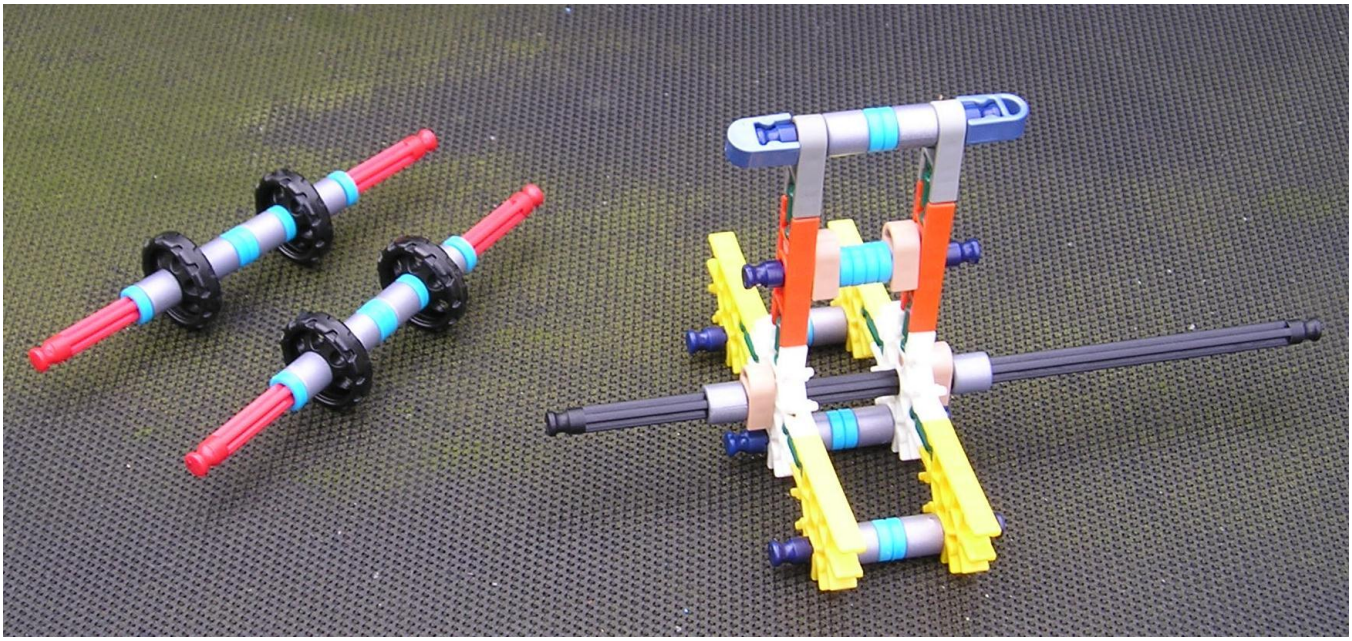
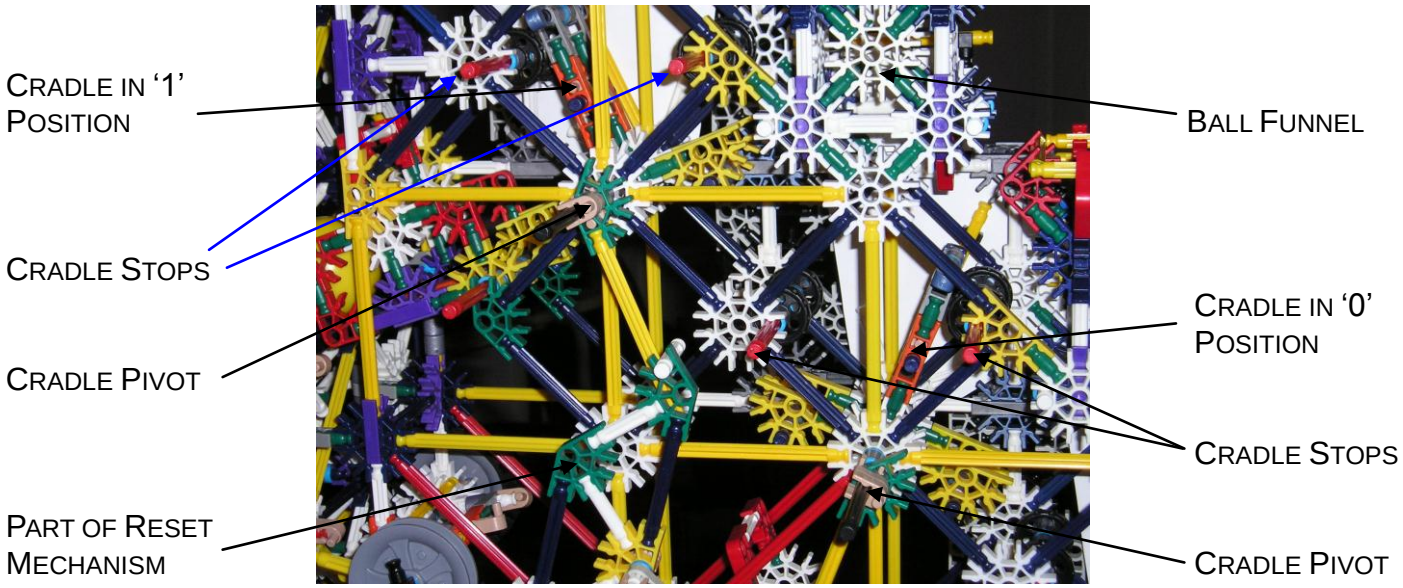
K’Nex Binary Machine

This machine can be used either as a binary counter or as a binary calculator and is worked by K’Nex balls.

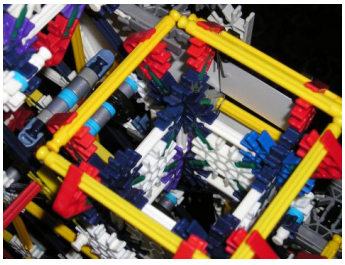
Each ball falls through a funnel into a cradle which lies in one of two positions, and in doing so flips the cradle from its current position to the other one.



ON THE RIGHT IS A CRADLE, AND ON THE LEFT ARE THE CRADLE STOPS.



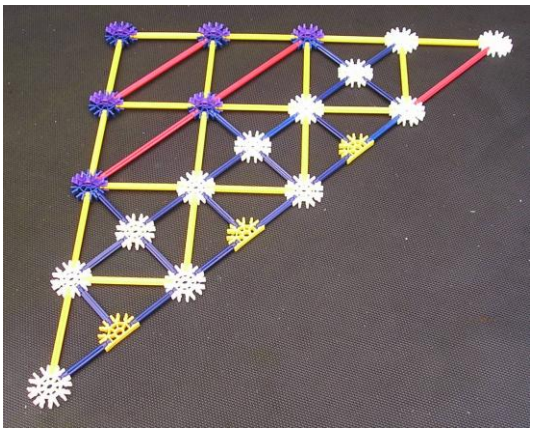
THE MACHINE WITHOUT THE BALL RELEASE MECHANISM



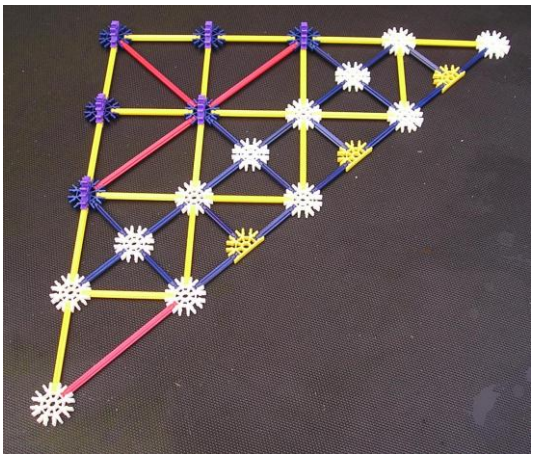
BALL FUNNEL

A Simple 2-bit Example

Here is a very simple example of a 2-bit machine:

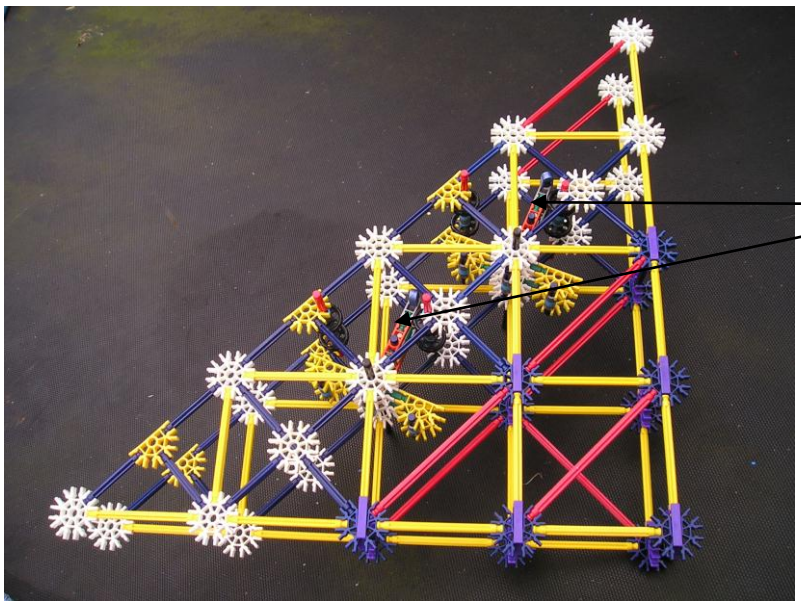


FRONT SIDE



REAR SIDE

Make the two sides above, and insert two cradles and four cradle stops so that it looks like this:

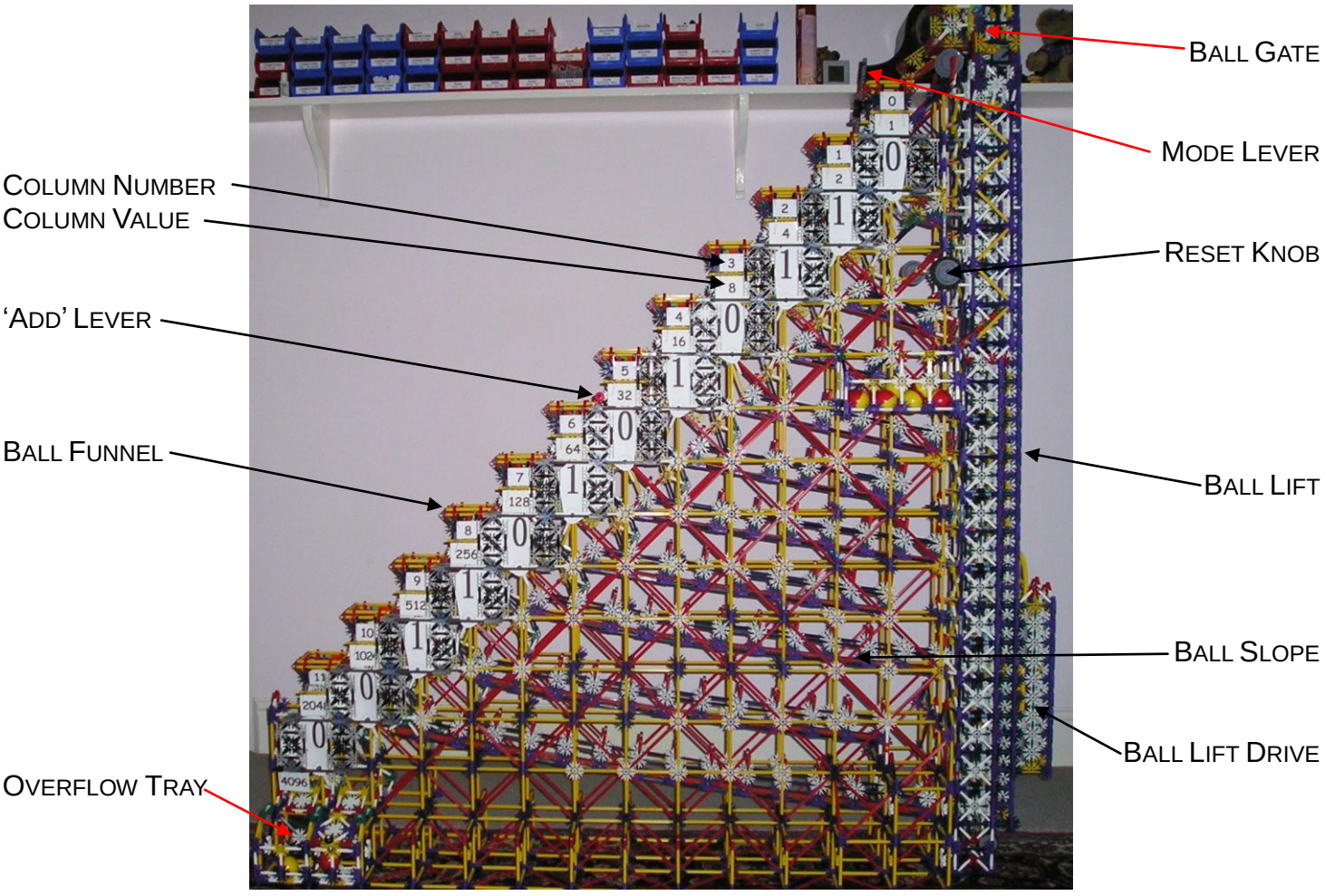


If the two cradles are set to 0, the insertion of a ball four times into the right-hand cradle with cause the machine to represent, from 00, the values 01, 10, 11 and then 00 again.

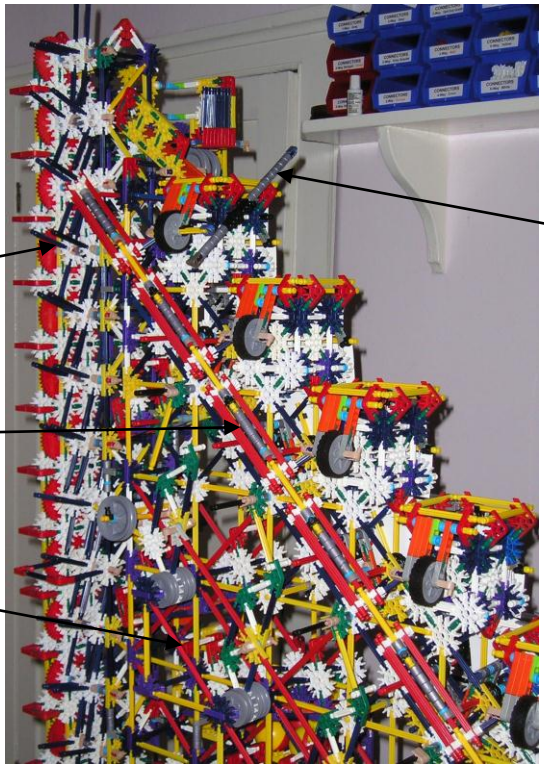
In the actual K'Nex Binary Machine, there are various embellishments:

- There are 12 columns
- There is a ball funnel over each column to make sure that the ball lands directly into a cradle
- A card has been attached to each cradle's pivot rod so that a 0 or 1 is displayed
- Fascias have been added to the front of the machine so that the other digits are hidden
- Cards have been added to each column which indicate the column number and the base-10 equivalent of a binary 1 in that column
- There is a motorised ball lift
- All inserted balls are sent to the ball lift once they leave the cradles
- There is a rest knob to return all the digits to 0
- A gate has been installed at the top of the ball lift so that either the balls get sent to the cradle in the rightmost column (for the Counting mode), or they are directed to a tray on the front of the machine so that they can be inserted manually when using the machine in Calculation mode (i.e. adding, subtracting or multiplying binary numbers)
- There is an 'Add' lever which releases all the inserted balls at the same time.

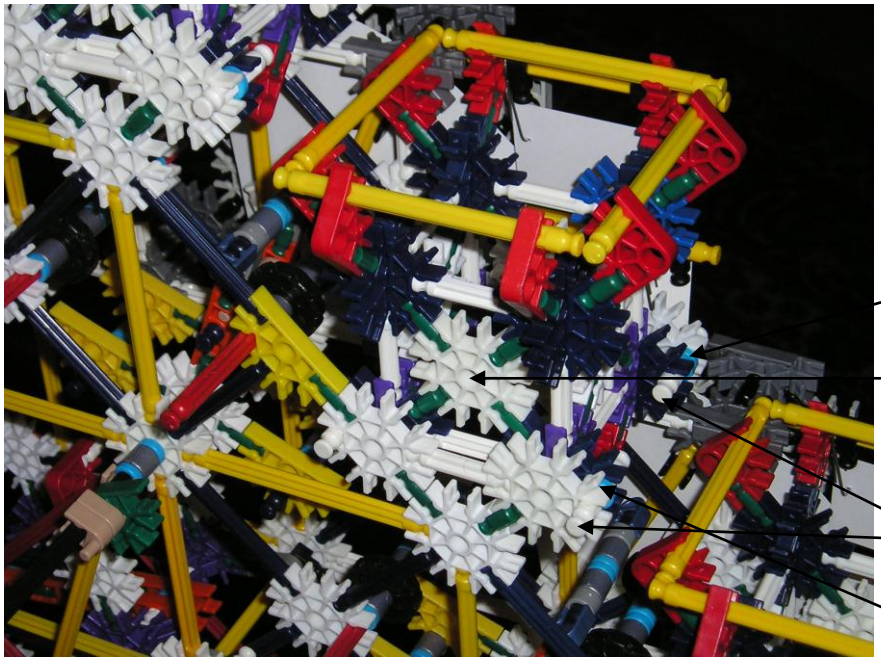
The Actual Machine



The Machine from the Front

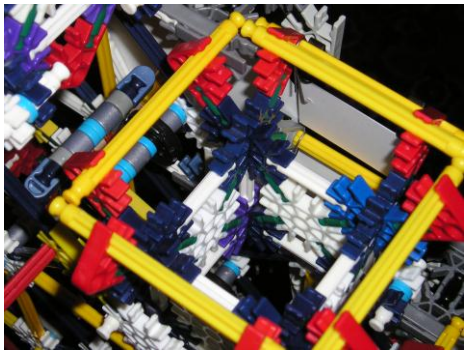


The Machine from Behind

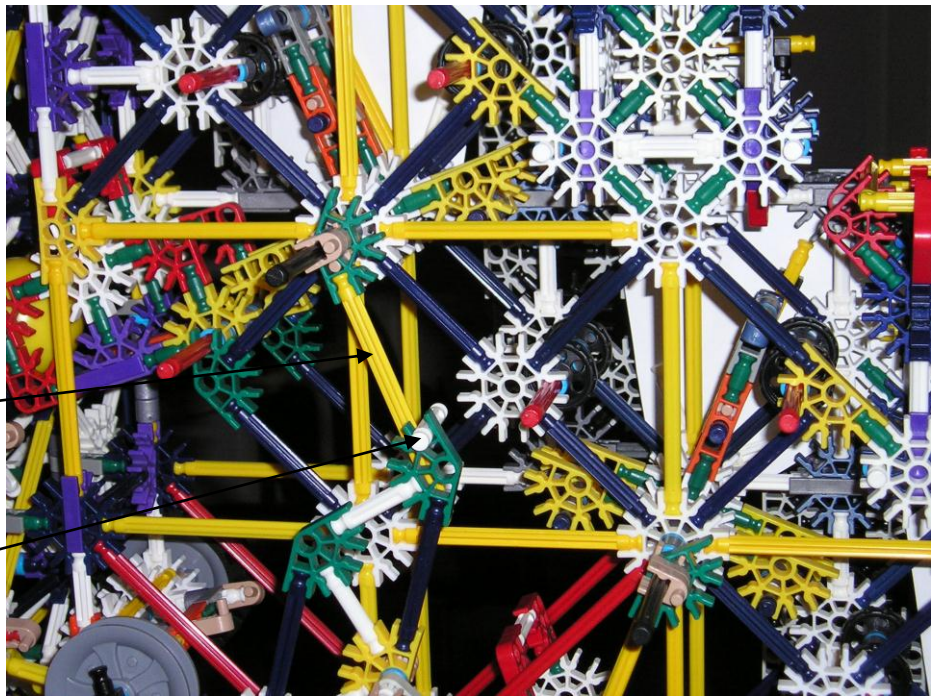


A Ball Funnel (Shown without the Ball-release Mechanism)

Note that the ball funnel's square cross-section (which is based on white rods) is necessarily just a little bit bigger than the diameter of a K'Nex ball. This makes it a bit awkward to fit between the sides of the machine (which are separated by blue rods).



A view of a ball funnel
from above



A VIEW FROM BEHIND SHOWING THE RESET MECHANISM

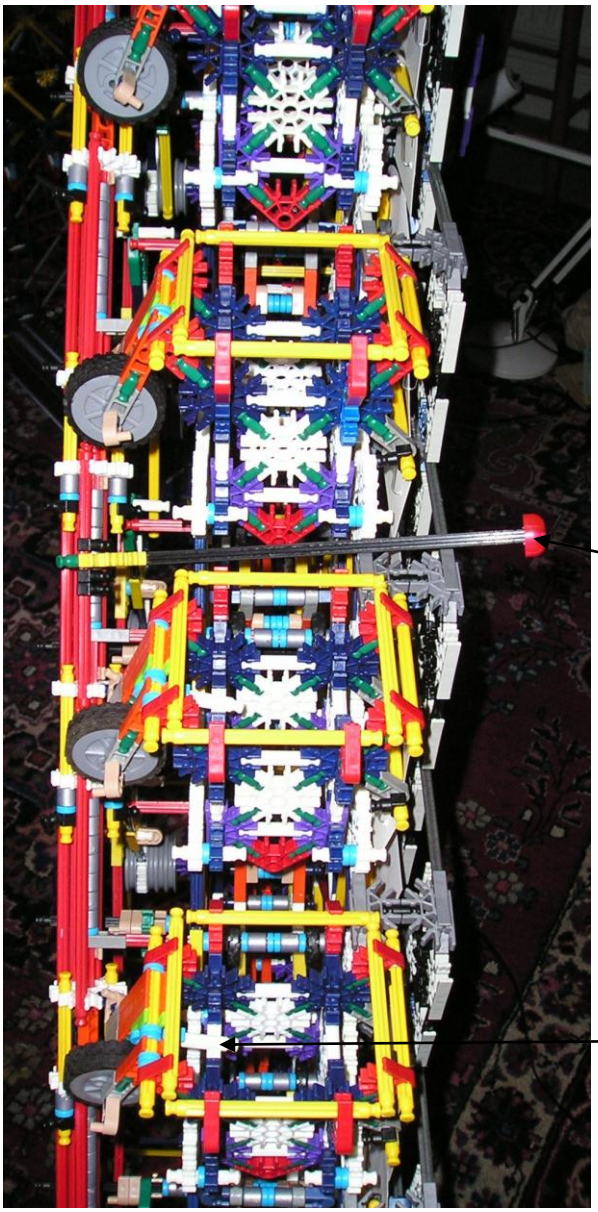
The machine has two modes: counting and calculating.

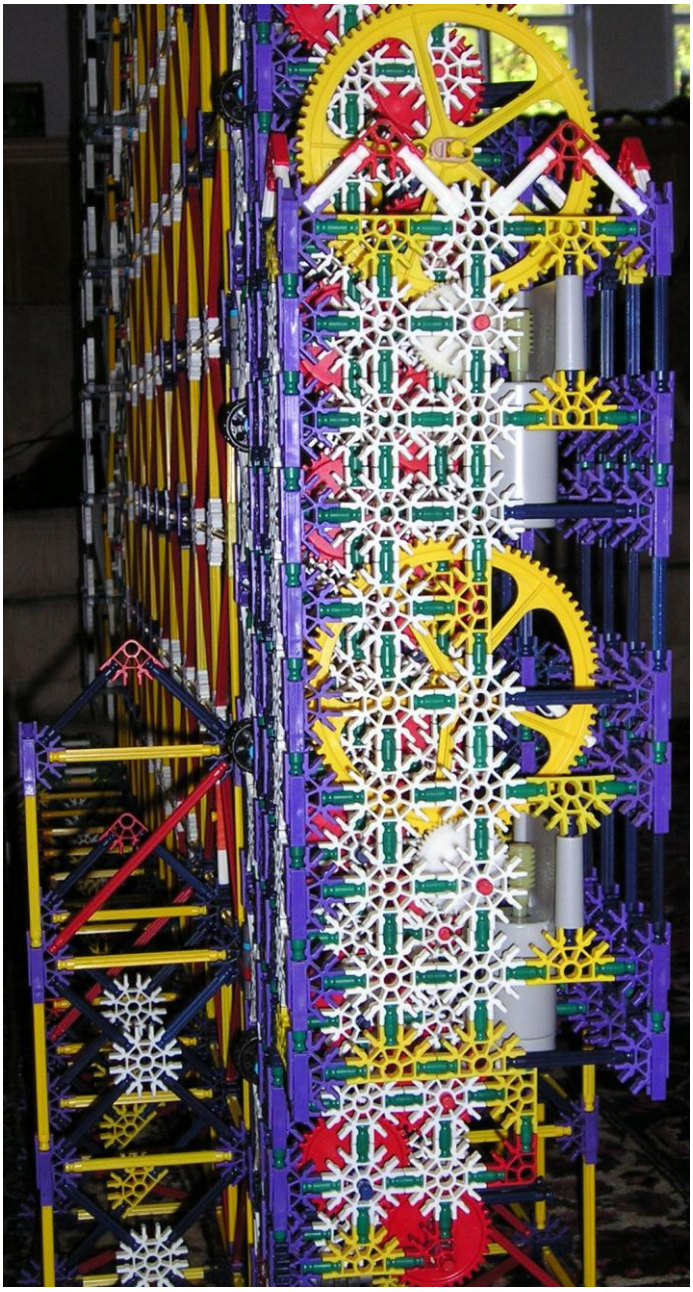
In calculating mode, when the Ball-release Lever is lifted, any balls which have been placed in the ball funnels will be released into the cradles.

All the funnel pins have to be pulled to one side at the same time. This is achieved by the construction of a very long pseudo-rod which has been built from red and yellow rods and white connectors (details are shown in the photo at the top of Page 4). When the Ball-release Lever is lifted, the pseudo-rod is rotated anti-clockwise when viewed as on the right, that action pulling the funnel pins by about 5mm – this is just enough to release the balls.

The Ball-release Lever has been installed midway between the columns in order to minimise any torsional effect.

The tyred wheels act as counter-weights, returning the funnel pins when the lever is released.





THE BALL LIFT DRIVE

The machine needs two 12-volt motors for the ball lift.

One motor on its own tends to struggle when lifting five balls, but two motors can handle 16 balls or so with no problem. The power consumption is about 6 watts. The machine can be connected to a 12-volt solar panel so that, in Counting mode, it can be used to measure the sunshine – the higher the daily count, the more the sun has shone!

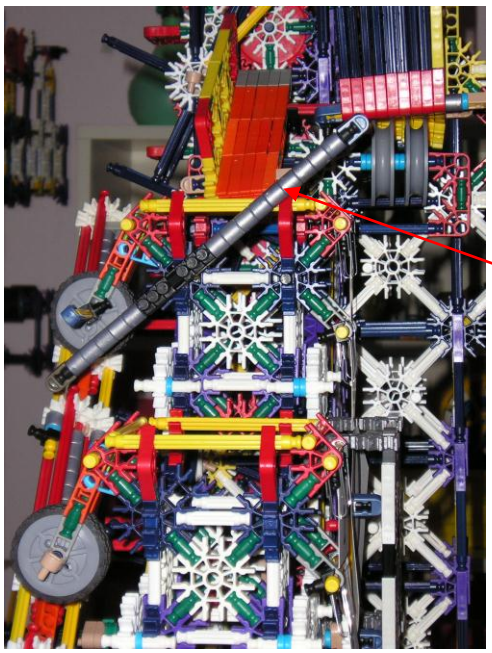
It is very important that both motors are turned on simultaneously; if only one motor is turned on either a clip will break or gears will slip.

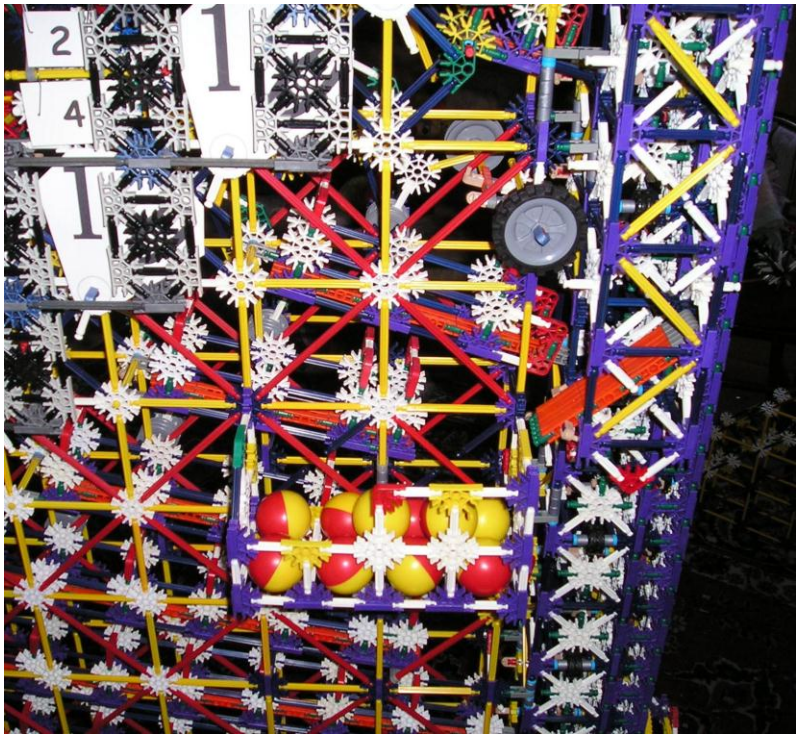
In Counting mode the maximum number of balls which can be handled is ten – more than this will result in balls jamming in the top cradle owing to the shortness of the top slope. Ten balls provide a continuous supply for the ball feed, because they queue up to get into the ball lift. However, if an overflow takes place because 4096 has been reached, there will be the odd gap in the feed.

When in Calculating mode, 16 balls should be used, otherwise the wait for them to be deposited in the ball tray can be quite long at times.

The Mode Lever is in the raised position for the Calculating mode, and lowered for the Counting mode. All that happens is that the funnel pin is pulled out for the Counting mode so that each ball from the feed can enter Column 0!

In Counting mode, the ball gate must be open so that all the balls are released from the ball lift into Column 0, and so EITHER the Mode Lever is raised and the ball gate is closed OR the Mode Lever is lowered and the ball gate is open. If the Mode Lever is raised and the ball gate is open, the balls will pile up on the top of Column 0 and end up all over the floor – there is scope for an improvement here but it's not obvious how to do it!





In Calculating mode, the ball gate is closed so that as the balls leave the top of the ball lift, they fall down a chute into the ball tray as a supply for the operator.

The chute has obstructions on the sides so that the balls wibble-wobble their way down instead of banging straight to the bottom.

There was a problem fixing the ball lift to the main machine.

The cradles are based on a frame which uses yellow rods – this was the only size which would work with K'Nex balls. However, the ball lift had to be based on blue-rod (or green-rod plus green-rod) spacings. The ball lift is therefore not attached as firmly as is desirable, and so care has to be taken when the machine is moved.

Another problem was with the ball slopes: ideally, each column would have its own ball slope so that balls joined the ball lift at 12 different levels. However, because of the incompatibility between blue-rod and yellow-rod spacings, this was not achievable. Fortunately, two yellow rods are 2 x (86mm + 20mm) = 212mm long (the 20mm allows for the connectors), and three blue rods are 3 x (55mm + 20mm) = 225mm long, and these were close enough to enable two ball slopes to correspond to three ball-lifters, the slight stagger not being a problem.