Repairing Williams C.P.U. boards.

System 3, 4, 6 and 7.

Test−IC to check basic functionality of the cpu and driver 'out' of the pinball machine.

To my amazement I found almost no information about repairing these cpu−boards. Even the most known site for repair manuals, Clayss pages at marvin3m.com, don't give any help for these first types of solid state Williams pinball games. Even repairconnection.com which does repairs, doesn't accept boards of system 3 and 4 anymore.. Only on the french site of Arcajeux there is one very good article about these boards, but they warn to treat them VERY carefully if they still work. I quote the french text: " On ne touche pas un flipper Williams qui marche. Le démontage ainsi que le transport sont une source d'ennuis quasi infaillible!!!..... ." which says: Don't touch a Williams pinball game if it works. Transporting it or taking it apart is asking for troubles !!!!!" The article at Arcajeux can be found here.....

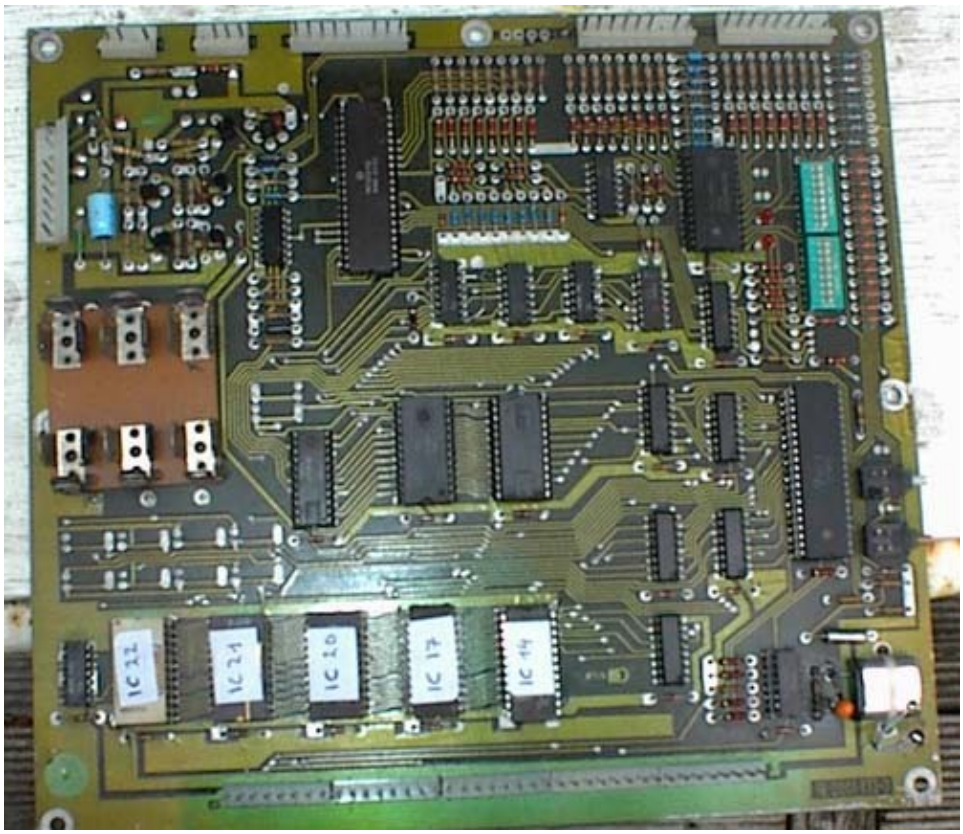
There's an english document about all these types at the known manual site,look for..Williams−sys7−fix.....

As said, I was amazed hearing all this. These pinball machines have been in bars and arcades, where they weren't treated well and moved a lot. So don't touching them sounds strange..

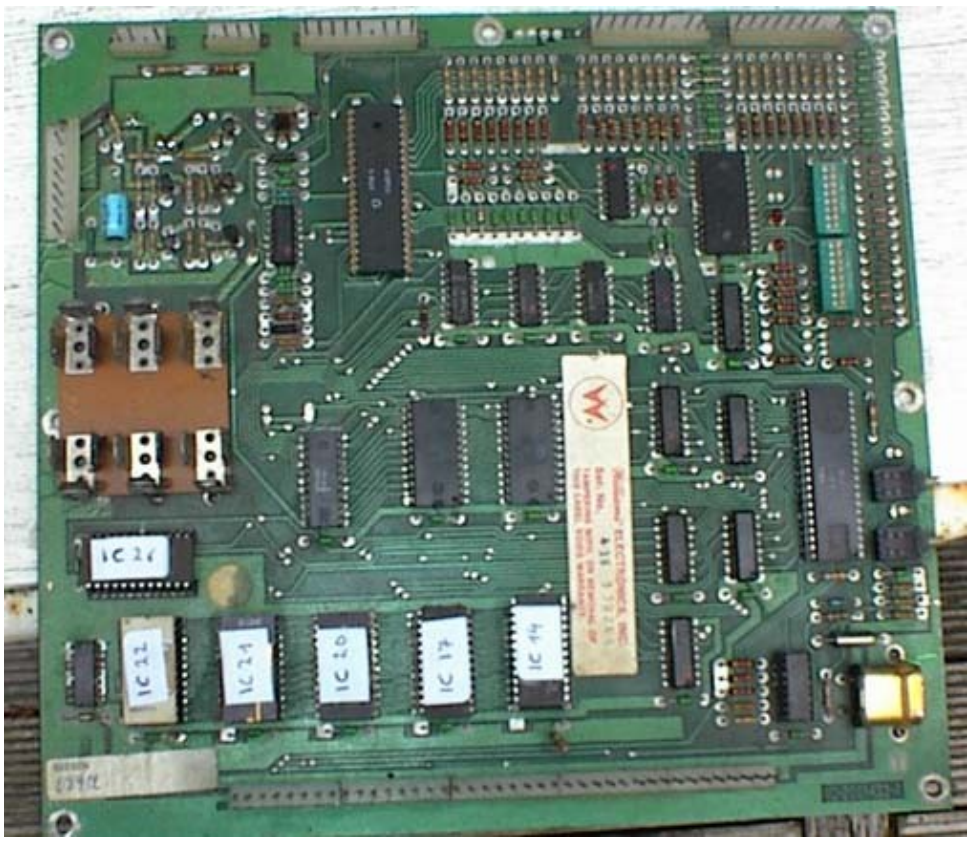
By coincidence I don't have any of these first models of Williams in my collection (of 15 machines).. I bought lately a Williams test−bench, which didn't work, and some cpu and driver boards, so I started to check myself where all the problems were.....

The beginning:

Between 1977 − 1984 a lot of different models of cpu boards have been used. The oldest, type 3 and 4, can be identified easily: type 3 does have a place for IC14 but there's no socket soldered for it. System 4 has an extra IC: IC26, and the socket for IC−14 is present. On the pictures you can see these boards, but on system 3 the socket for IC14 is present, because a lot of these boards have been adapted by their owners. There is a must to add IC14 which I'll explain later.



Type 3 (with socket for IC14). I numbered the IC's so you can see what their place is. They do not have to be all present at the same time! Also notice of the orange dot at the bottom right, this is an added 33pF condo, why.. is explained further in this text.



Type 4, you see an extra ic socket for IC26. Here also the ic's are numbered for clarity, but not all of these IC's must or may be present at once on the board.....

There is also a model in between the two, which has IC14 + IC 26 but does not have the sockets soldered.....

All of this all is not very important, we'll see that it's possible to convert all these boards to a type 4 using some small modifications.....

Type 7 will be discussed later when I am able to buy/borrom them. It is compatible or equal and can be used to substitute types 3,4 and 6, and the other way round.

Type 6 can be recognised because the battery−holder is at the right of the board, type 7 has it on the bottom left.

A type 6 board with the battery−holder on the right, i numberd the ic's so you can see where there emplacement is. Not all of them are always present on the board!! Remarque the jumper in the left top corner, he connects resistor R27 and condensor C23 (both upper sides)and is neccesairy to work on the test−fixture when only the 5 volt is connected as explained under 'manual '.

Practice

The first difficulty with these Williams pinballs is, when the cpu does not work, in a lot of cases, all of the coils will energise and all lamps will come on...Result the fuse blows or the coils or their drivers burns...The same thing happens if you turn on the pinball without his cpu−board in place.....And again the same if only one signal 'blanking' is and stays 'low'.... This is enought to make a "bad reputation" for this pinball's . Repair men had to remove the cpu/driver boards out or had to remove some fuses to do

'research' and there where almost no indications...only the two leds on the cpu and their "information" was not at all reliable.....So most of the time it was nessecairy to put the boards on a test−fixture what means that the repair could not take place 'on the spot'.....My solution to this problems is double.....

A) Do some modifications and "pré−repairs" on the board, and get rid of 'aging−problems'.

B) Use a simple test−fixture (only a 5 volts supply) and a special test IC , witch i propose to download freely.....

My tests have resulted in some basic rules.

ALL IC sockets MUST BE REPLACED !! Don't think you can skip this rule. There are at least 5 on the cpu board and 3 on the driver board. Even whilst the boards I have looked "good" without any traces of battery damage or any other damage, there were a lot of bad contacts in the IC sockets which make the cpu board and driver board unreliable...

Always convert your board to a type 4, the modifications are limited. Using IC14 replaces IC 21, 22 and 26, so you don't have to replace these sockets because they aren't used anymore.....

Make a modification to the reset−circuit, it's only 10 minutes work.... (not nessesairy on model 6)

Check the oscillator circuit, if necessary put add a 33pF condo over the cristal, 5 minutes work....

Look for and repair cracked solder−joints.

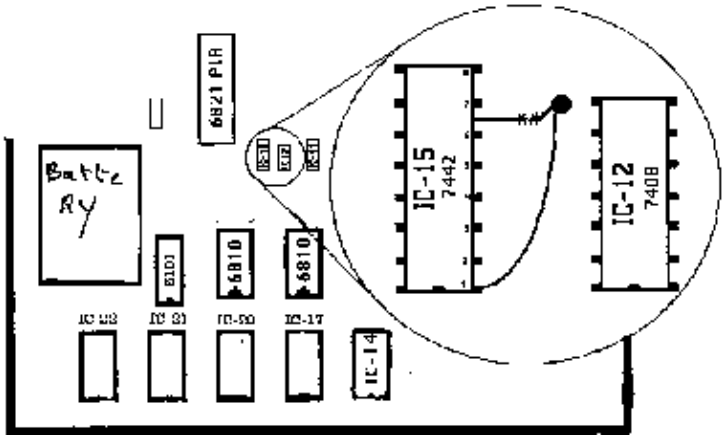
With these modifications I noticed that these cpu boards work very well and reliable, I can treat them normal, put them on the workbench, solder something in or out, without having any problems.....

1) the IC sockets, they have to be changed, their quality did not resist time.. take your time and be careful. Just lift the black plastic by putting a small screwdriver beneath it and pull the plastic out. Then you can desolder the metal springs, one by one. Insert a new socket of the best quality, they don't cost much more and are really better. If you add IC14 (which you should), you don't need to replace IC21, 22 and 26. Also the sockets of the CPU (IC1) and PIA (IC18) have to be replaced. It takes some time, but it's really necessary.....

2) How about IC 14 ? Well, Williams has "Game Roms" and "Roms". Roms are 2716 eproms which are in IC17 and IC20. The "Game roms" are 2 or 3 and they are in IC21, IC22, IC26, these are 7614 roms. These 2 or 3 can be added into one 2716 eprom (which has 4x capacity of a 7614). This 2716 eprom has to be placed on IC14 and replaces the two or three others. On all websites where you find rom−images, also Williams itself, you'll find the image for IC14. The content of the obsolete 7614 can't be found anymore. If your 7614 roms are still good then you can leave them, but of course don't forget to replace their sockets ! ....and you don't need IC14.

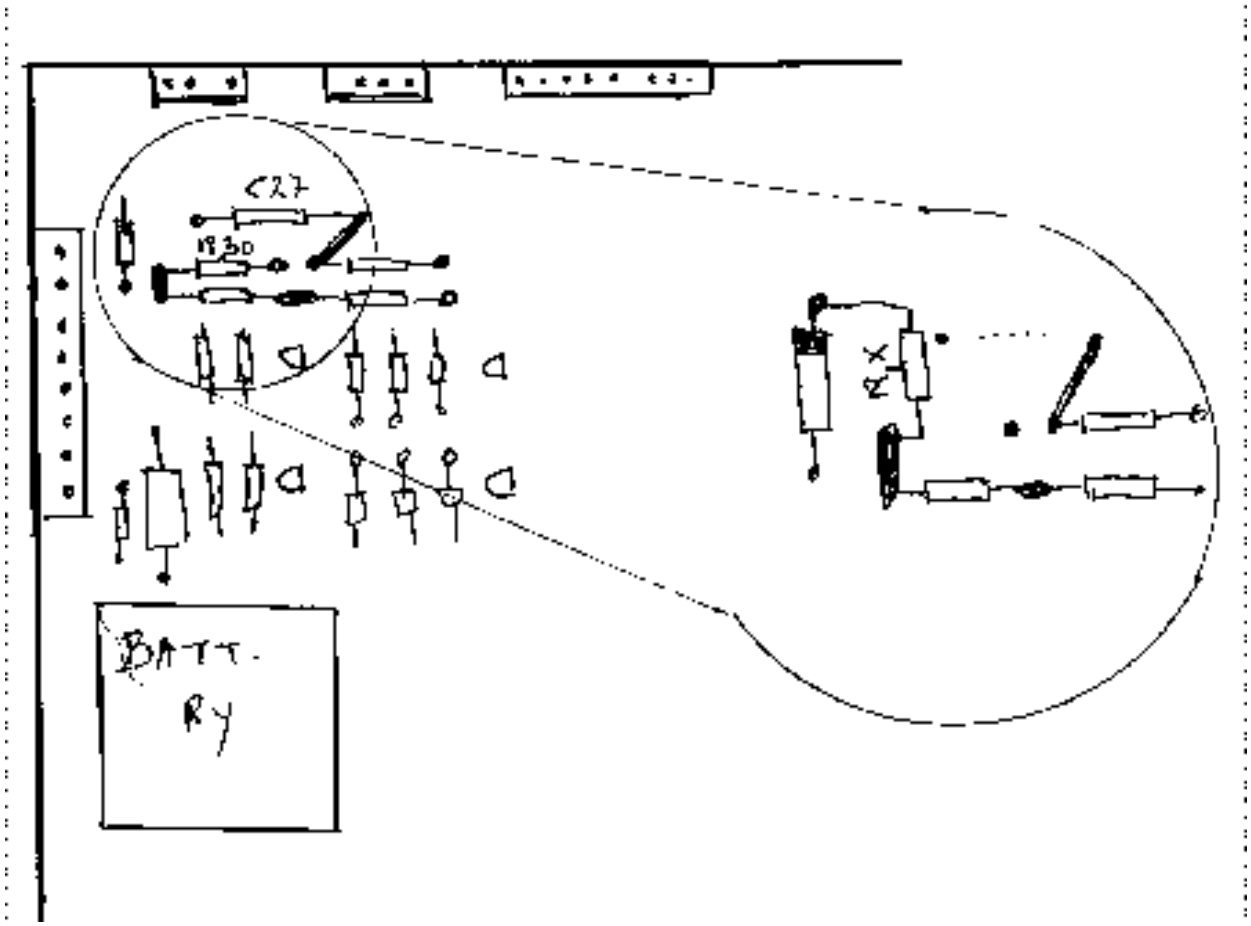
If you want to use IC14, you can convert a type 3 to type 4 by adding socket 14 and converting the selection circuit for IC14. Should you want to use a type 3 board in a type 6 game, these modifications are required, as a system 6 game always uses IC14. So how do we modify this selection ?

Like this:



Find IC15, bteween pin 6 and 7 there's a trace which goes to a round solder point. Cut this trace and connect the round solder point with pin 1 of IC 15. That's it !!!!!!!!

3) The reset − circuit. This modification was presented by Williams and goes like this:(not nessesairy on model 6).



Search in the top left corner 5 transistors and several resistors. There are 4 horizontal resistors with just above them a condensor. It's ok to remove this condensor (c27), also resistance top left (R30). Add a new resistor (Rx) of 10K−ohm like shown in the drawing, between the top side of the zener−diode and the left connecting point of the removed R30. That's it...

4) The oscillator circuit. (Model 3 and 4)

These Williams boards use a special chip, designed to work together with the 6800 cpu. This chip takes care of the oscillator−cicuit, reset circuit and another signal: "BUS 02". In some 'old boards' there are 2 parts less used, L1 and condensor C68, I think because of this the oscillator doesn't always start correct.... resulting in a pinball machine which doesn't start..... How to check this: if you have a working cpu board, you should be able to put your hand on the crystal and chip and the oscillator must not stop.., signals Q1 and Q2 must continue. You can check these at pin 3,36 and 37 of the cpu 6800.... These should be about 2,5 volt zijn.... Is the oscillator stops when touched, or if he doesn't work and starts when being touched, then the components aren't stable enough, and it's advised to solder a 33pF condo parallel to the cristal connection....(This is different with model 6, here a CPU6808/6802 is used−and the clock circuit is different).

5) Check al the solder joints of all the connector pins, as well on the cpu as on the driver−board! Use a magnifier −glass I'm sure you will find some cracked solder joints with the crack just around the pin....Warm the joint and add a little new solder on it.!

With these changes you have good working cpu boards !!!

The test IC:

You can download the contents of test Eprom 2716 here and create the test−chip with an eprom programmer ..... 

If you don't have a eprom burner and don't know someone who can do it for you, you can buy them from me, for the cost of the eprom.....15 euro..... 

This eprom has a small program which does the following:

Put the outputs PA0 to PA7 and PB0 to PB7 of PIA chip IC18 (cpu) and of PIA chips IC11, IC10 and IC5 on the driver board, HIGH and then LOW, over and over again. Same for ports CA2 and CB2 of these chips. This goes in a rhythm. This program does not lock−up. This means if any output of a chip is bad, the program will continue to work. This way you're able to use a led in series with a 2K ohm resistor, a multimeter or a logic probe to read all outputs of chips and see if everything works. The 2 leds on the cpu−board will also flash, because they're tied to the signal CA2 of IC18. The test only checks the cpu 6800 (IC1 model 3 and 4)6808/6802 model 6, and the 6820/21 chip and is not dependent of mempory chips (IC13 IC16 IC19) and certainly not of program Eproms (IC26 IC22 IC21 IC20 IC17 or IC14). Of course clock chip IC5 must work correct....(exists not on model 6) also selection−chip IC15 and the buffers of the address and data lines, but this is easy to check (see further).

To make it clear I add here that the PIA's are the output−chips who control all functionalitys, coils, lamps, displays.....

At the same time this means that if the program does not work, only a few components on the cpu board can be responsible. (read the manual..)

Manual.

The program is used with the cpu board outside the pinball machine, connected to +5 volt.(Pin 3=gnd pin 4=+5 on connector IJ2.) Do not forget to adapt the reset−cicuit on model 3 and 4 boards, for model 6 make the jumper between the upper sides of R27 and C23.

Remove program chips IC 26,22,21,20,17, batteries are not needed. Put the test chip in IC17 and power up.

If the led's flash in rhythm you're lucky and are able to check the outputs of IC18. If they doesn't flash then first try a new 6800 (6808/6802 in model 6). Still no result, then try a manual reset by connecting pin

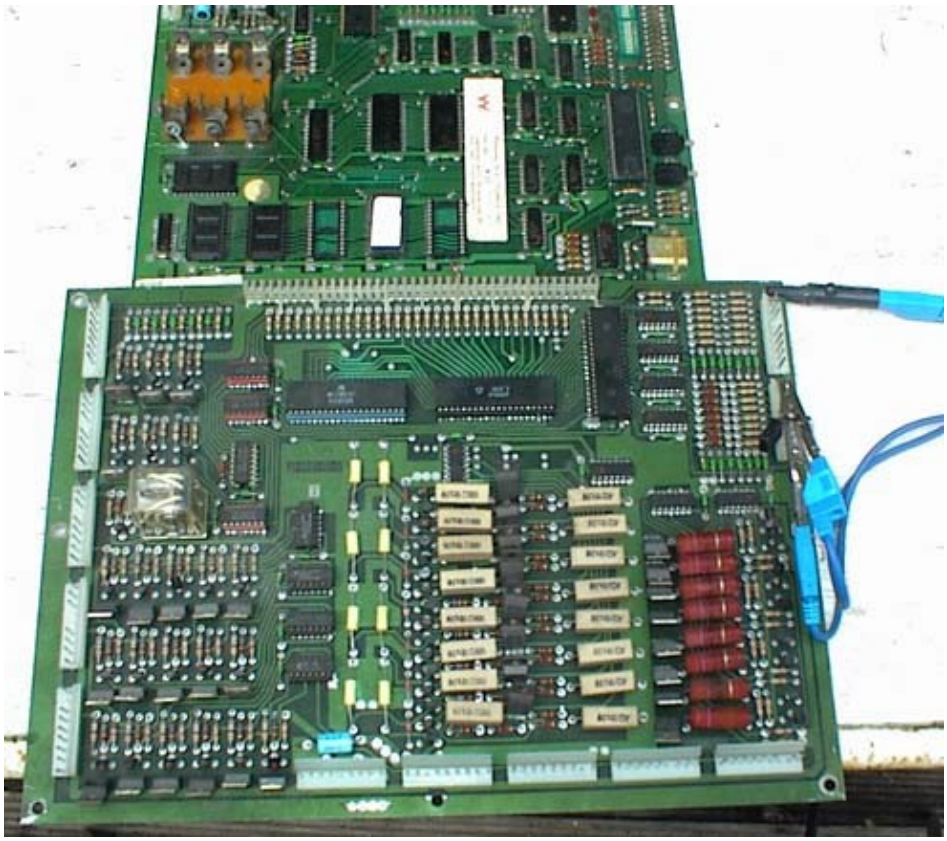
40 of the 6800 (IC1) or 6808/6802 (model 6) to ground. Check then if there's +4,5 volt present at pin 40. If this isn't, the problem is in the reset−circuit. Most of this is IC5 for model 3 and 4 boards. For model 6the reset circuit is made by the transistors Q 1/2/3/4/6/7/8 and 9.

Next step if it doesn't work is check signals at 6800 (IC1), pin 3 should have a clock signaal. If not, check and follow this missing signal back on IC5. Same for the second clock−signal on IC1 pin 36 and 37. (clock signal is about 2,5 volt). Next signal to check on 6800(IC1) is pin 2, should be +5 volt zijn. Finally check the voltage on pin 5 which should be about 2,8 volt.For model 6 you find the clock on pin 37 (2,5 volt) and you must find on pin 5 also 2,5 volt.For all models 3/4 and 6 check if the buffers of address lines and data lines work, these are chips IC4, 3 and 8 for the address lines and chips IC9 and 10 for data−lines. On the schema you can see the inputs and outputs, which are drawn opposite each other, i.e. A0 is pin 2 IN and pin 3 OUT... A1 is pin 4 IN and pin 5 OUT, and so on.. the input signal must be the same as the output−signal !! One of the signals we're checking now must have been bad if the 6800 /6808 / 6802 has been replaced and is ok now, you trace any bad signal back to its source and take away the short or the other source of non−function. A final option could be the selection of IC17 or IC18 not working, check if you get signals on the address, data and chip−select lines of IC17 pin 20) , and selection signals on IC18 (pin 35, 36, 23, 24, 22 and 25). Now all exits of IC18 should go high and low. If there's an output on chip IC18 which doesn't go up and down, connect this with the output next to it. If this other one also fails then there's a closure on this output, check for that first. If both outputs go up and down after connecting them, then you can be sure that this chip (IC18) is broken. A final test is putting the normal program chips in their sockets (except IC17), their presence shouldn't interrupt the test. Should one of the chips change the test, then there's something wrong with it. Conclusion: if your outputs all work correct, you may put program chip IC17 back and check if the cpu works ok. At least you are sure that 6800/6808/6802 and its circuits, also PIA (IC18) are ok, and there are no shorts on data and address lines. You can start checking memory chips and doubt program eproms.. This depends on how your led's act when you push the diagnostic pushbutton. Both leds should flash , as described in the documentation of your pinball machine...

If you also want to check PIA's of your driver board, then connect the driver board to your cpu−board, put test−chip in IC17 and power up the board. The leds on the cpu board will start flashing and also the relay on the driver−board will start clicking. This relay is connected to CB2 of PIA (IC5). If the relay clicks this is also a test on the most important signal BLANKING.. which occurs in many different circuits. Should the relay not click along with the rhythm of the test, replace the condensor C32 on the CPU board, because it happens that the value of this 0,05mf condo decreases and then the blanking signal becomes unstable....The blanking signal enters the driver via pin 37 of 1J1 if it is not there follow it back on the cpu where IC 23 is the source of it.....

Now check if outputs of the 3 PIA's go up and down. Caution the outputs of PIA IC5 model 3 and 4 or IC11 model 6 , PA0 to PA7 are always forced low... To bypass this connect all pins of connector 2J3 to ground (7 pins... use an alligator clip to ground) and then these outputs will also dance like the others.....

If there are some PIA's who don't work at all, again you'll have to check the selection of the PIA on it's selection−pins, these are 35, 36, 23, 24, 22, and lok at pin 25 for 2,5 volt. If one of these signals is missing, follow it back to its source, using the schematics and logic−probe or oscilloscope. If it's only some outputs who don't work, connect it to a working output, if they both DON'T work then there's a short on the non−working output, if they DO work then your PIA is defective...



Here's the setup to test the driver board. Connected to the cpu, in IC17 is my test−eprom, and you'll notice both sockets next to it have been replaced..

Connector 2J3 on the driver board has been connected to ground with all its pins..

Conclusion:

Once you know the outputs of the PIA's work, from there on you can use the standard lamp− and coil−tests.....

I hope that this very technical document will help a lot of people and wish you a lot of success..!!

Any questions ? Email me !! .....

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