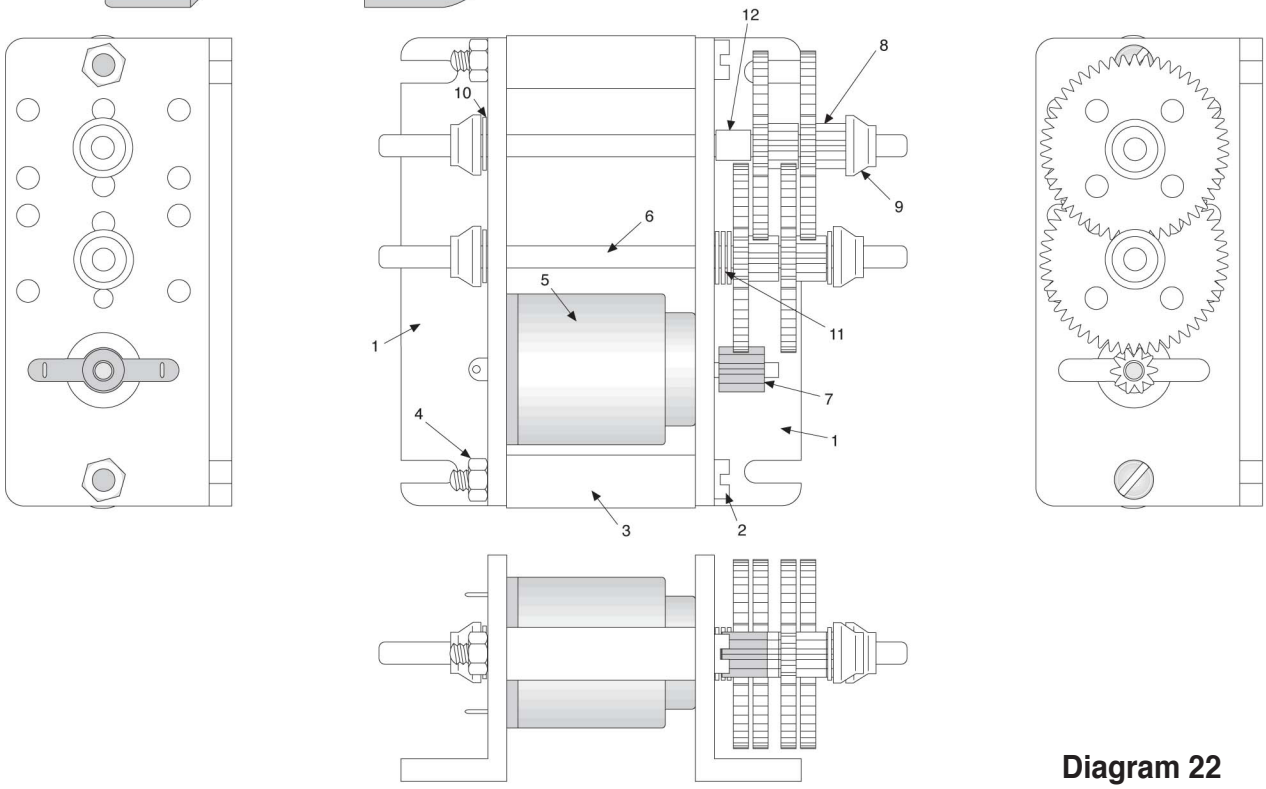


Diagram 22

3.4.1 Sit the motor (17) in between the mounting brackets (14) insert the distance tunes and fasten them with the M3 x 35mm set screws (31) and two M3 nuts (33) (diagram 24)

3.4.2 Build the remainder of the gearbox as shown in diagram 22

Firstly insert the shafts (13) and slide the two distance spacers (12) add 5 M3 washers(34) and the brass tube (16) and 4 double gears (18) on both of the shafts from the inside to the outside
The red gear is mounted last of all. Check that all the gears mesh properly.
All the white gears should be able to move freely on their shaft,
Slide the motor drive gear (19) on to the motor shaft
Only the small drive gear and the outer red gear should be tight fit on their shafts.

3.4.3 Testing

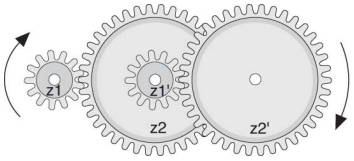
Turn the motor gear with your fingers and the second shaft should turn as the gears mesh.

3.4.4 Calculation of the gearing ratios

The difference in the number of turns of the input gear to that of the output gear in known as the gear ratio.

If we call the input gear N1 and the output gear N2 and the Ratio as R we can use the following formula to find the Ratio.

$$R = \frac{N1}{N2}$$



Gears Z1 and Z1= 13 Teeth
Z2 and Z2 = 39 Teeth

Diagram 23

If for example the out put gear turns once, whilst the input gear turns twice the ratio can be shown as follows :

$$R = \frac{N1}{N2} = \frac{2}{1} = 2$$

N1 always shows the input and N2 the output

It is also possible to calculate the ratio by using the number of gear teeth (Z1 and Z2) or the diameter of the gears (D1 and D2):

$$R = \frac{N1}{N2} = \frac{Z2}{Z1} = \frac{D2}{D1}$$

When the ratio of the gears are required to run so that the output is faster than the input, they will provide less power
When the ratio of gears are required to run so that the output is slower than the input, they will produce more power.

As the ratio influences the speed of the gears, then logically it influences the transference of power.

In short:
when the output is faster, the less the power it can transfer , and when it is slower more power can be achieved.

The degree of power is proportional to the speed of the gears. When the speed is halved
The power is doubled (Naturally the input speed must stay the same)

3.4.5 Calculating the gearbox ratios

The ratio shown in Diagram 23 is made up of two coupled geared ratios, each one with a ratio of 3:1. W
Together they multiply up to final ratio of 9:1
In diesem Fall sollte man von einem Gesamtübersetzungsverhältnis (iT) sprechen, vorausgesetzt in der Übersetzungsrechnung sind zwei oder mehr Übersetzungen.

The formula for the complete ratio is: $R = \frac{Na}{Ne}$

Where Na stands for the no. of turns of a gear (input) and Ne the no. of turns of a gear (ouput)

$$R = \frac{Z2 \times Z4 \times Z6 \times .....}{Z1 \times Z3 \times Z5 \times .....}$$

Where Z = the number of gears 1 2 3 4 .....shown.

$R = i1 \times i2 \times i3 \times i4.....$ Where i1,i2 the single ratios.

In example shown in Diagram 25 we have Z1 and Z1 = 13 Teeth and Z2 and Z2 =39

$$R = \frac{Z2}{Z1} = \frac{39}{13} = \frac{3}{1}$$

$$R = \frac{Z2'}{Z1'} = \frac{39}{13} = \frac{3}{1}$$

$$R\ Total = \frac{Z2 \times Z2'}{Z1 \times Z1'} = \frac{3 \times 3}{1 \times 1} = \frac{9}{1} = 9:1$$

Results:

Our gearbox (Diagram 26) has an arrangement where the speed is lowered but the power increased!

The ratio is as follows:

$$R = \frac{Z2 \times Z4 \times Z6 \times Z8}{Z1 \times Z3 \times Z5 \times Z7} = \frac{50 \times 50 \times 50 \times 50}{10 \times 10 \times 10 \times 10} = \frac{625}{1} = 625 : 1$$

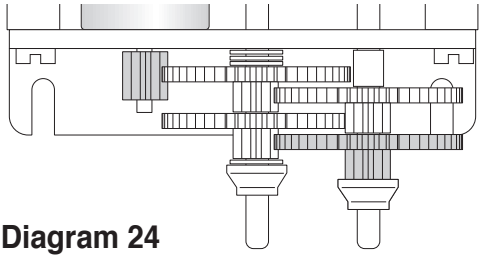


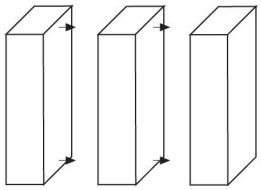
Diagram 24

3.5 Assembling the individual parts

3.5.1 Fix the motor and gearbox on the base with four screws 2.9 x 9.5mm See diagram 29 and 30

3.5.2 Fit the connector block (20) strip using two screws 2 x 12 (37) and the battery case (39) with two screws 2.9 x 9.5mm (See diagram 27 and 28)

3.5.3 The counterweight is made up from 3 blocks of wood 40 x 15 x 10mm (see step 3.2.9) glued together.
Insert 2 eye rings (35) in the counter balance weight as shown in the diagram.. Prise the eye on the side ring so that a thread can pass easily through.



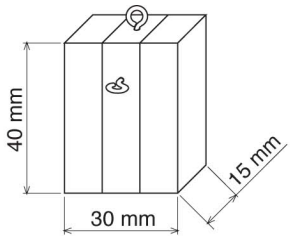


Diagram 25

3.5.4 Insert the other screw eyes (35) on the inside of the left hand support arch. See diagram 29
Take a length of thread (10) and tie tightly between the screw eyes.
This thread is the guide for the counterweight.

3.5.5 Tie a knot in the end of a 40 cm length of thread (10) and pull it through the slot in the end of the central cross member in the middle of the bridge. Pull the cord until it is tight against the spar.
Tie the other end of the thread tightly to the screw eye on the top of the counterweight.
Guide the thread over the pulley (7) on the left hand side.
Slot the guide thread through the opened eye on the side of the counter weight.
Test the system by pulling up the bridge by hand. The counter weight must not touch the floor when the bridge is open.

3.5.6 Cut a further 70cm length of thread. Again tie a large knot in the end and thread it through the other slot in the end of the middle cross member , again pull it until the knot wedges in the slot.
The other end of the thread is tied on to the end shaft on the motor and gearbox.

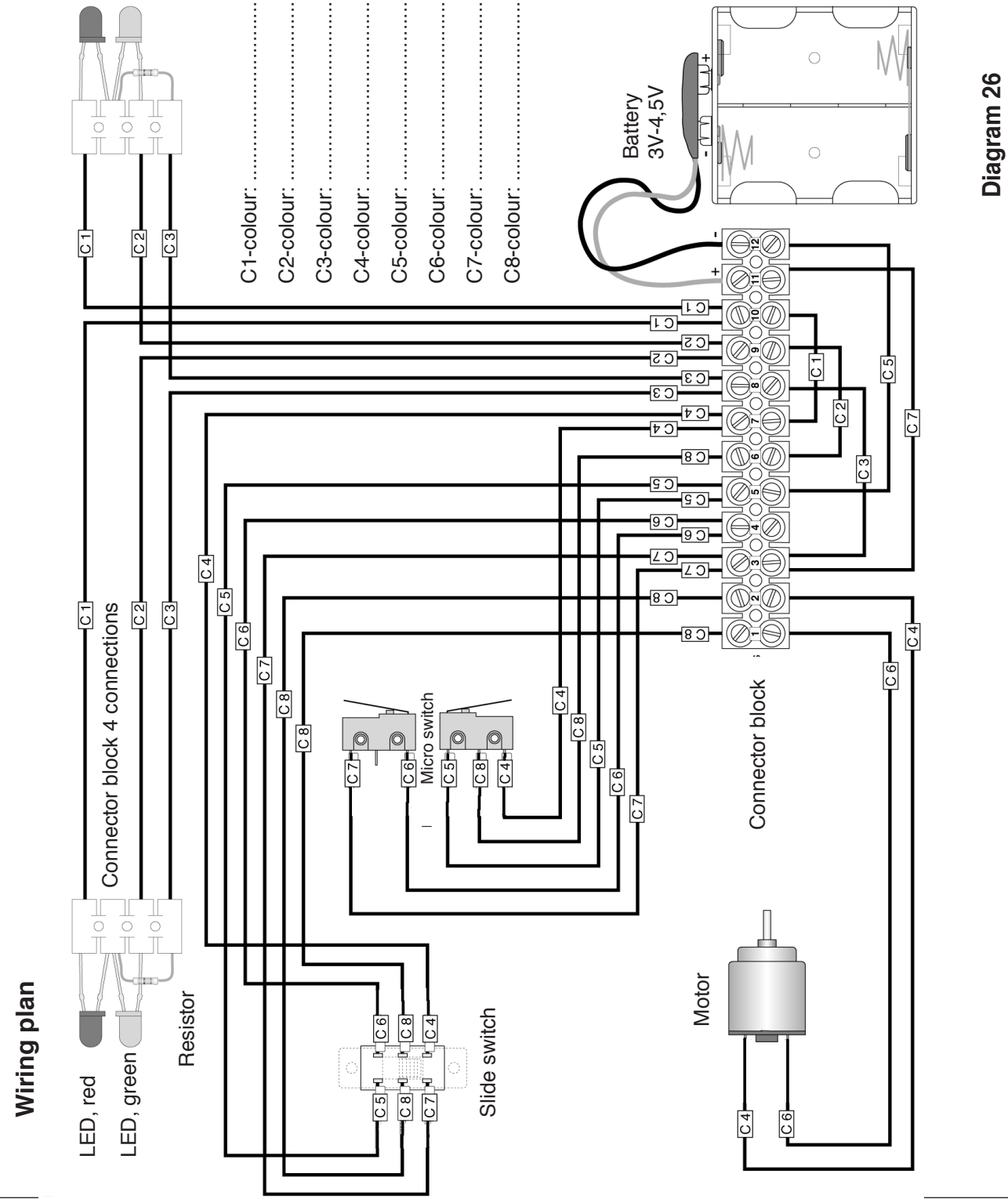
Note: The shaft on the gearbox is very smooth and to stop the thread slipping it is better to roughen it with a file (If necessary glue the knot on the shaft)

Pass the thread over the pulley (7) on the right side of the bridge arch.
Connect the motor and gearbox directly to a battery and let it run until the thread winds up tight on the shaft, without it pulling the bridge up.

3.6 The Electrical connections

The cable joints (27) for the motor, slide switch (25) and micro switches (24) must be soldered to the ends.
The ends of the cable that are inserted in the connector need to be tined with solder so that a good joint ensures
All the connections are shown in diagram26
Before you start to wire up the bridge it is best to sort out a colour code. This way any faults that may arise can be sorted out easily.
In diagrams 29 and 30 you can see all the points where the cable must be inserted.
When connecting the slide switch (25) it should be noted that the cable must not interfere with the opening of the bridge.

When the wiring is complete and the function has been checked so that everything works. They can be fixed down at intervals with a hot glue gun or PVA.



4. Function:

Clip the batteries (not in pack) in the holder and connect to the clip (40)
When the bridge is in the level position the green LED on the side of the bridge is on
And the motor must not turn.

Slide the switch to ‘on’ and the motor will turn winding up the thread on to the gearbox shaft.

When the bridge is up the barrier will lower. The green LED goes out and the red LED comes on.

When the bridge is fully open the motor will stop because the other micro switch has been activated.

The red LED comes on again and the green goes out.

If the slide switch is moved to the other position the motor turns in the opposite direction and the bridge will automatically lower again The red LED is still on and the green out.

Once the bridge has reached it horizontal position, the barrier rises again the red LED goes out and the green LED comes on again. The motor stops because the lower micro switch is off.

If the bridge does not work it is probably an electrical fault.

Check the cables once more against the wiring diagram.

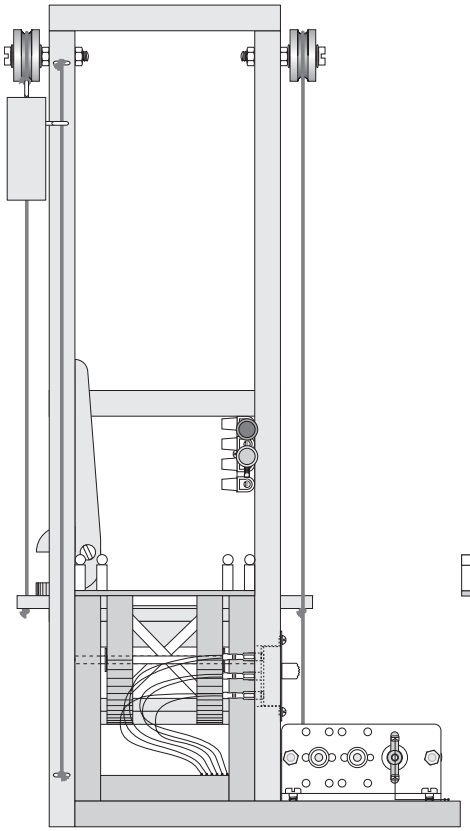
The direction of the motor can be affected if the connections are the wrong way around or the slide switch is wrongly connected (eg the connections are the wrong way around)

If the LEDS do not light check that their polarity is correct.

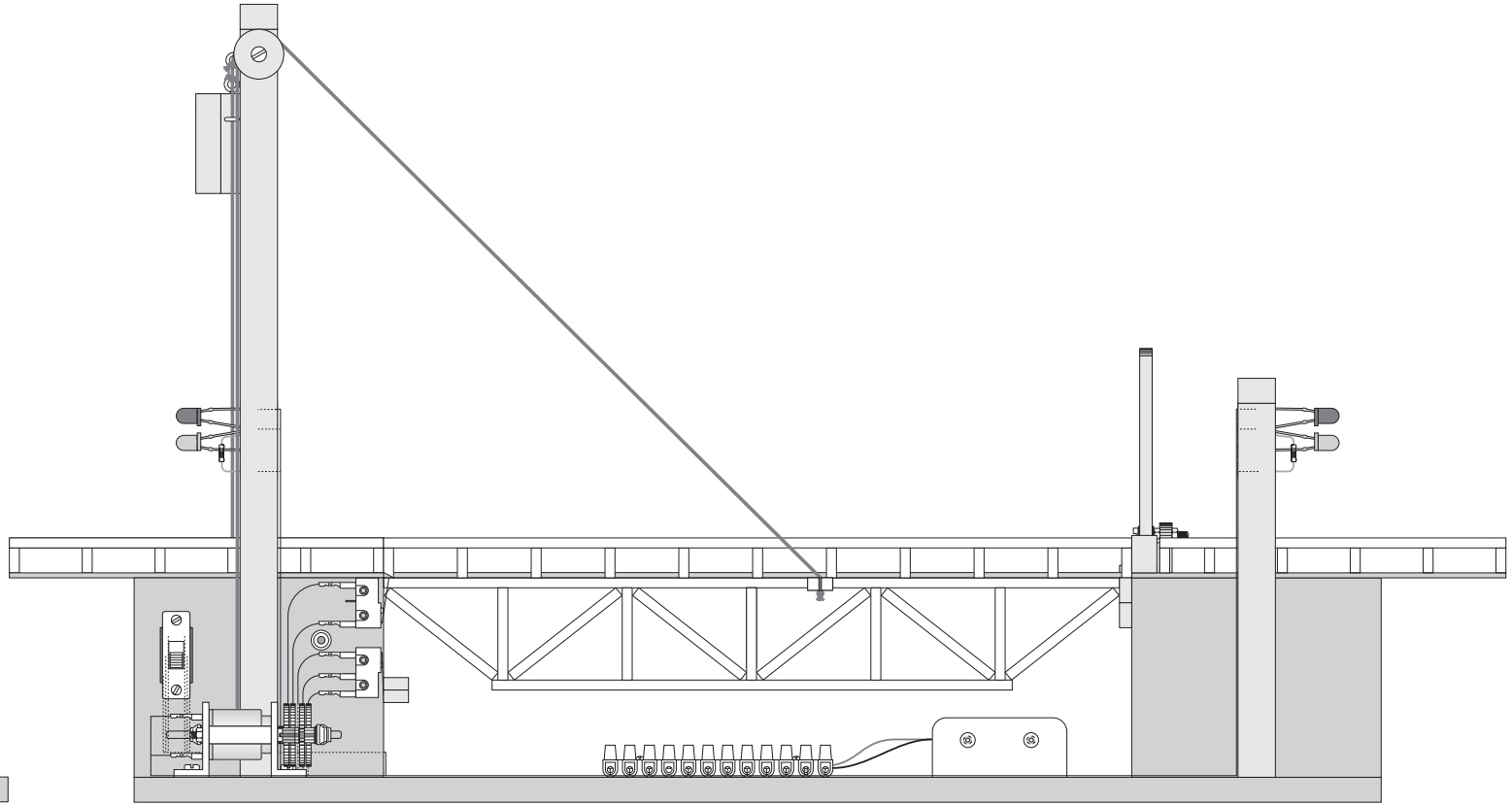
If the motor stops too early or late adjust the positions of the micro switches back or forward.

If the motor stutters or jams check that the gears run freely.

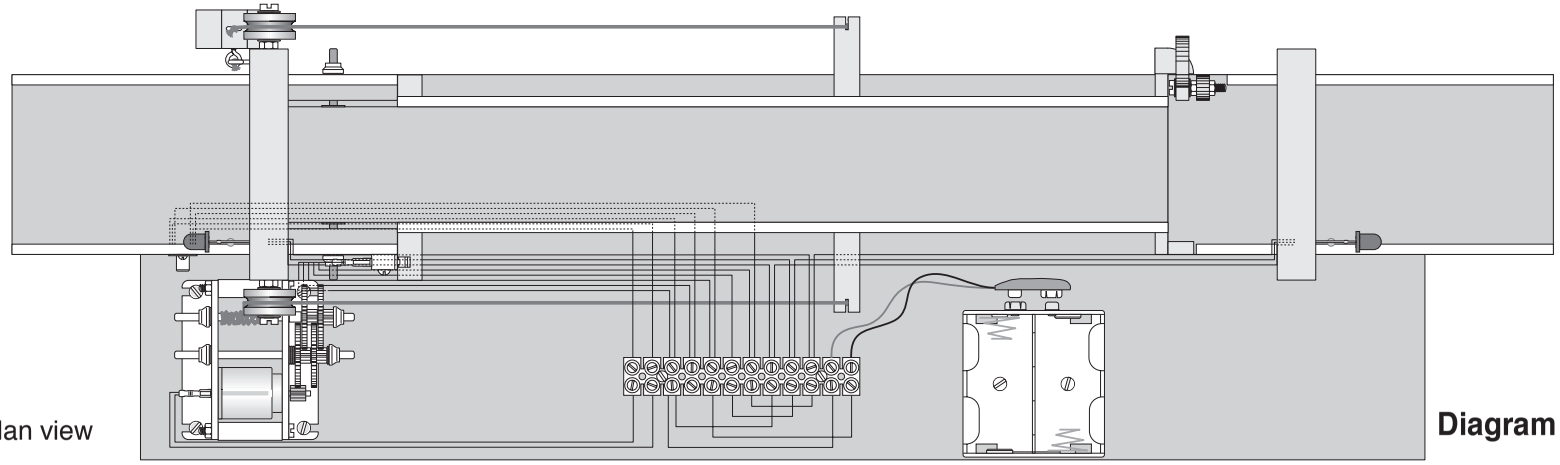
If any parts of the bridge rub or stick they can be sanded.



Side view



Front view



Plan view

Diagram 27

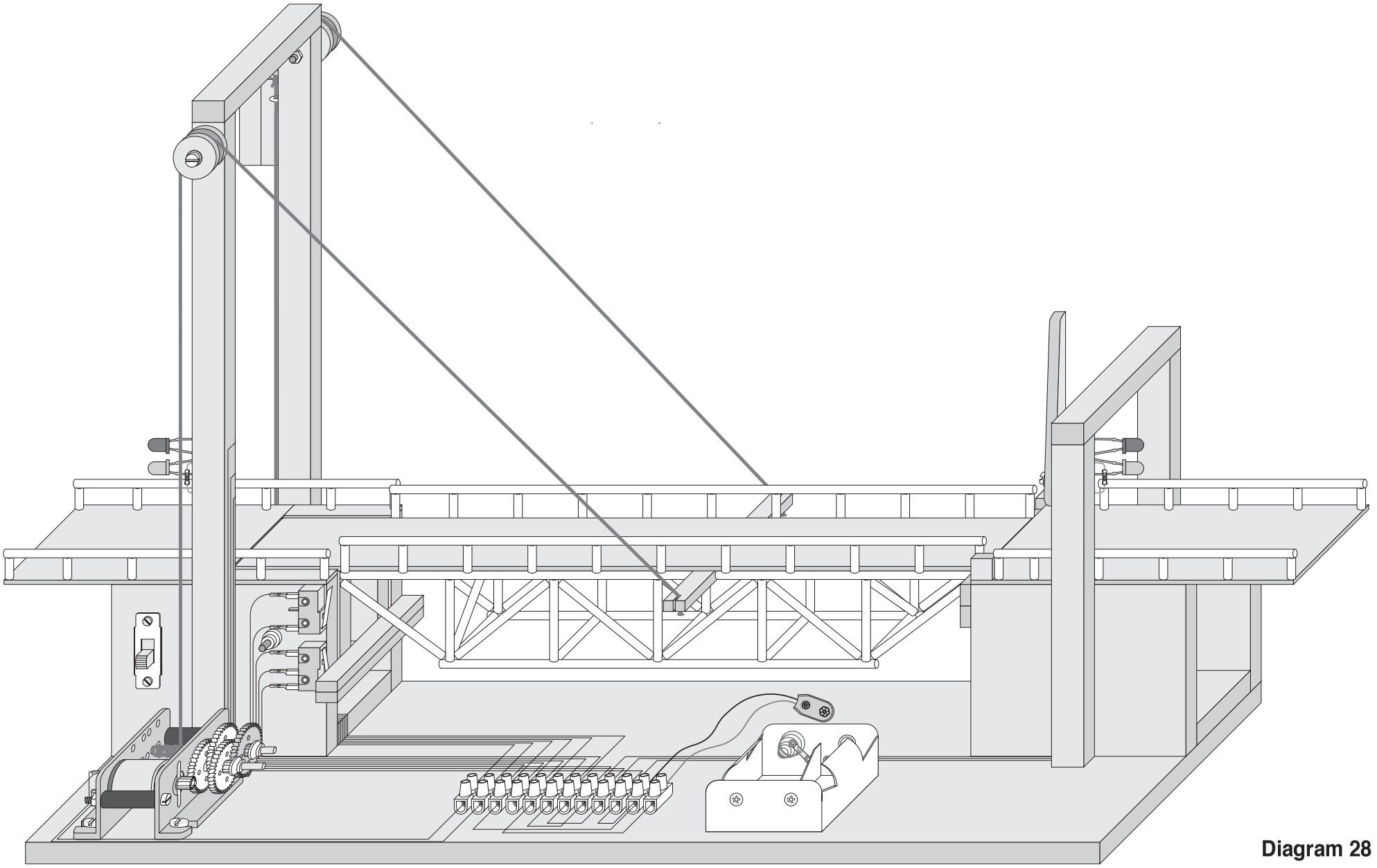


Diagram 28

Pattern

Scale 1 : 1

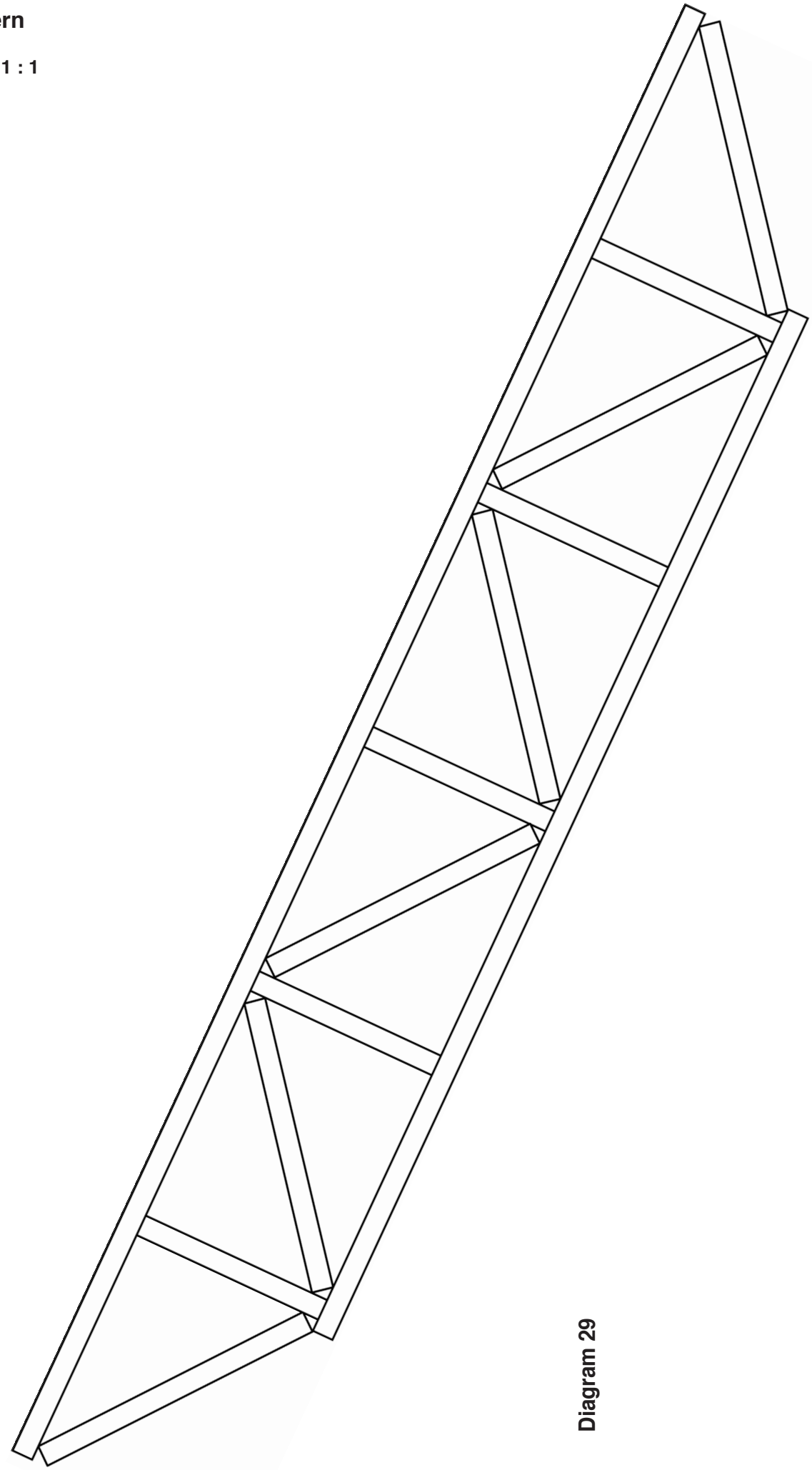


Diagram 29