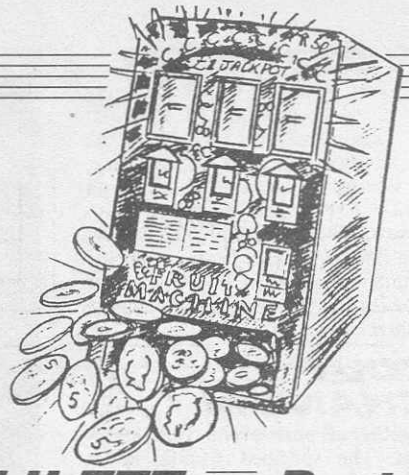
Constructional Project

EPE FRUIT MACHINE



BRETT GOSSAGE and JULYAN ILETT — Part 2

A coin operated fruit machine that really pays out!

OPERATING principles of fruit machines and the design approach adopted for the *EPE Fruit Machine* were discussed last month. Also, the full circuit description and construction of the circuit board were covered. This month we conclude with the mechanical construction, checking and operation.

MECHANICAL CONSTRUCTION

Building the coin detector and payout mechanisms is not difficult, but should be carried out with reasonable accuracy to ensure reliable operation. Most of the parts are simple rectangles which can be cut from the plastic sheet using a Stanley knife or large modelling knife.

Score the plastic down to about half its depth, then simply snap the plastic apart by bending. Be extremely careful as these knifes are very dangerous, NEVER cut towards your fingers. Don't use the knife to cut the pipe, use a junior hacksaw, and clean up with emery paper.

A number of circular holes have to be cut. For the small holes, a drill can be used. For the larger holes, start by drilling a 3mm to 4mm pilot hole, then use a reamer to take the hole out to a larger diameter, and finally, for best results, use a Q-max hole cutter.

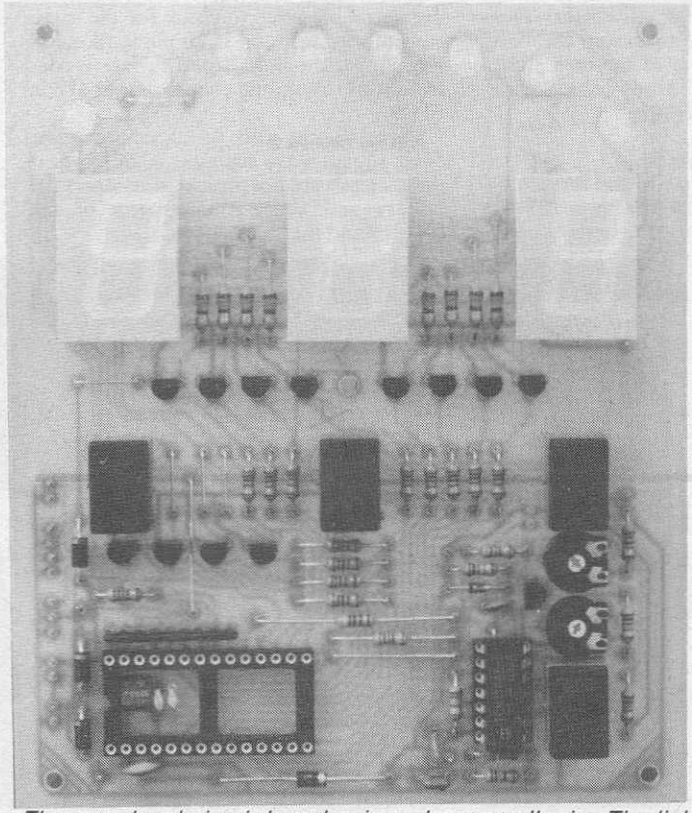
This project needs only one hole cutter, size 20mm, but they are rather expensive. The 21mm holes can be punched initially to 20mm and then enlarged using fine emery paper, but care should be taken not to let the hole become eccentric.

The plastic parts should be glued together using "Plastic Weld" or a similar solvent glue. This substance isn't really glue at all, it dissolves the plastic, welding it together. It was found best to apply plenty of glue using a fine paint brush then hold the parts together for several seconds until the plastic starts to re-set.

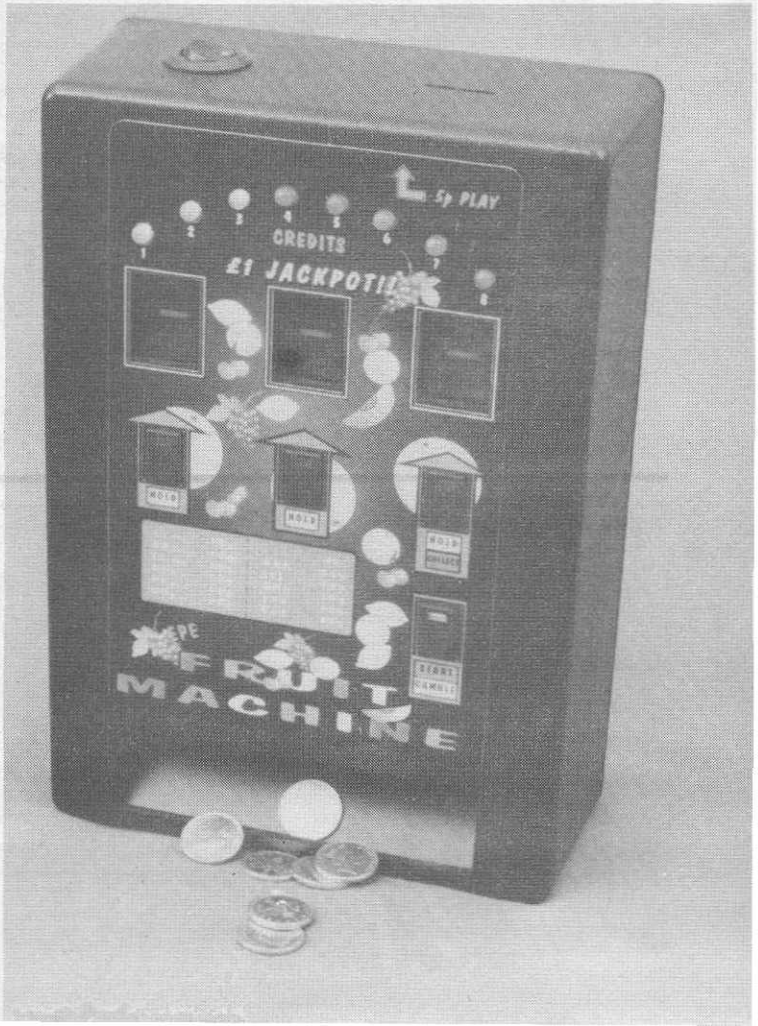
It takes much longer, however, for the plastic to set hard, hours rather than seconds. It may be a good idea to experiment with the glue and a few offcuts of plastic, in order to establish a good technique for making these welds. The author's first attempts resulted in some rather fragile joints!

All the plastic parts required are detailed in Fig. 5, Fig. 7 and Fig. 12. Check the details carefully as although most parts are made from 80 thou' white plastic sheet, there are a few exceptions.

Side and underside views of each of the mechanisms are shown in Fig. 6 and Fig. 8. The letters can be used to cross-reference the drawings with the parts in Fig. 5, Fig. 7 and Fig. 12. These figures should be used in conjunction with the photographs when fitting the various parts together.



The completed circuit board, minus the controller i.c. The link J1, used when "testing", is positioned just left of the Hold switch.

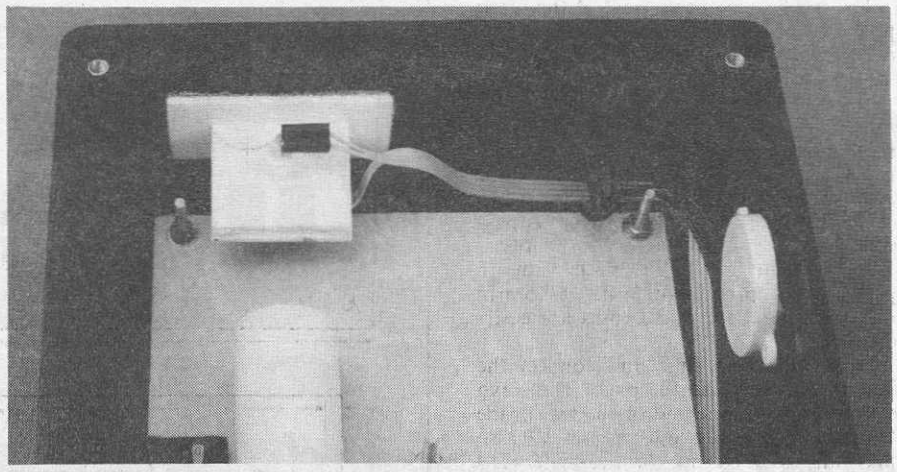


COIN DETECTOR

Glue together all parts of the coin detector mechanism, then glue the infra-red l.e.d. and phototransistor (TR14) into the small plastic pipe pieces. Unfortunately, these two devices look identical, although the l.e.d. may have much longer legs than the transistor. Check carefully the wiring from these devices to the 4-pin connector (SK4), details are given in Fig. 11. Solder wires to the legs of the devices and insulate with heatshrink sleeving.

PAYOUT MECHANISM

Glue together all parts of the coin payout mechanism. The specified Futaba servo motor comes with rubber mounting blocks which are first pressed into the holes on the servo chassis. M3 bolts should be used with suitable length spacers to mount the servo onto the payout mechanism base-plate.



The completed coin detector mechanism is glued behind the coin cutout slot in the top of the case. Ribbon cable is used to connect the infra-red l.e.d. and phototransistor back to the p.c.b. – see Fig. 11.

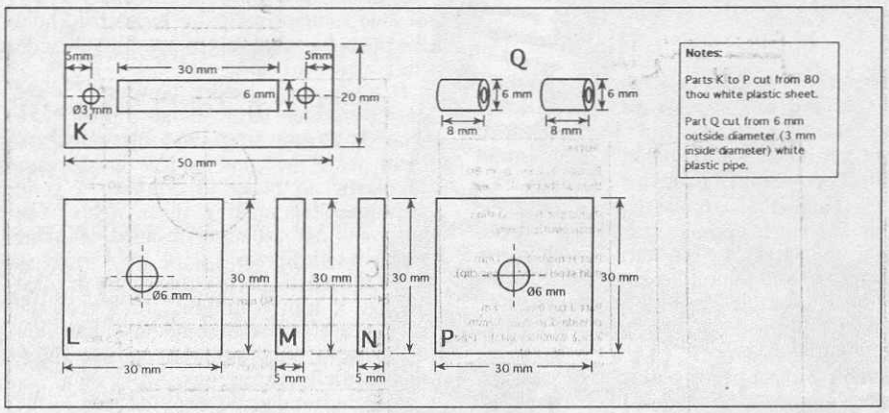


Fig. 5. Plastic parts for the coin detector mechanism.

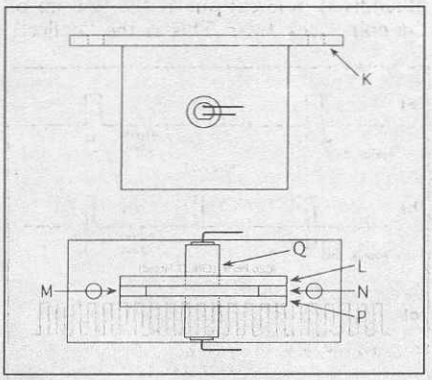


Fig. 6. Coin detector mechanism. The infra-red l.e.d. and phototransistor are glued in the small tubes either side of the coin slot.

The connecting link which connects the coin slide to the servo actuator arm requires special consideration. The actuator is initially supplied with four arms, three of which should be cut off as shown in Fig. 8. The arm should then be used to find the mid-position of the servo shaft's full range of travel.

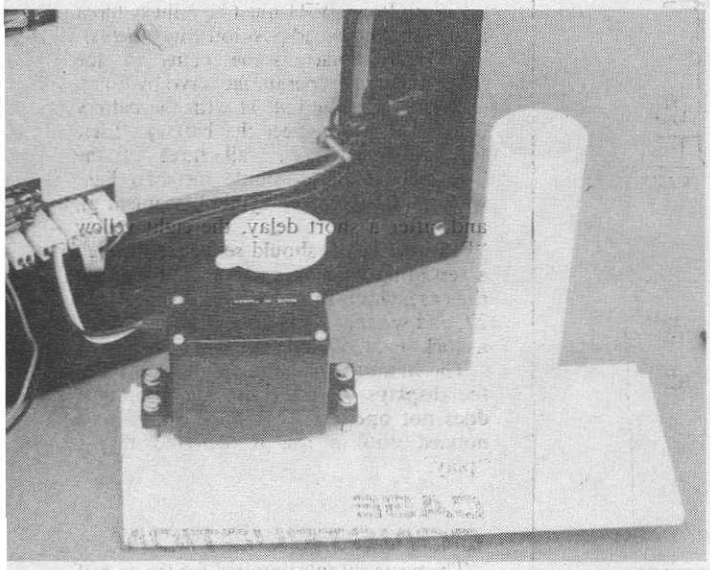
Leaving the servo shaft in its mid-position, remove the arm from the shaft. Link the coin slide and the arm with the metal link and then press the arm onto the splines of the servo shaft so that it is perpendicular to the direction of travel of the coin slide as shown in Fig. 8.

The coin slide should now be half way between its extremes of movement. This alignment is necessary to ensure the best possible range of travel of the coin slide. Finally, screw the arm firmly to the servo shaft using the screw provided.

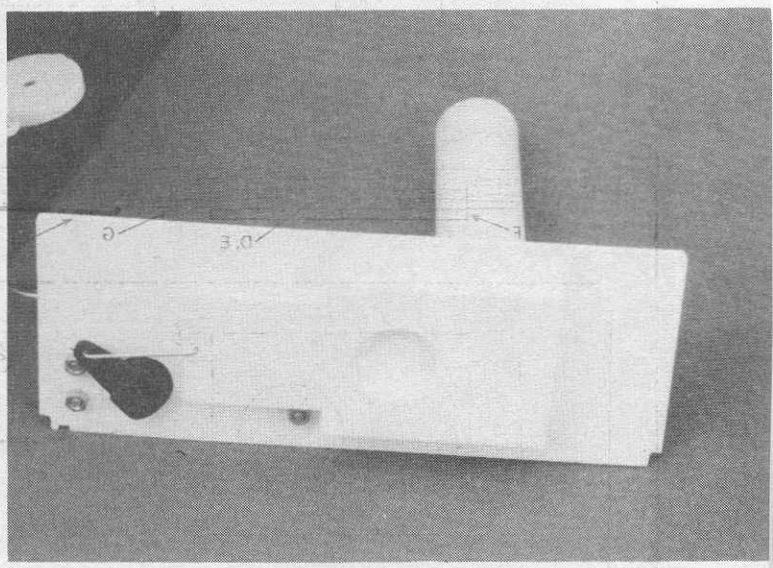
TESTING

Turning now to the p.c.b. and servo, ensure that the microcontroller chip (IC1) is NOT fitted. Connect just the battery pack to the p.c.b. (PL1), and link the two pins of PL2 (on/off switch connector). If possible use an oscilloscope to check for the servo control waveform on IC2b pin 9. (See *a* in Fig. 9). Fit the link J1 and the servo control waveform should change to that of *b* in Fig. 9.

There should also be an approximate 50Hz square wave signal at IC2a pin 5. If these signals are not present, disconnect the battery and check the polarity of the supplies and the connections.



The payout mechanism showing the coin collection tube and the servo motor plugged into the p.c.b. connector.



Underside of the servo mechanism base-plate showing the modified servo actuator arm and coin slide linkage.

The mechanical adjustment of the servo position needs to be quite accurate so that coins are dispensed correctly. With the coin mechanism disconnected from the rest of the unit, and the servo link (paper clip) fitted to the coin slide of the payout mechanism, manually push the servo arm round to both end limits, and check for smooth movement of the slide.

Next, fill the coin tube as much as possible (by now you should have saved lots of 5p pieces!) and holding the mechanism approximately upright, rotate the servo arm to and fro and see if the coins are easily dispensed.

Empty the coin tube and connect the battery and servo to the p.c.b. The servo should move to one end of the travel, the "payout" position. Adjust preset VR1 so that the hole cut-out in the slider has moved about one millimetre further than necessary to "payout" the coin.

Fit the link J1. Now adjust preset VR2 so that the same condition occurs with the other fixed hole cut-out at the bottom of the coin stack tube. This is the "collect" position. Preset VR1 must be adjusted first as it affects both end position adjustments.

Finally, place some coins in the mechanism and operate the servo by fitting and removing the link J1 with the battery connected. Disconnect the battery. Insert IC1 and switch on, all three of the 7-segment displays should instantly light with the BAR or "–" symbol (segment g), and, after a short delay, the eight yellow "Feature" l.e.d.s should sequence through a repeating flashing pattern. If this is not the case, check the CLK signal to IC1 pin 27, and see that it matches *c* in Fig. 19, i.e. a clock signal of 1MHz.

The first sign of battery failure is when the displays become dim, and the servo does not operate. This will not really be noticed until a *win* is achieved during "play."

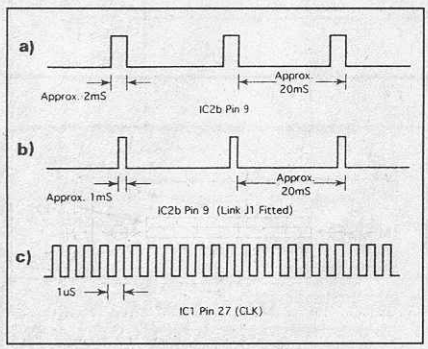


Fig. 9. Servo control waveforms.

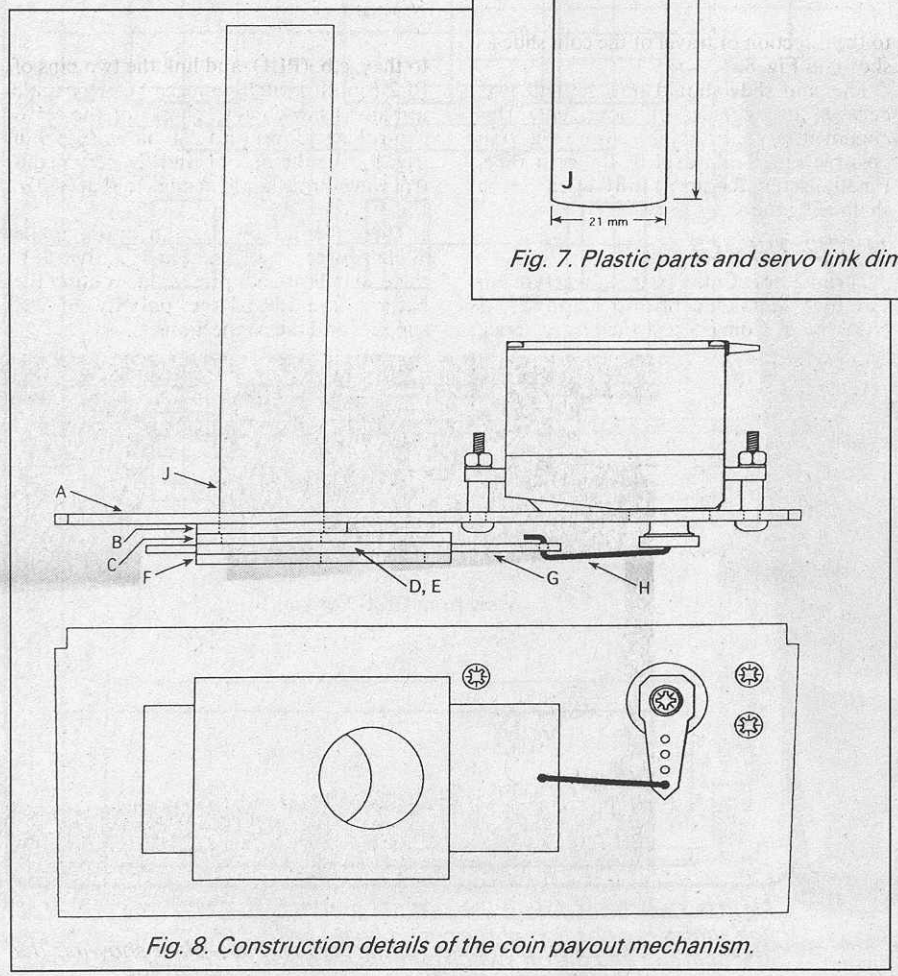


Fig. 8. Construction details of the coin payout mechanism.

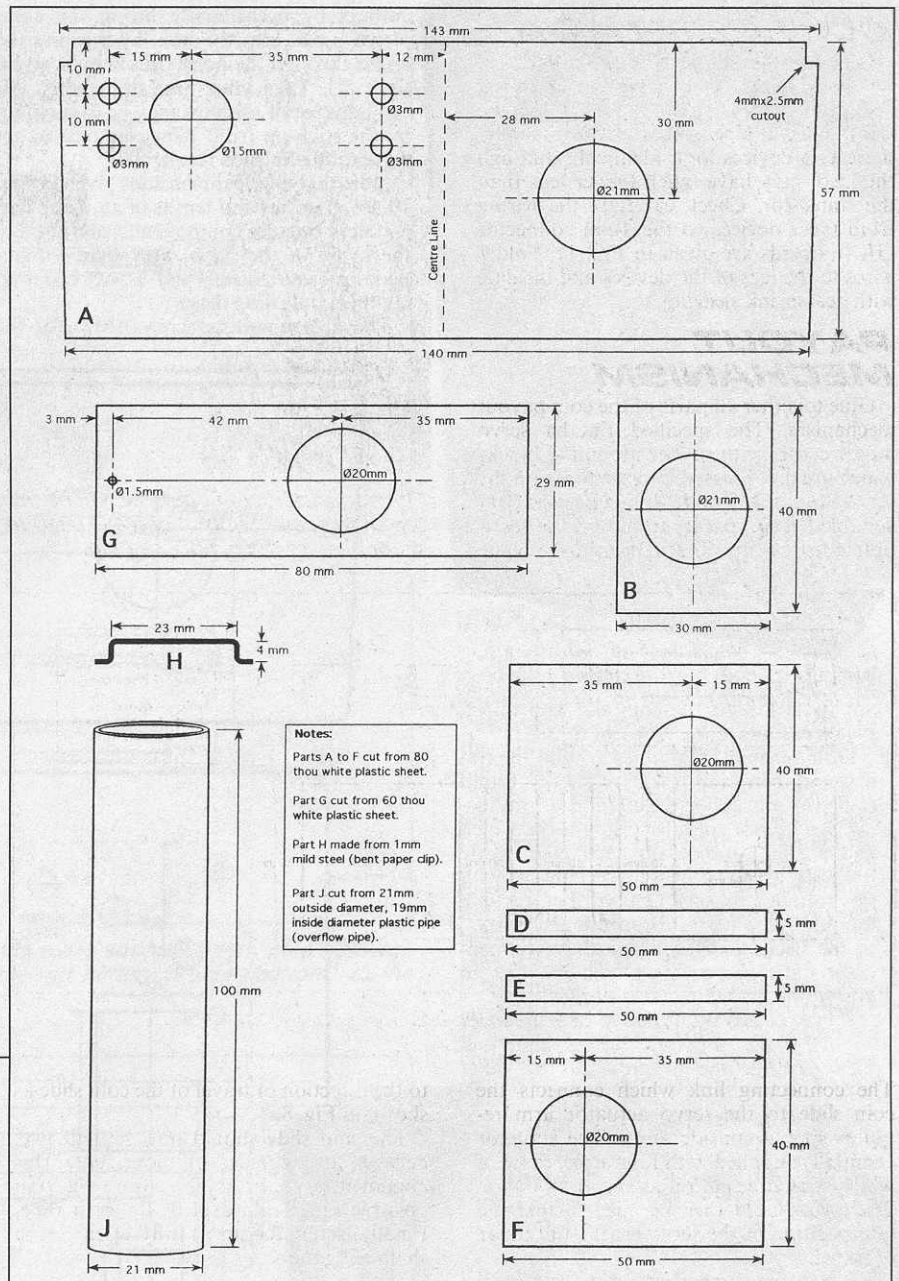


Fig. 7. Plastic parts and servo link dimensions for the coin payout mechanism.

CASE CONSTRUCTION

The basic cutouts required for the case of the Fruit Machine are shown in Fig. 10. These are mostly made in the front of the

MB6 plastic box (the bottom of the box, not its lid), with the coin slot and on/off switch cutouts in the "top" of it.

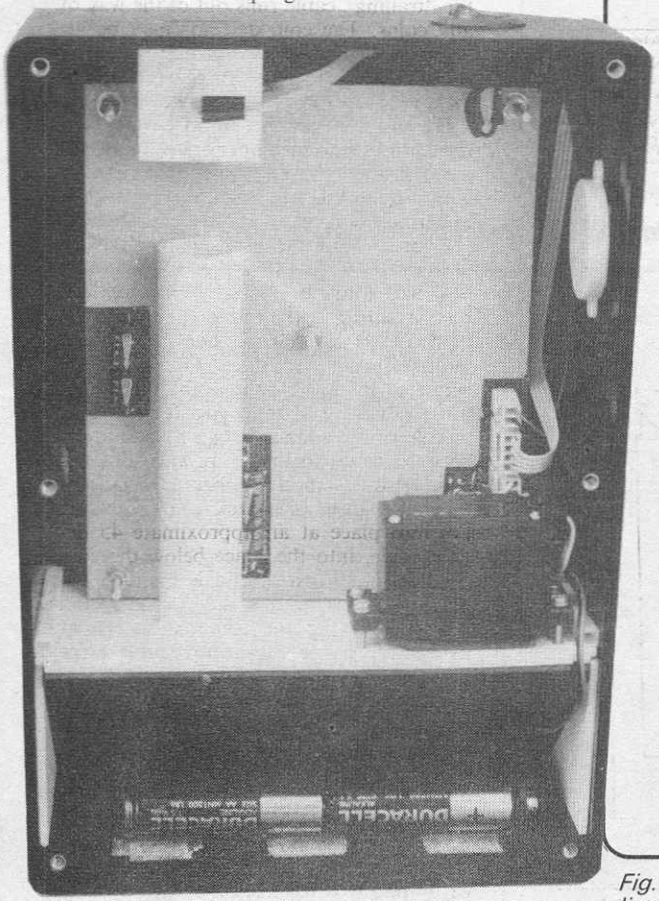
Drilling small pilot holes around the rim first and then using a square file was found to be the most effective method of producing the square cutouts. Using a file which had a slight radius on each edge made it easier to get neat square cutouts with tiny rounded corners. One word of warning though – don't try this on the new carpet, as the flecks of filed plastic have tremendous static charge, and tend to stick to everything, including your clothes!

It may be advantageous to drill the holes for the eight "Feature" l.e.d.s first, and then monitor the progress of the other cutouts by occasionally fitting the completed p.c.b. into the box, by pushing the l.e.d.s through the holes (this should give a tight fit). Take your time doing this. Although a lot of mishaps may be covered up by the stick-on front panel, its nice to get an accurate finished result.

Note that all the dimensions given in Fig. 10 are in inches and tenths of an inch. This is purely because component sizes (notably the i.c.s) on the p.c.b. are based on imperial measurements, and it was easier to lay them out using these.

The five mounting screws (M3) for the p.c.b. were glued to the inside "front" of the box on the prototype using an epoxy resin such as Araldite. This was to avoid having screwheads showing on the front, even though these would be covered by the stick-on front panel facia.

As the p.c.b. position is held quite firmly by the eight "Feature" l.e.d.s, the mounting screws can be first attached firmly to the p.c.b. with nuts either side, and then adjusted so that the p.c.b. height is correct in relation to the front of the box, allowing a 2mm to 3mm protrusion of the *start* and *hold* switches.



Positioning of the p.c.b. guard and siting of the payout servo. Also shown are the coin sensor and piezo sounder.

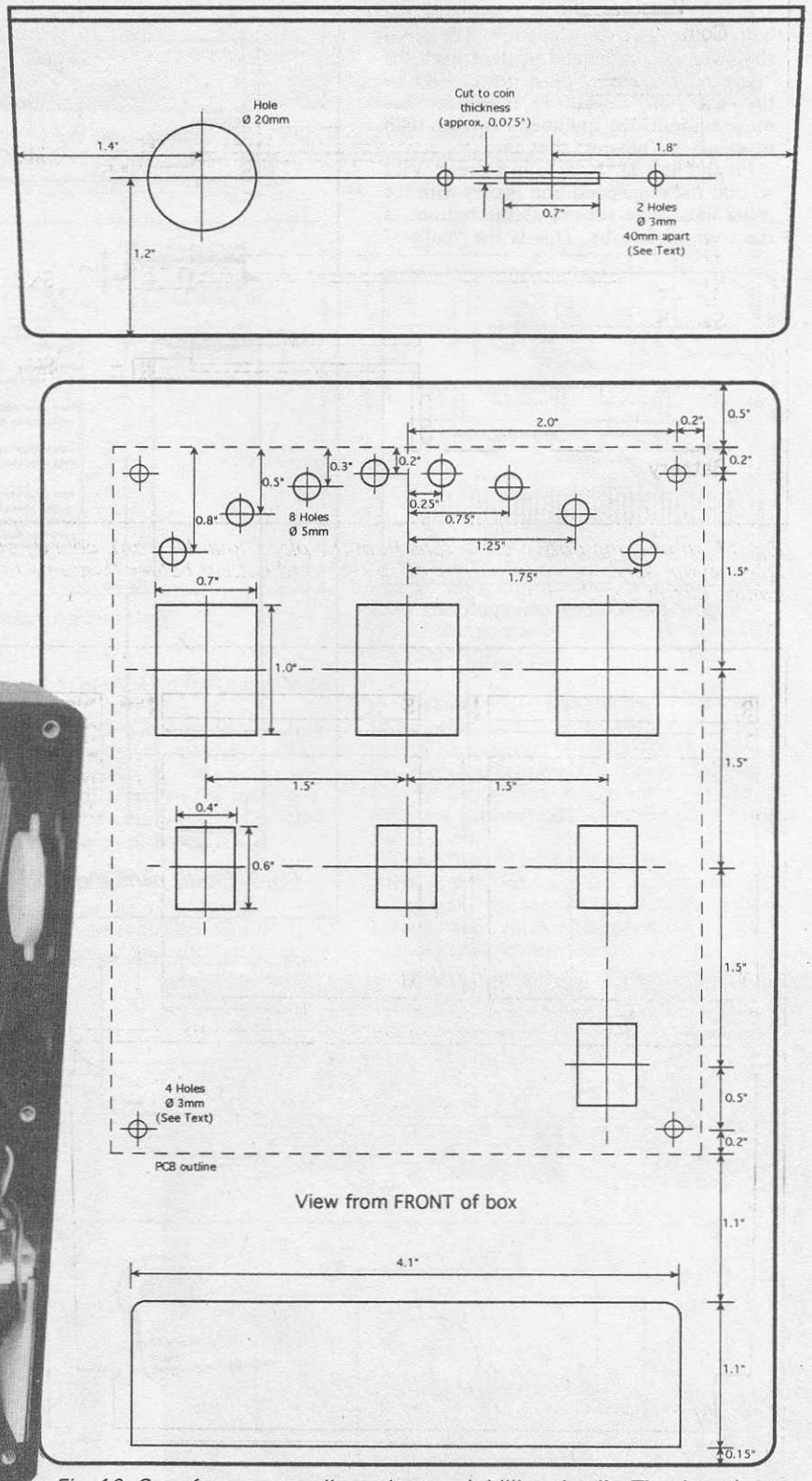


Fig. 10. Case front cutout dimensions and drilling details. The dotted outline shows the position of the circuit board behind the "front" of the case. The coin slot and on/off switch cutouts are made in the top – see above.

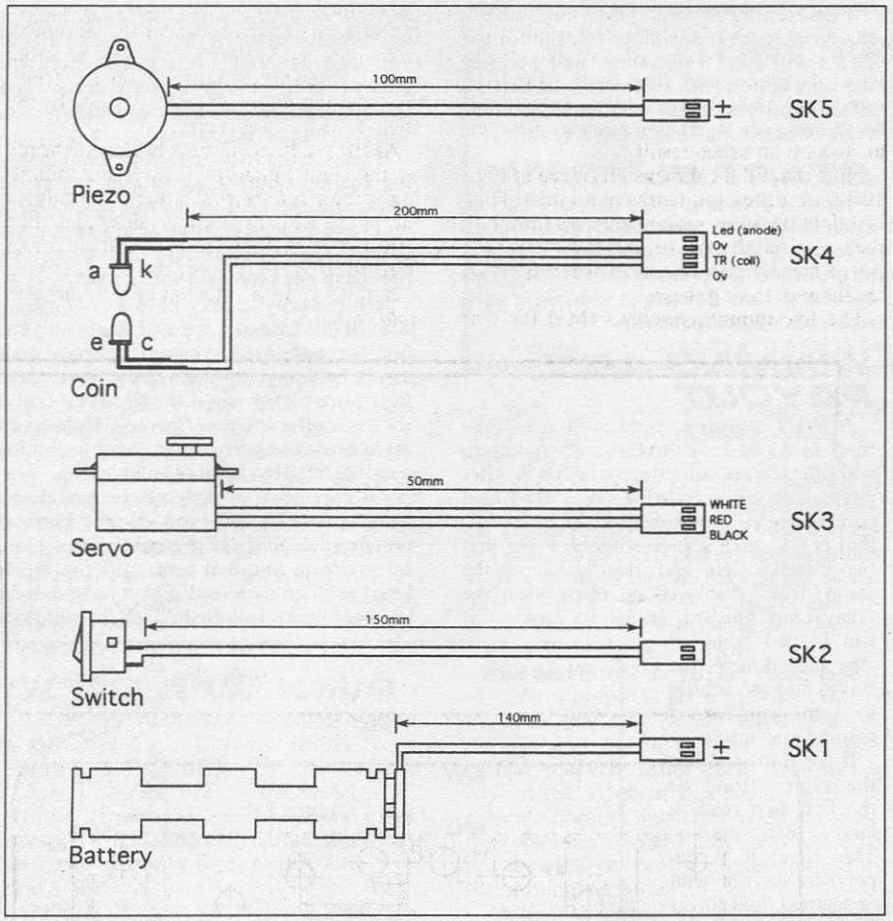


Fig. 11. Interwiring ribbon cable runs from the piezo sounder (top), coin detector, coin payout servo mechanism, on/off switch and battery holder (bottom) to the printed circuit board connector plugs.

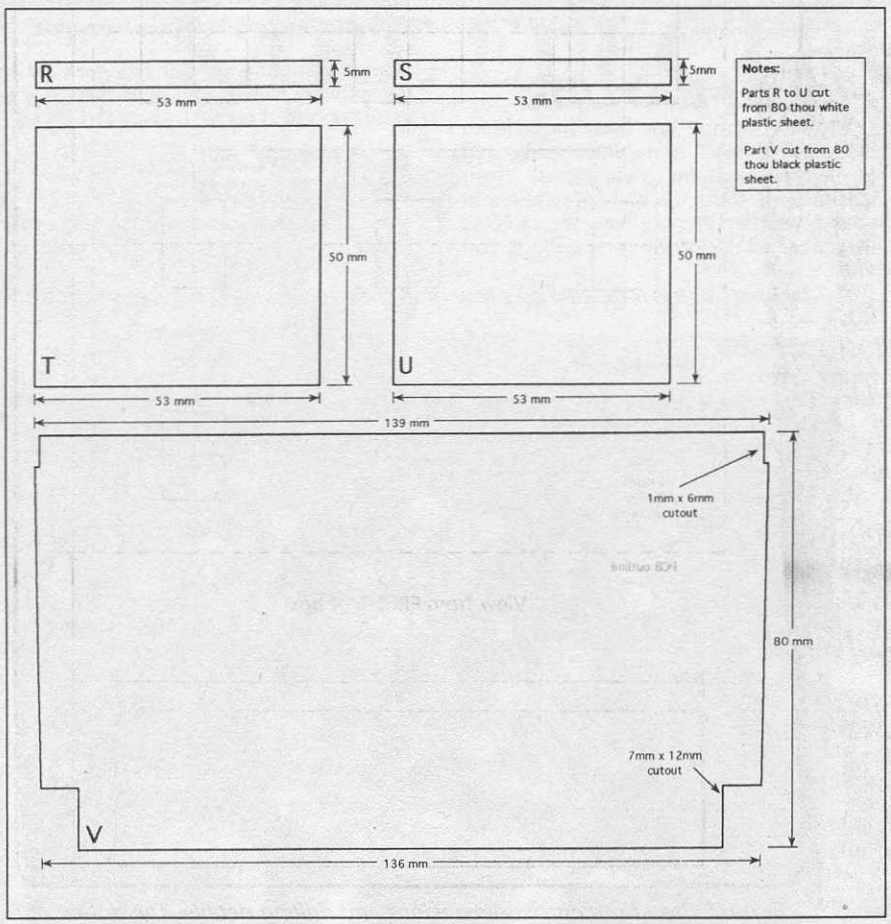
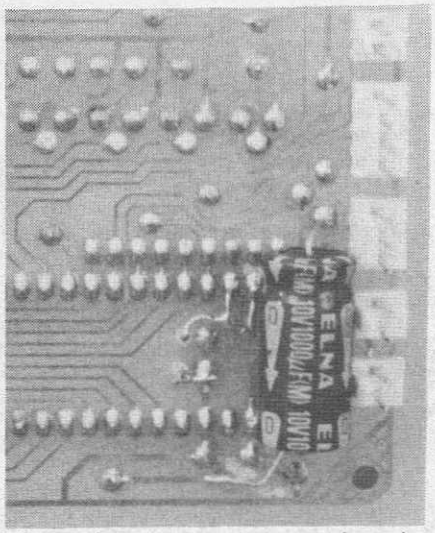


Fig. 12. Plastic parts and dimensions for the coin chute/battery compartment and coin mechanism support.



The p.c.b. connectors mounted on the track side.

FINAL ASSEMBLY

A guard for the back of the p.c.b. will be needed to protect it from damage or short circuits caused by coins dropping into the "money-box" portion of the machine (if the coin stack overflows). This can be made out of cardboard or stiff paper.

First cut out a piece the size of the p.c.b. and then make cutouts for the holes, capacitors and connectors. Mount the p.c.b. in the empty case with the guard flush to it, not forgetting positioning of the red display filter. This can either be glued to the inside of the finished box, or glued to the p.c.b. assembly.

Now make up the five wiring assemblies as shown in Fig 11. Glue the coin detector to the inside top of the box, in line with the cutout slot for the coin, and make sure that the "trailing" cable runs out of the way of any coins. The coin detector may be attached with two screws for easy removal, for instance, if there is a problem with the infra-red l.e.d. or opto-transistor.

Fit and connect the on/off switch, and the connector to the battery pack. Glue the piezo sounder to the upper middle right hand side of the box, and connect it to the uppermost connector on the p.c.b. (PL5).

Place, or glue the two square pieces of plastic "T" & "U" (See Fig. 12) as low as possible, into the bottom sides of the box, ensuring correct orientation (50mm high, 53mm deep). These hold up the coin mechanism at the sides. Glue the two runners "R" & "S" above the pieces just fitted, allowing a 2mm gap for the coin mechanism to slide in between them. Connect the servo to the p.c.b. and slide the completed coin mechanism into these slots.

Finally, push the black coin tray slide (V) into place at an approximate 45 degree angle, into the space below the coin mechanism. When the lid is fitted to the box, the angle of this slide is fixed, and it also holds up the coin mechanism at its centre, giving the construction extra rigidity.

Fit the battery pack into the area at the base of the box with Velcro or double-sided sticky pads, and connect it to the battery clip. Cut a little slot into the right hand side of the black coin slide, to accommodate the wires for the battery clip, so that the lid does not trap them when fitted.

Note that the coin mechanism can be easily removed for inspection at any time by removing the lid, then the tray slide, and then sliding the mechanism out.

MECHANICAL CHECKS

The electronic part of the fruit machine operation should be fault free, however the mechanical parts do have their limitations.

The first and perhaps most obvious, is that this fruit machine can only be operated in an approximate upright position, purely due to the coin stacking and payout mechanism. It works well if hand held in a slightly tilted position away from the operator.

If the coins inserted in the slot do not pass the coin sensor within a specific time, then a credit will not be accepted, and the credit l.e.d. will not light. This is a software implemented "tamper" fail-safe, so don't try poking lolly sticks into the slot!

There is the possibility of over filling. As the machine has a estimated payout of about 80 per cent, there will be a net gain by the machine over a long period of playing. Eventually the coin stack will fill up (about 65 coins) and then it will overflow. Any more coins inserted will still be registered as credits, but they will fall into the enclosed space around the coin stack within the machine.

This is acceptable, as there are no moving parts to jam in this area. This is considered to be the "money box" area of the machine, as these coins can never be paid out by the mechanism. Eventually, this area will also fill up, and if the coin sensor continually fails to register credits, or is blocked, then remove the back panel of the machine, and clear out any excess coins.

During testing, the payout mechanism was found to be very reliable, but if coin jams occur in the coin mechanism, check the servo operation and try resetting the start and end points of the servo travel with presets VR1 and VR2 (see "Testing").

OPERATION

The operation and features of this fruit machine have been made to mimic commercial gaming machines as much as possible, and those of you that are familiar with the operation of these machines will already know a lot of the following, but read on anyway!

SWITCHING ON

When the unit is first switched on, the 7-segment displays will all show the BAR symbol. (Something had to be picked, so why not the jackpot!) The eight yellow l.e.d.s in an arc above the main display are the "Feature" l.e.d.s, and they will flash in a set sequence repeatedly, luring you to put a coin in the slot. When you have done this, these l.e.d.s will go off (with the exception of the left hand l.e.d, showing one *credit*) and the green *start* l.e.d. should light.

CREDITS

If you decide to be ambitious with your investment and put in further coins, you can do this! The first eight credits will be registered by lighting up the arc of l.e.d.s above the main display from the left hand side to the right, except during a WIN sequence. Further coins can be inserted up to a total of 255 (£12.75), and the total will be stored in the microcontroller memory. Any further coins inserted will be "lost" credits.

After each "play" the credit count will be reduced by one. When the credit count falls below eight, the l.e.d.s above the main display will go out from the right to the left, warning you of the last few credits available.

Finally, after the last "play" has finished, the green *start* l.e.d will go off, the feature l.e.d.s will start sequencing, and pressing the *start* button with no credits will have no effect! You can insert coins at any time, even when the machine is paying out.

START BUTTON

Insert a coin and press the *start* button. Each of the three "reels" will cycle through a sequence of letters and symbols (six in all), which correspond to the "fruits". This cycle will slow down and stop with each reel from the left to the right.

WINNING AND PAYOUT

A WIN sequence starts with the "Feature" l.e.d.s flashing through a short pattern with the piezo sounding, and ends after paying out coins with the green *start* l.e.d coming on. (If you have remaining credits, that is.) A small win is achieved if the first two "reels" (left and middle), have the same "fruit" displayed on them when the "play" has finished. In all six cases, this win is two coins or 10p (i.e. double the stake and is similar to some commercial gaming machines).

If the third reel has the same "fruit" as the first two reels, a larger win results. This time, it is dependent on the fruit concerned, and this is listed in the Odds and Wins table in Fig. 13. The "jackpot" or highest win corresponds to the three dashes or "bars", and this combination pays out 20 coins (£1).

Low wins				High wins			
–	–	ANY	10p	–	–	–	£1.00 (Jackpot)
A	A	ANY	10p	A	A	A	50p
L	L	ANY	10p	L	L	L	40p
O	O	ANY	10p	O	O	O	30p
P	P	ANY	10p	P	P	P	20p
C	C	ANY	10p	C	C	C	20p

Fig. 13. Payout odds and possible win combinations.

HOLD FEATURE

The *hold* feature has been included to make the "play" more interesting, and is incorporated on virtually all fruit machines. It shifts the odds of winning in your favour by keeping reels the same as they were in the previous "play". If you have a *hold*, the three red l.e.d.s in the switches underneath the reels will flash. If you wish to hold any reel (i.e. keep the current "fruit" on the selected reel), press the appropriate *hold* button, and the l.e.d. will stay on continuously.

If you decide to change your mind, pressing the *hold* button again will cancel the hold, and the l.e.d. will flash again. After you have decided on what *hold* you require, press the *start* button and only those reels that have not been held will change.

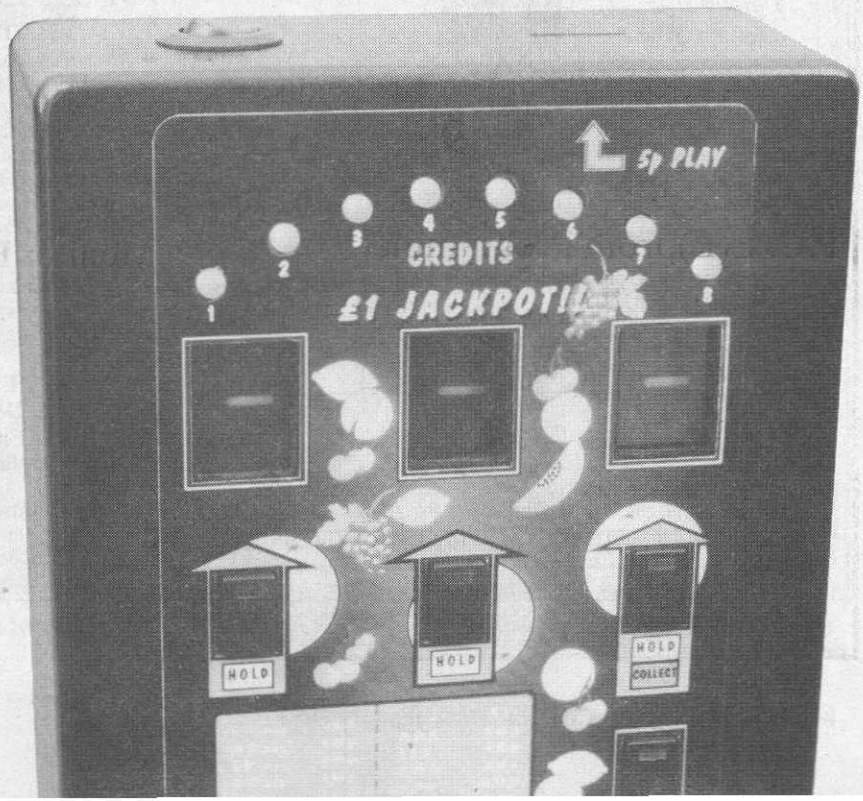
Remember, you may have a *hold* after a win! In this case, if it is a win where only the first two reels are the same, these two reels can be held to guarantee a two coin win, and possibly a higher win if the third reel is also the same after the next "game". Holding all three reels is wasteful (unless after a winning combination) but this is a valid option.

Another point to remember is that if you have no credits left, you do not know if you have a *hold* on the next game. Only by inserting another coin, will the credit l.e.d. will come on and if you have a *hold*, the *hold* l.e.d.s will flash. This feature does come up at random, but has been set in the software to happen about every one in three "plays".

GAMBLE FEATURE

An added bonus is that after each of the higher wins (three "fruits" the same), the

A "Jackpot" win is indicated by a row of dashes appearing in the reel windows.



gamble feature is implemented. Here, the green *start* l.e.d. and the red *hold* l.e.d. above it will flash. Now the player can *gamble* by pressing the *start* button, or he can collect the displayed win by pressing the right hand *hold* button which is marked "collect".

If the *gamble* is taken, the three reels will either "step up" to the next highest win, or they will step down to the next lowest win. Because of this, the *gamble* feature does not happen on the highest win, the three bar jackpot.

If the *gamble* is lost, the three reels will step down to the next lowest win and the machine will pay out this amount. If this happens on the lowest value "fruit" i.e. three cherries, then the game is lost.

If the *gamble* is won, the three reels will step up to the next highest win and then there will be a further opportunity to *gamble* again, in which case, the entire process is repeated. This may continue right up to the three bar jackpot if you are lucky! The highest number of successful *gambles* is five, starting at three cherries, and gambling up to the jackpot.

ODDS AND WINS

The format of the winning combinations is shown in Fig. 13. There are six fruits per reel: "–" = BAR; "A" = APPLE; "L" = LEMON; "O" = ORANGE; "P" = PLUM and "C" = CHERRY. This amounts to 216 different combinations that can come up on the three reels ($6 \times 6 \times 6 = 216$).

Only 36 of these are winning combinations. Of these winning combinations 30 occur when only the first and second "reels" are the same, paying two coins, or twice the stake. This occurs 30/216 times, or once in approximately every seven games.

If all 216 different conditions happen in the same number of "plays" (the theoretical average), then 112 coins will be paid out during these 216 games. This amounts to one of each of the six "high" wins, $20+10+8+6+4+4 = 52$ coins, and together with the 30 "low" wins, $30 \times 2 = 60$ coins, give a total of 112 coins.

This means that the payout percentage is 112/216 or about 52 per cent. This value is raised dramatically by the introduction of the *hold* and *gamble* features. The precise maths involved using these features is beyond the scope of this article (and the author's brains!), but after extensive tests, the actual payout percentage was found to be around 80 per cent, a similar amount to real gaming machines.

There may appear to be a curious effect where *wins* and *holds* do not seem to occur at random, but happen in groups. After playing many fruit machines, this is acutally quite normal! Quite often a high *win* may quickly follow a previous high *win*, and then it will *hold*!

This can be quite disconcerting to a player who has had a long run of losing, and the next player captures all the winnings, but this is all part of the fun! There is a small amount of strategy and skill involved to get the maximum possible wins from the machine, but it was thought best to leave the constructor or player to find these out!

The *hold* feature occurs at random 33 per cent of the time after a game, (one game in three) and the *gamble* feature occurs when there is a *win* line of three similar "fruits". (When a *gamble* is won, the feature repeats until either the *gamble* is lost, or the *win* is collected). □

Brett and Julyan would like to give special thanks to Mandy Harding for producing the front panel artwork.

PLEASE TAKE NOTE – Part 1

The component designations for the p.c.b. connectors listed in the "Components List" were incorrectly given. Although the actual types and quantity required are correct they should be designated as follows:

Plugs: PL1, PL2 and PL5 2-way. PL3 3-way. PL4 4-way.
Sockets: SK1, SK2 and SK5 2-way. SK3 3-way. SK4 4-way.

In the Fruit Machine circuit diagram Fig. 3, the electrolytic capacitors C6, C7 and C8 should, of course, be connected the other way round i.e. the negative side of the capacitors should go to the 0V line, the p.c.b. layout is correct.

The Futaba servo motor should be type **FB. S148.**

Finally, a change of address should be noted when sending for the ready programmed PIC microcontroller, self-adhesive front panel and a set of three 7-segment displays. The new address to write to can be found by turning to the *Shoptalk* page.