Some Thoughts on

Switch

Management

or

How much can a small brick do?

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1 The half-a-pair-realignment — a basic technique

If you are reading this essay, then you hopefully already know the basics of the *switch* element in the game of Bricks. A square with a switch can be either *open* or *closed*. Other bricks are free to move on top of an open switch, but a closed switch hinders the movement of any brick. The key feature is that the states of the switches can be toggled from open to close and back. Such toggling happens, whenever a brick moves away from a previously covered open switch exposing it to open air. This toggling affects ALL the switches of a level simultaneously with the important exception that the state of open switches covered by any brick will not get toggled. This behavior really explains the name 'switch', and gives the element its unique charming character. Hovers interact with switches somewhat differently from all the other bricks. A hover covering an open switch will 'protect' that switch from being toggled, but moving a hover away from an open switch will not trigger the universal toggle. This is similar to the way hovers work together with e.g. traps.

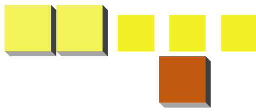


Figure 1: A single 1x1 brick next to a bank of five switches, two closed and three open

Exercise 1. *Is it ever possible that all the switches in a Bricks level are simultaneously open? I can think of only two situations, when this might happen. What about you?*

We often face the problem that while the switches do allow us to get started in our master plan of moving certain bricks around, our progress is stalled at some point, because a switch has been toggled to block all further motion. An option occurring to beginners at that point is to make anothermove for the sole purpose of toggling the switches, and then continue moving the other brick. This approach has the advantage of simplicity, but it wastes moves. Ideally we would like to *align* the switches in advance, if at all possible, because then we may achieve our objective with less moves. The price we have to pay is the need to plan ahead. As the optimization of most Bricks levels requires such planning anyway, this should not deter us.

But how to effectively realign the states of the switches? Assume that we want to realign a single switch S, i.e. change its status with respect to the other switches, and that we have access to both open and closed switches. Again the beginner's approach of

1. occupying switch S with a brick,
2. toggling the remaining switches by temporarily occupying an open switch and immediately releasing it,
3. revacating S by e.g. undoing the move of step 1,
4. toggling the states of all the switches by repeating step 2,

has the disadvantage of taking as many as four moves. Ok, it usually takes only three moves as steps 3 and 4 can often be combined, but even that may be too many. Ideally we would like to get away with just one move. The point I want to emphasize in this essay is that sometimes we can! Even more importantly, we can do it in such a way that we can continue, and realign another switch with the same move. As we shall see, it is sometimes possible to realign a bank of switches in almost any which way we want with an intelligently designed single move. This results, of course, in impressive savings in the number of moves needed to solve the level.

Below you will see several diagrams of switches. For the purposes of simplifying the diagrams I leave out the other parts of the playing area, so for example you must imagine that the solution of going around the switches is not available. In most diagrams there will be a single 1×1-brick that will do most of the work. I will describe its motion compactly with hopefully self-explanatory notation such as ↑→↓ denoting a move, where that brick first goes up one step, then one step to the right, and then one step down.

The key building block throughout this text is the sequence of steps that might be called half-a-pair-reversal. This tactic requires that there are two adjacent open switches, both accessible from the side of the playing area, where our 1×1-brick resides in. The steps taken are the following:

1. occupy the first open switch with the 1×1,
2. continue its motion to the other open switch,
3. revacate that other switch (usually returning to the same side that we left from, but sometimes we prefer to cross to the other side).

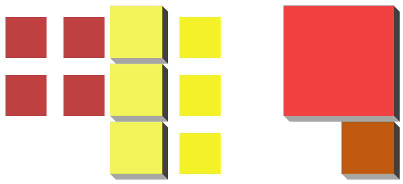
Here there were two steps, when an open switch was vacated, so all the other switches have been toggled twice, and thus they have returned to their original status. The same applies to the first member of the adjacent pair. But the latter half of the pair was covered by the moving 1×1-brick during the first toggle, so its status has changed only once. Thus that switch has been realigned with respect to the other switches. Starting from the position of Figure 1 we can do two such reversals: we can either do (up, right, down) to realign the rightmost switch, or (up, left, down) to realign the center switch.

Figure 2: From the position of Figure 1 the steps ↑←↓ realign the center switch (left), and the steps ↑→↓ realign the rightmost switch (right).

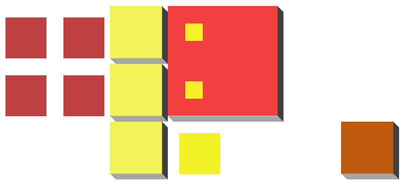
Ok, so it is nice that we can decide, for example, whether in the example bank of 5 adjacent switches the three leftmost or the three rightmost switches are aligned. But what if we need to move a brick of width four through this set of switches? Can we cater for that as well? Yes! That is easy. Again starting from the position of Figure 1 we first toggle everything, and then do half-a-pair-reversal to realign the second switch from the left. This gives us four adjacent closed switches as shown in the right half of Figure 3. Toggling everything again gives us the desired alignment of four adjacent open switches.

Figure 3: From the position of Figure 1 the steps ↑↓ toggle everything (left), and the steps ←←←↑→↓ realign the second switch from the left (right).

Example 1. *Let us see how a beginner might (?) bring the master brick (I color masterbricks red) to the destination using three moves, and how the same can be achieved in two moves by doing two half-a-pair-reversals.*



Solution. A most natural thing for a beginner to do would be to simply bring the master bricks as far to the left as it can, as seen in the following figure.



At this point the master will call its 1×1 servant for help, asking for it to hit the remaining open switch in order to toggle the status of the two closed switches blocking the route to destination. The first move was done by the master, the second by the small brick, and the last by the master gloriously moving to its target. A total of three moves.

A player who has mastered the technique of half-a-pair-reversals might go about this differently, letting the servant first prepare the road for the master. We begin by realigning the topmost open switch — pairing it up with the one below it. After that we can then realign the switch in the middle by pairing it up with the bottom open switch. Then to finish off we toggle the entire scene using the remaining open switch, and the servant brick can rest after a job well done. Most importantly all this realigning can be done with a single move. The exact sequence of steps is given in Figure 4.

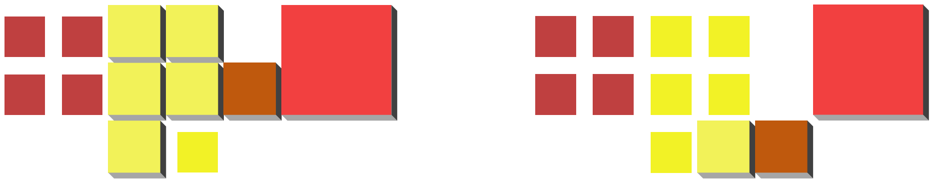


Figure 4: A double realignment sequence of ←←↑←↑→↓↓←↑→ leaves the position on the left diagram. Toggling everything with ↓←→ then leaves a clear path for the master.

Two remarks are in order. When doing multiple half-a-pair-reversals it is important to do the realingments in the correct order. Here it was absolutely essential to first realign the topmost switch. If we first carried out the steps realigning the center switch, then the center switch could no longer be used as the other half of the pair of open switches needed to realign the topmost switch. The other remark is that good Bricks-players are never satisfied. In fact:

Exercise 2. *Using the technique of half-a-pair-reversals we saw how the problem in the previous example could be solved in two moves. How do you solve it in a single move?*

The preceding remark can be generalized. We can realign several switches with a single move as long as we process the switches in the correct order. In Figure 5 I show the sequence of steps the faithful 1×1-brick needs to follow to realign the three top switches in a vertical bank of four. Only a single move is needed.

Also observe that by doing three half-a-pair-reversals realiging the topmost switches, instead of realigning the bottom switch and then toggling everything, may be the preferred way of going about it. In practical play there are often other switches elsewhere, and we may not want to toggle their states.

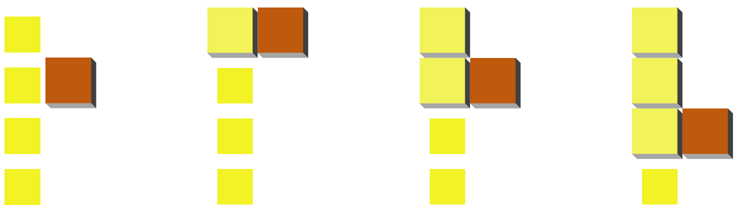
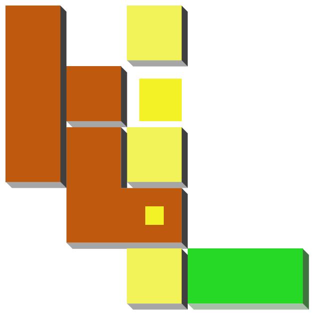


Figure 5: A triple realignment move with sequences ←↑→, ↓↓←↑→, and ↓↓←↑→.

2 Managing a linear bank of switches

A recurring theme in recent levels designed by various authors has been the need to create space by moving several bricks thru a linear bank of switches. After moving a brick or two, the alignment often becomes hopelessly garbled, and the task at hand is to realign the bank as smoothly as possible. The following example is from the middle of a level, hopefully scrambled enough not to be immediately recognizable.

Example 2. *How do you efficiently move the tall 1×3 brick to the area East of the bank of switches? You are also determined not to bring the L-shaped tromino over to that side.*



Solution. A natural first move is to toggle by bringing that 1×1 through the open switch, so that we can then move the tromino further down. The key question is: where do we leave the tiny brick? It turns out to be crucial to bring it to rest on top of the topmost switch (that becomes open, after the 1×1 has moved through the only currently open switch). The position before and after this first move is shown in Figure 6.

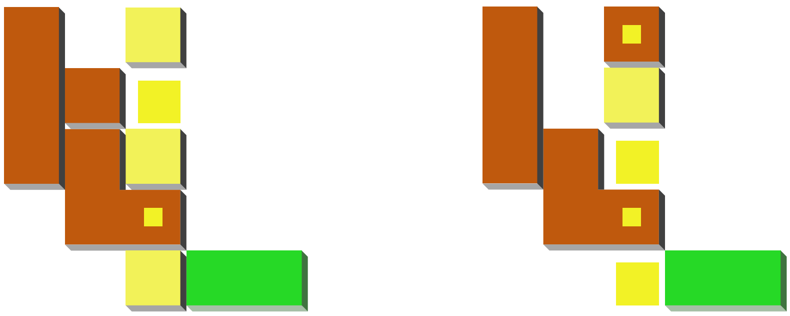


Figure 6: Moving the 1×1-brick $\rightarrow\rightarrow\uparrow\leftarrow$

We can now move the tromino down one step (=move number two), and then continue with the 1×1 by moving it one step to the right. We shall continue working with the 1×1, but let's take a look at the position now, see Figure 7.
We have already managed to clean up the vertical bank of switches a bit. The four switches not covered by the L-brick now form two pairs of identically aligned adjacent switches. The position is ripe for half-a-pair-reversal. So we finish move three by first reversing the alignment of the third switch from the top, and then toggling everything. As seen in Figure 8, the path is now clear for the tall 1×3 to come through in move 4.

What should we learn from this example? We can in a way measure the level of disorganization in a linear bank of switches by counting the number of groups of switches. The

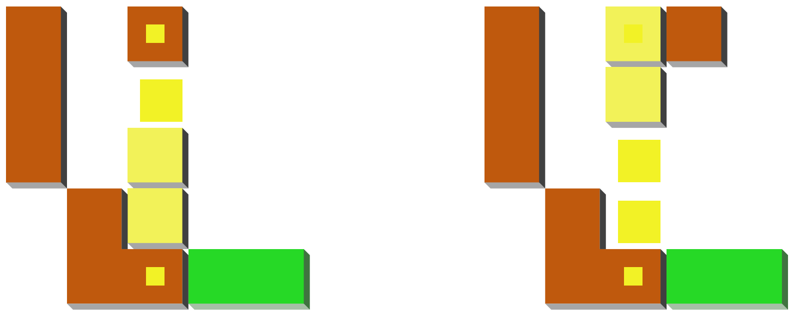


Figure 7: Moving the tromino down one step (left diagram) and the 1×1 one step to the right (right diagram)

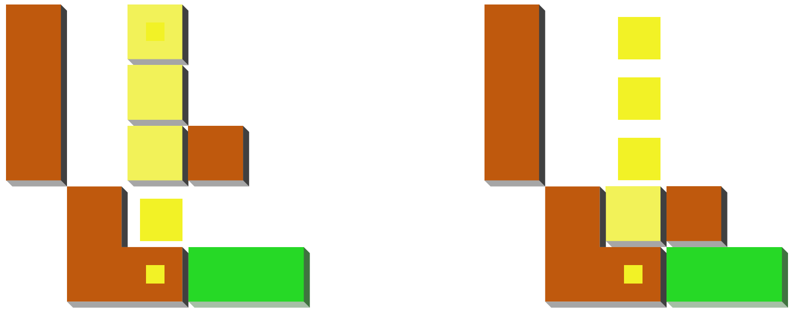


Figure 8: Moving the 1×1 first ↓↓↓←↑→ (left diagram) and then ↓←→ (right diagram).

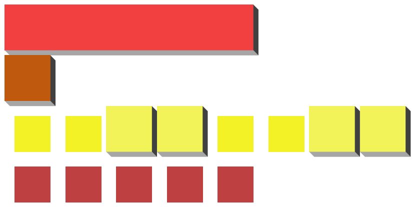
idea is that *adjacent identically aligned switches* count as a single *group*. So in the beginning of the previous example there were three groups, each group containing a single switch. But in the position on the right half of Figure 7 the number of groups was down to two, what we viewed as an improvement.

Half-a-pair-reversals will change the sizes of groups. If a group has at least two switches, we can realign the switch at either end of the group. Consequently that realigned switch will join in the neighboring group. The net effect is that one group grows by one, and the other shrinks by one, but the number of groups stays the same. An exception is formed by the switch at the end of a bank. See the right half of Figure 2 for an example of this. We see that by realigning a switch that was not connected to a neighboring group, the number of groups increased by one. Of course, if we realign a switch in the middle of a group of three or more, the number of groups will increase by two. As a summary we can state that a sequence of half-a-pair-reversals can increase the number of groups, but cannot bring it down. We need to use the beginner's "cover-and-toggle" technique to cut down the number of groups.

MAXIM: Keeping the number of groups in a bank of switches as low as possible is usually to your advantage.

Let me illustrate these principles with the following example.

Example 3. *Bring the master in this diagram through the switches to its destination in two moves.*



Solution. We see that the bank of switches has 4 groups, sized $2+2+2+2$. We shall step-by-step increase the size of the leftmost group to 5. Because we want to do it in a single move, we cannot bring the number of groups down from 4. Therefore we are aiming at groups sized $5+1+1+1$.

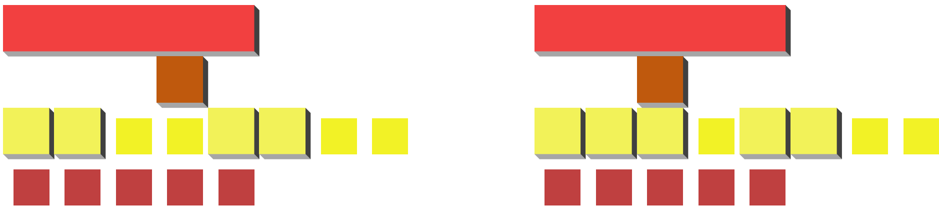


Figure 9: Moving the 1×1 first ↓↑→→→ (left diagram) and then ↓←↑ (right diagram).

The first step is to increase the size of the leftmost group to three. So we toggle everything, and then realign the left switch of the second group (the third switch from the left). The steps of the 1×1 and the new position are shown in Figure 9.

In order to get the fourth switch from the left to join in the first group, we must increase the size of the second group. This can sensibly be achieved only by stealing a switch from the third group. We first need to toggle everything. The steps are shown in Figure 10.

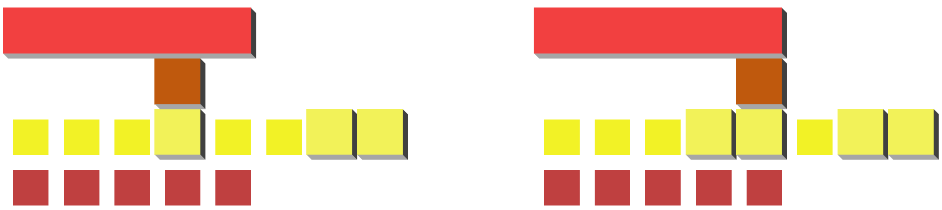


Figure 10: Moving the 1×1 first →↓↑ (left diagram) and then →→↓←↑ (right diagram).

At this point we can make the fourth switch from the left to join in the first group. First toggle, and then half-a-pair-reversal in the second group.

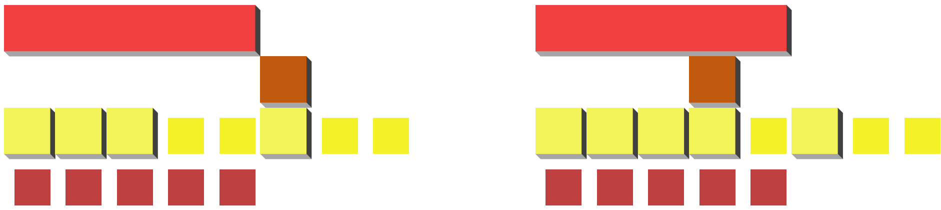


Figure 11: Moving the 1×1 first $\rightarrow\downarrow\uparrow$ (left diagram) and then $\leftarrow\downarrow\leftarrow\uparrow$ (right diagram).

Next we want to repeat the dose and increase the size of the second group. To be able to do that we first need to increase the size of the third group at the expense of the last group.

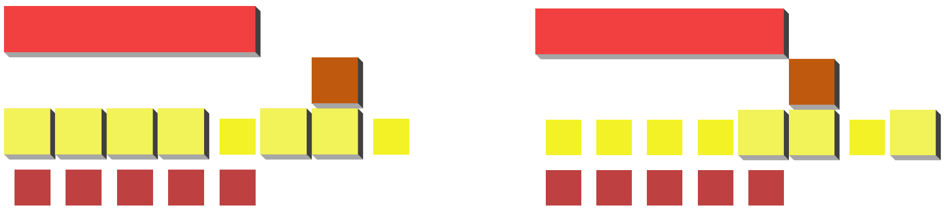


Figure 12: Moving the 1×1 first $\rightarrow\rightarrow\rightarrow\downarrow\leftarrow\uparrow$ (left diagram) and then $\rightarrow\downarrow\uparrow\leftarrow\downarrow\leftarrow\uparrow$ (right diagram).

We are then finally well placed to join the fifth switch to the leftmost group, and finish off by toggling everything.

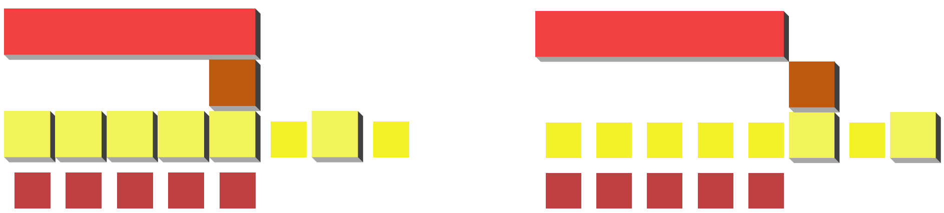
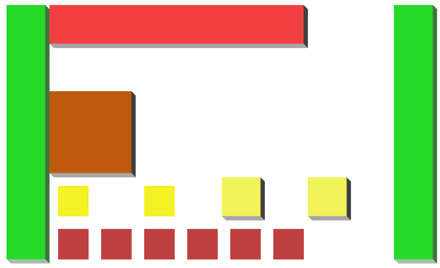


Figure 13: Moving the 1×1 first $\rightarrow\downarrow\uparrow\leftarrow\downarrow\leftarrow\uparrow$ (left diagram) and then $\rightarrow\downarrow\uparrow$ (right diagram).

Exercise 3. *Reverse the sequence of the previous example. In other words, assume that you for some strange reason want to realign the bank of the right half of Figure 13 to look like the left half of Figure 9.*

Exercise 4. *How do you bring the master to its destination in two moves starting from the following position?*



3 Negotiating the bends

In the previous section the switches formed a linear bank - all the switches were on a single line, and we had access to any one of them. In this section I will discuss how the same principles can be applied to a curved line of switches, see Figure 14 for an example. Again, half-a-pair-reversals are the basic tactic. Another key similarity is that we want to keep an eye on the number of groups of switches. When working with a single 1×1-brick, we still cannot decrease the number of groups, so we need to be careful about creating new ones.

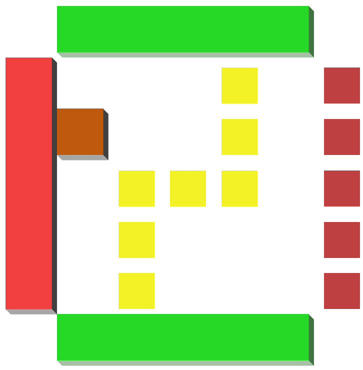


Figure 14: A curved bank of switches. Task: move the master through the switches in two moves.

A key difference is that the bends limit our access to some of the switches. For example, we cannot access the switch at the Eastern bend in Figure 14 from the West side, nor can we access the switch at the Western bend from the East. Using these switches as member of a realigning pair is thus somewhat limited.

Another new element brought along with the bends is that we need to plan the target alignment carefully. This is because moving the master along the intended path will result in switches being released, and this will result in a universal toggle. In actual play, this problem can be solved either by thinking it through, or by following the good ole 'trial and error' -method: Move the brick until you encounter a position, where a misaligned switch blocks the forward motion. Revert the move and correct the alignment for the next attempt. Rinse. Repeat.

Anyway, starting from the position of Figure 14 it is relatively easy to figure out that the alignment in Figure 15 will do. When the master leaves the leftmost switches, the rightmost switches will be toggled. Therefore we must have reverted those three switches on the right, so that a universal toggle will open them. Try it, if you don't see it right away!

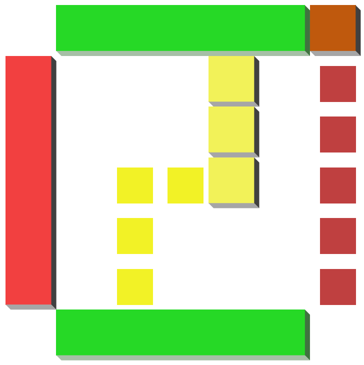


Figure 15: An alignment that allows us to move the master throught the bank in a single move.

So how do we do it? We can begin as we would with a linear bank, and realign the topmost switch. Using the switch just below as the former half of an open pair. But in order to continue we need to be on the Eastern side, so we also use this opportunity to cross over. The resulting position is shown in Figure 16.

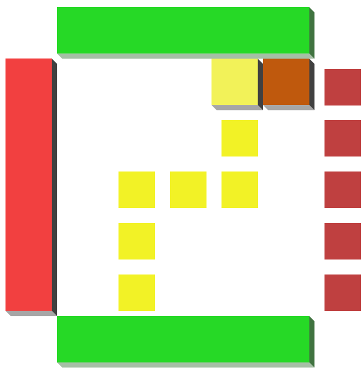


Figure 16: One half-a-pair reversal: →→→↑→

From the Eastern side we have no problems realigning the other two switches on the right. The second from the top uses the switch below it as the first half of a pair, and that switch is paired up with the switch to its left. For the steps and the positions see Figure 17.

We can now complete the first move by getting the 1×1 out of the way, and then let the masterbrick come home.

A word of warning. While crossing from West to East (or back) take care that you don't leave yourself in a position, where all the switches you can access are closed. That is too

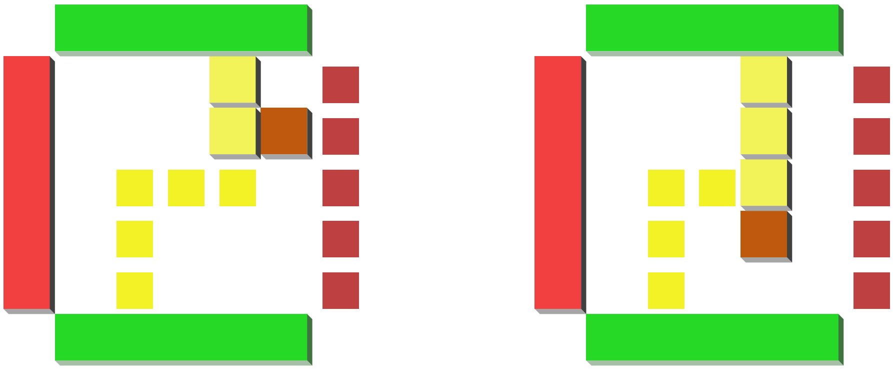
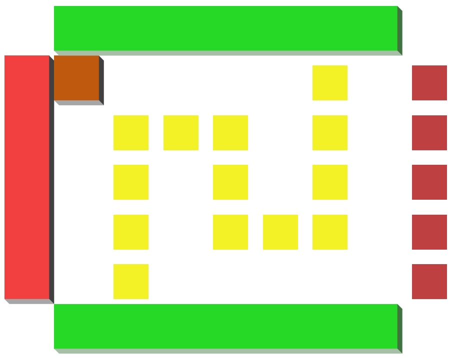


Figure 17: ↓↓←↑→ realigns the second switch from the top and then ↓↓←←↑→↓ realigns the the third switch.

embarrassing a fate for words. In the above example it was essential to do a half-a-pair-realignment while crossing, because that left us with plenty of open switches to choose from. If we had simply plowed through the bank, we would have had no open switches to toggle.

Exercise 5. *Negotiate the bends, and bring the master to its destination in two moves starting from the following position!*



4 Circular banks of switches

In this section I will discuss how the same principles can be applied to a *circular bank* of switches, see Figure 18 for an example. Half-a-pair-reversals are again the basic tactic.

A difference to a linear bank is that a circular one will not have switches at the ends. Therefore any one of the switches can be either member in half-a-pair-reversal. This is to our advantage, because it gives us more options. As in the case of bent banks of switched we face the problems of limited access to some of the switches, and the need to determine a useful alignment before we begin. In our example case it is relatively easy to figure out that the alignment depicted in Figure 19 will do. When the top and bottom parts of the master

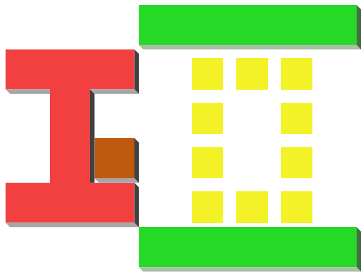


Figure 18: A circular bank of switches. Task: move the master through the switches in two moves.

fully cover the respective parts of the O-shaped bank, the mid-section of the I-brick will have just vacated the two switches on the left. Therefore we must have reverted the alignment of the two switches on the right in advance, so that a universal toggle will open them.

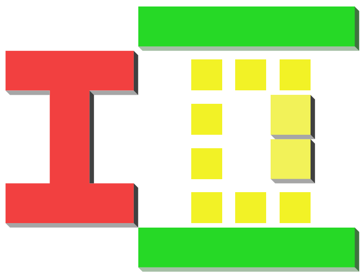


Figure 19: An alignment that allows us to move the master throught the bank in a single move.

Ok, so now that we know what we want, the real work may begin. The first thing that we record is that the number of groups in the desired configuration of Figure 19 is two. This is bad news in the sense that we must be conscious about not creating many new groups. But we must create one right away! Why? We need to move our workhorse to the other side of the O-bank, but if we just try to plow through, we will embarrassingly get stuck inside the ring without access to an open switch for toggling. So we have to enter the ring by means of a half-a-pair-reversal. We then later need to "rotate" the newly created group to the correct place. Sounds difficult? May be, but if we want to achieve our goal in two moves, this is the only way!

So let's begin our work with a half-a-pair-reversal involving the two leftmost switches at the bottom. This manouver brings the 1×1 inside the ring. The position is shown in the left half of Figure 20. We want to continue to the other side. As we must not create any more groups, the only half-a-pair-reversal we can do next is the one involving the two lowest switches on the righ vertical part of the O. After all this we have crossed to the other side, and have also created a second group of size two. See the right half of Figure 20.

The general approach is that we want the small group of two switches to grow in one direction and shrink in the other. A single half-a-pair-reversal involving the two middle

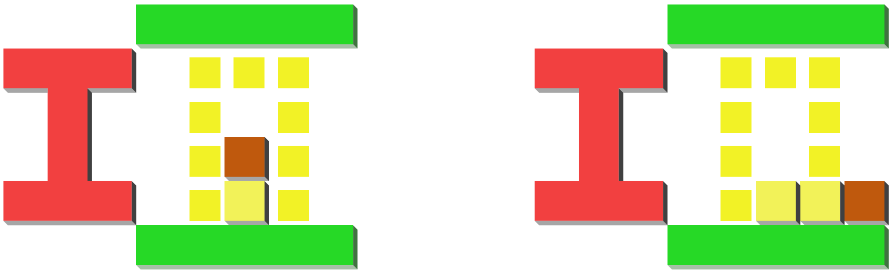


Figure 20: Two half-a-pair reversals take us to the Eastern side.

switches on the right side of the O immediately increases the size of the group to three. In order to allow the switches at the bottom of the ring to rejoin the bigger group we first need to toggle everything. These two manouvers are shown in the two halves of Figure 21.

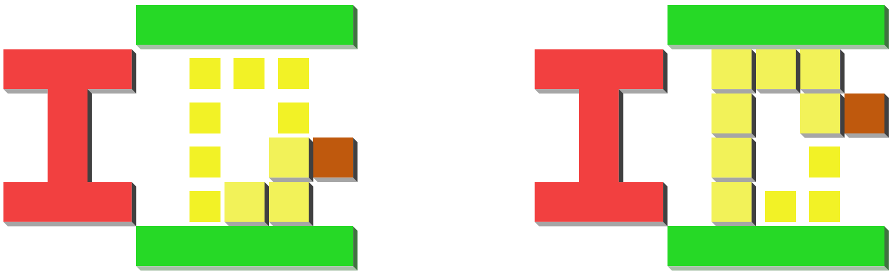


Figure 21: Add a third switch to the small group and toggle everything.

Now we are in a position to revert the two first manouvers. In accordance with the general principles we first realign the center bottom switch, then the right bottom switch, and arrive at the position of Figure 22.

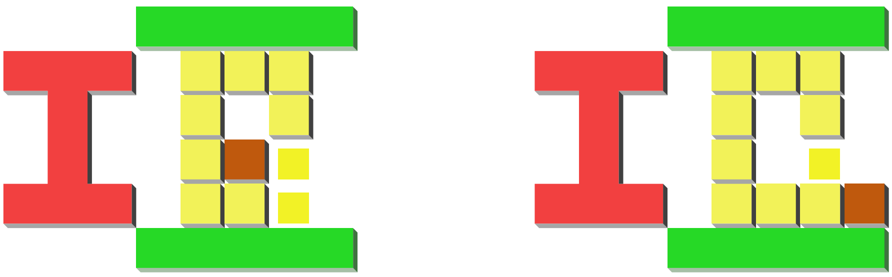


Figure 22: The switches in the bottom rejoin the bigger group.

The rest is easy. All we need to do is to toggle everything, and then realign the second switch from the top on the right side of the O. The effects of these two manouvers are shown in Figure 23. We close our study of this example with the observation that it would have

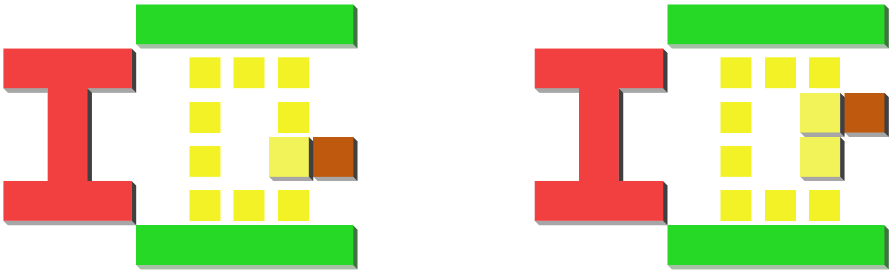


Figure 23: After a universal toggle we can reach the desired alignment with a single half-a-pair-reversal.

been possible to do this last manouver before we entered the ring for the second time. But checking out possibilities like that is mostly for the step optimizers. The important thing was to add at least that third switch to the smaller group, so that we can exit the ring in the right half of Figure 22.

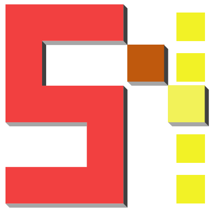
5 Closing remarks and more exercises

This concludes what I have to say about switch management. Note that we haven't touched the management of *switchfields*, 2-dimensional configurations filled with switches. This is mostly because I don't think I'm the right person to discuss that. At least I haven't found any useful pieces of general theory and/or subclasses of problems that could be simply described and easily absorbed. Anyway, my experience is that thinking in terms of half-a-pair-reversals is useful even there. Extra care needs to be taken, because simple moves take you to the middle of the switchfield, and you must ascertain that you can carry on.

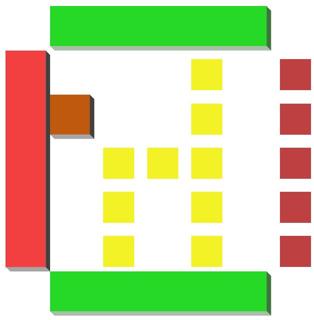
See the letter S on the cover page. You will see that the faithful 1×1 could travel along that S without interruptions as the switches will always toggle to make way for further progress. While travelling that path all the switches on it (with the important exception of the first) will become realigned. This is easy to understand. All the others, save for the first, served in a way in the role of the latter member of a pair. Or in yet other words, all those bricks were protected from the universal toggle exactly once by the moving brick. You can try and build your own set of tactic for managing switchfields using this observation as a basis.

But now that you are familiar with some techniques you can try and solve the following exercises.

Exercise 6. *What preparations are needed to bring the S-shaped master through the vertical bank of 5 switches (assume that you can get the* 1×1 *out of the way)?*



Exercise 7. *How to realign here, and again solve this level in two moves?*



Exercise 8. *Find a useful alignment of these switches, and design a way of bringing the master to the other side of the switches in two moves.*