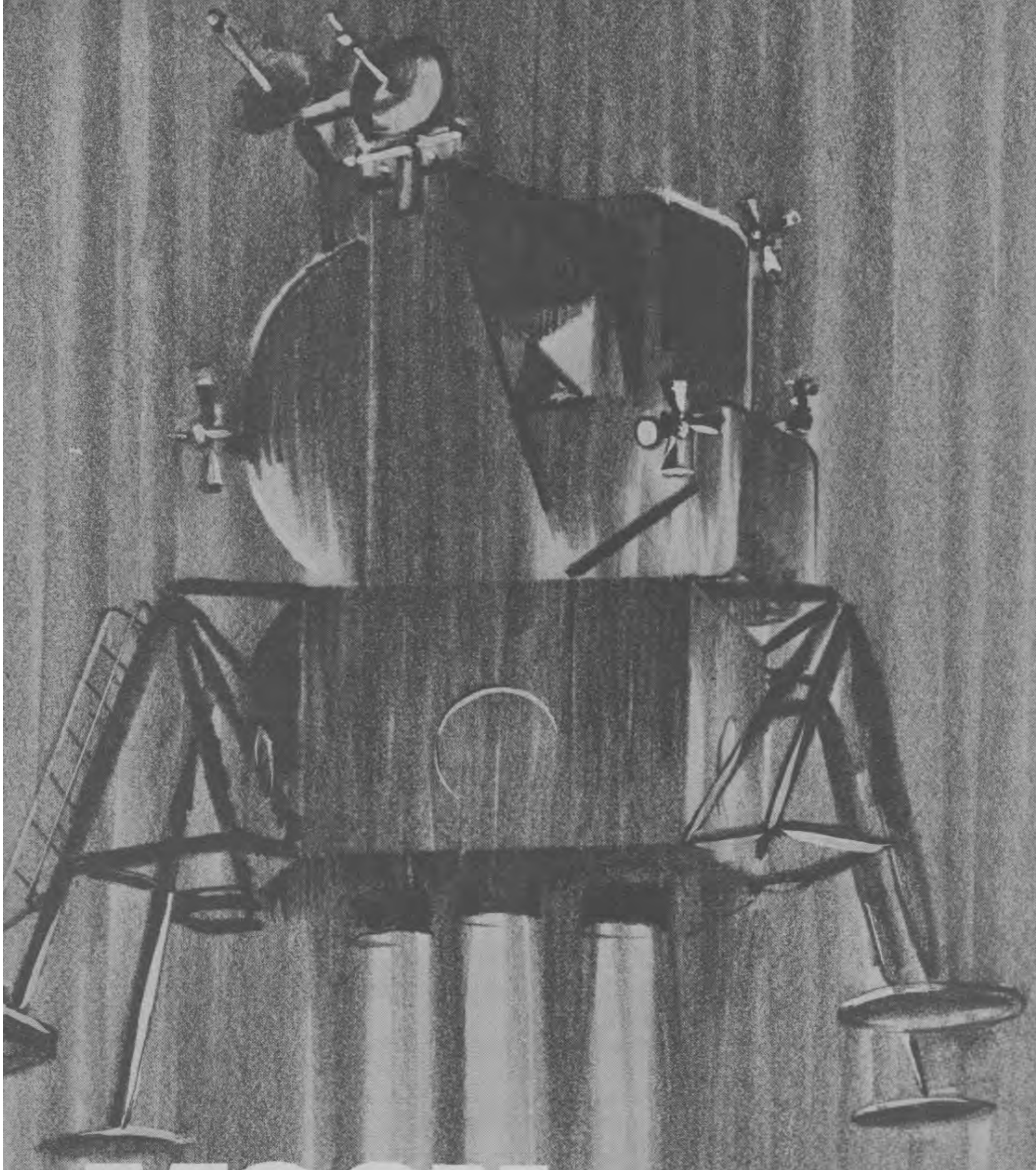


MOON LANDING GAME

A. RUSSELL

AT the controls of this game you can land your own space ship on the Moon and test your skill and timing by guiding the rocket to a safe landing before the fuel runs out.

Moon Landing is essentially a hard wired analogue computer which simulates approximately the dynamics of a space craft landing on the Moon. Additional circuitry monitors the computer and switches off the rocket motor when the fuel runs out, indicates when the craft has landed, and shows when a safe landing velocity is achieved.

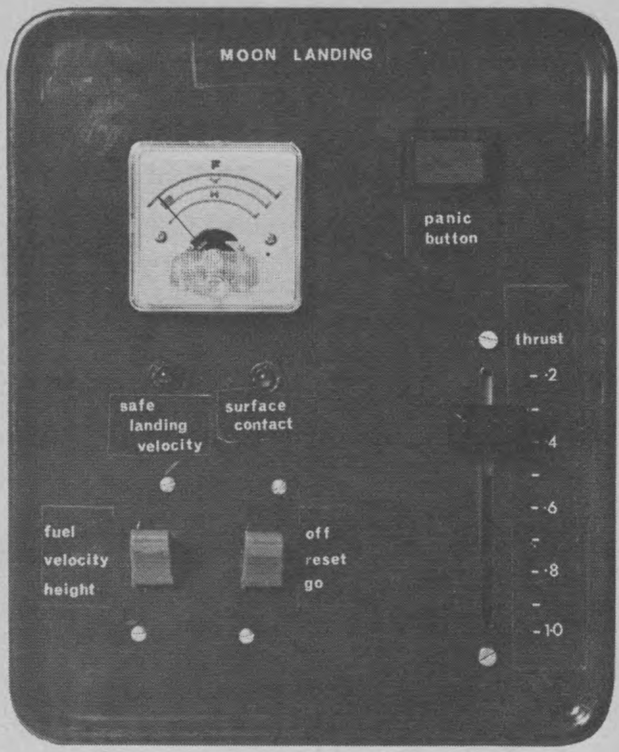
Playing the *Moon Landing* game gives children a feel for the concepts of distance, velocity and acceleration and the relationships between them. Thus as well as being fun to play it also has an educational value.

CONTROLLED DESCENT

You are pilot of the first British expedition to the Moon. At one minute before touchdown the flight control computer blows a fuse, leaving you to land under manual control. There is a lever to control rocket motor thrust and a meter which can be switched to read velocity, height or fuel reserves. Your object is to achieve touchdown at a safe landing speed.

Two lights are provided; one tells you that you have landed and the other indicates whether or not the touchdown was at a safe velocity. Therefore when both lights are on together you have completed a successful landing.

A "Panic" button is provided. In the event of fuel running out before landing (because of a bit of ham fisted driving on the part of the pilot) it will divert the contents of the medicinal whisky tank into the rocket fuel tanks, giving an extra 15 per cent fuel.



Control panel layout

SCHEMATIC

The analogue computer in *Moon Landing* represents a simplified view of a space craft landing on the Moon. No account is taken of the changing mass of the rocket as it burns fuel or changing gravitational attraction, etcetera.

A schematic diagram of the game is shown in Fig. 1. It is not intended to explain in detail the theoretical background of integral calculus and analogue computers. Those interested in finding out more could start by reading the "Analogue Computer" series currently running.

In Fig. 1, the value of thrust selected by the pilot is fed into Integrator 1 which calculates the total quantity of fuel used. When fuel runs out a level detector switches off the thrust. A "Panic" switch feeds more fuel into the fuel tank when it is pressed. Thrust from the rocket engines is added to Moon gravity to give total acceleration acting on the ship. Integrator 2 calculates the resulting velocity and a level switch lights the "Safe Landing Velocity" light when the downward velocity of the space craft falls below a certain value. Velocity is integrated by Integrator 3 to give space craft height and another level switch detects when this is zero to light the "Surface Contact" light.

CIRCUIT

The circuit diagram is shown in Fig. 2. Switch S2 has three positions. In the "Off" position power is disconnected from the circuit. In the "Reset" position capacitors in each integrator are charged to +5·1V to fill the fuel tanks (Integrator 1), give the rocket a large downward velocity (Integrator 2) and set the initial height above the Moon (Integrator 3).

When S2 is moved into the "Go" position the analogue computer starts its calculation. Slider pot VR1 ("Thrust") controls the voltage across R4. This voltage is fed into Integrator 1 (IC1) through R3. Output voltage of IC1 falls at a rate determined by the voltage across R4 (the "Thrust" setting) until point A goes sufficiently negative to forward

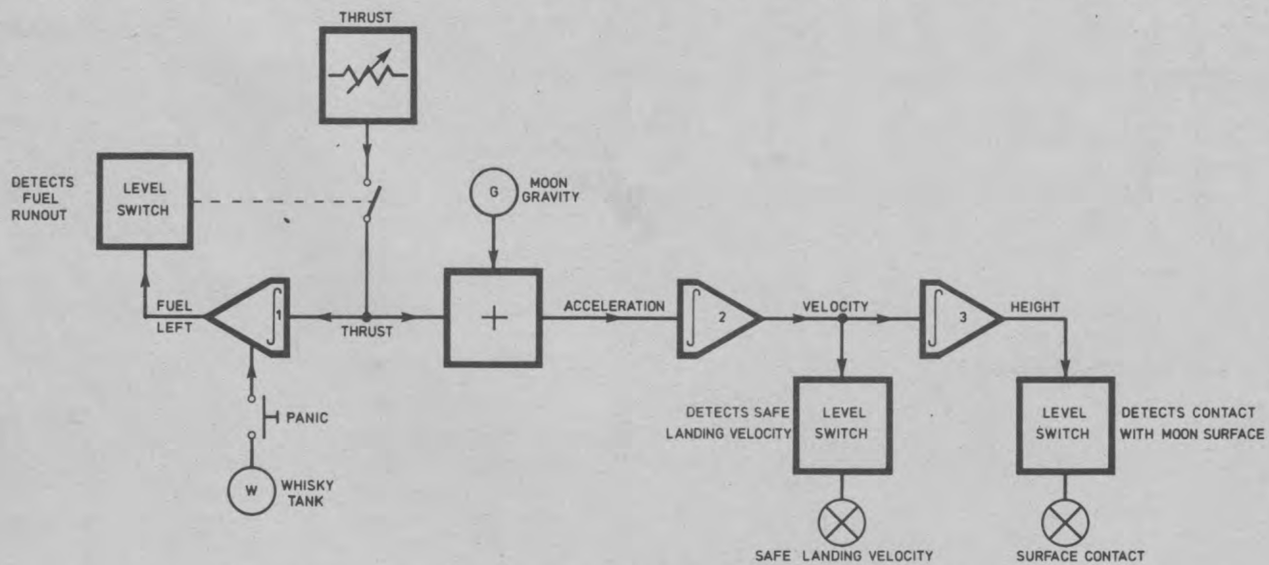


Fig. 1. Schematic diagram

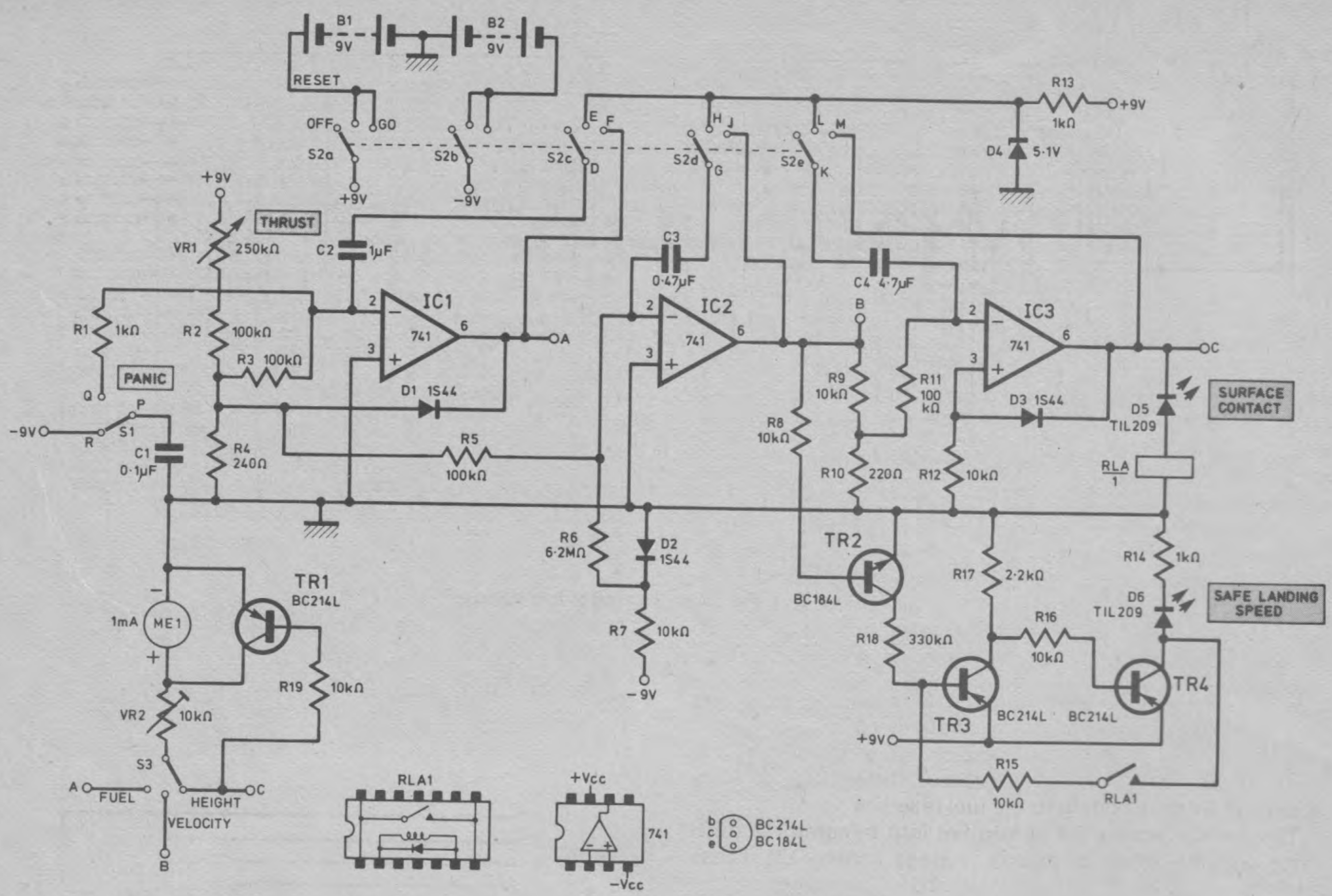


Fig. 2. ***Moon Landing*** **circuit**

COMPONENTS . . .

Resistors

R1	1kΩ	R11	100kΩ
R2	100kΩ	R12	10kΩ
R3	100kΩ	R13	1kΩ
R4	240Ω	R14	1kΩ
R5	100kΩ	R15	10kΩ
R6	6·2MΩ	R16	10kΩ
R7	10kΩ	R17	2·2kΩ
R8	10kΩ	R18	330kΩ
R9	10kΩ	R19	10kΩ
R10	220Ω		

All resistors $\frac{1}{8}$ watt 5% carbon

Capacitors

C1 0·1µF
C2 1µF
C3 0·47µF
C4 4·7µF
All capacitors polyester

Diodes

D1	1S44
D2	1S44
D3	1S44
D4	5·1V Zener
D5–D6	TIL209 (2 off)

Transistors

TR1 BC214L
TR2 BC184L
TR3 BC214L
TR4 BC214L
IC1 741
IC2 741
IC3 741

Potentiometers

VR1 250kΩ slider pot
VR2 10kΩ trimmer pot

Switches

S1 s.p.d.t. push-button
S2 PO type 1000 lever switch
S3 PO type 1000 lever switch

Miscellaneous

ME1 1mA meter. B1 and B2 PP3 batteries and suitable connectors. RLA d.i.l. reed relay 500Ω coil 3·7–10V operation. Veroboard, suitable plastic case, nuts and bolts, etc.

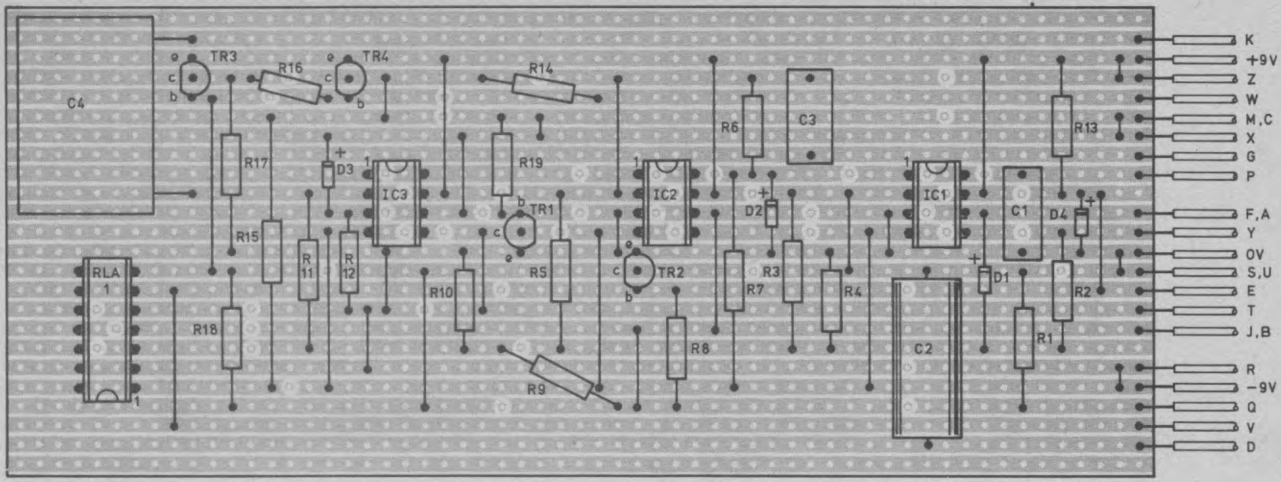


Fig. 3. Veroboard component layout

bias D1. Current drawn through D1 reduces the voltage across R4 to zero and effectively switches off the thrust.

If the "Panic" button is pressed, charge on capacitor C1 is fed into Integrator 1 which increases the voltage at A by about +0·9V thus adding to the fuel reserves.

The voltage across R4 is also fed into Integrator 2 (IC2) along with the effect of gravity (voltage across D2). These two inputs represent the accelerations acting upon the space craft and the output of Integrator 2 is the resulting velocity.

This output is monitored by TR2 which forms the "Safe Landing Velocity" level switch. When the voltage at B is above +0·5V, TR2 is biased on and feeds current into the base of TR3, via R18, which also switches on.

TR3 collector voltage is about +9V when it is switched on and so no current can flow through R16 to switch on TR4. D6 is therefore off. As the voltage at point B falls below +0·5V TR2 switches off and so TR3 also switches off. TR3 collector voltage becomes more negative, current flows into TR4 base, switching it on and lighting D6. When the relay pulls in upon landing, TR3 and TR4 are connected into a bistable circuit, by feedback through R15, which remembers the condition of D6 at the instant of landing.

The voltage at B ("Velocity") is fed through a potential divider R9 and R10 and then into Integrator 3 (IC3) which calculates the space craft height. When the voltage at C ("Height") falls to about −0·4V ("Surface Contact") diode D3 becomes forward biased and current flows through R12. The resulting voltage across R12 appears on the non inverting input of IC3 and is amplified in a positive feedback loop which forces the output of IC3 to −9V. D5 becomes forward biased and lights ("Surface Contact") and the relay is energised which latches D6 into the state it was in when the rocket landed.

METERING

The meter ME1 may be switched by S3 to read "Fuel", "Velocity" or "Height". When the voltage at C switches to −9V on landing, TR1 is switched on and shorts out the meter so that all readings fall to near zero on landing.

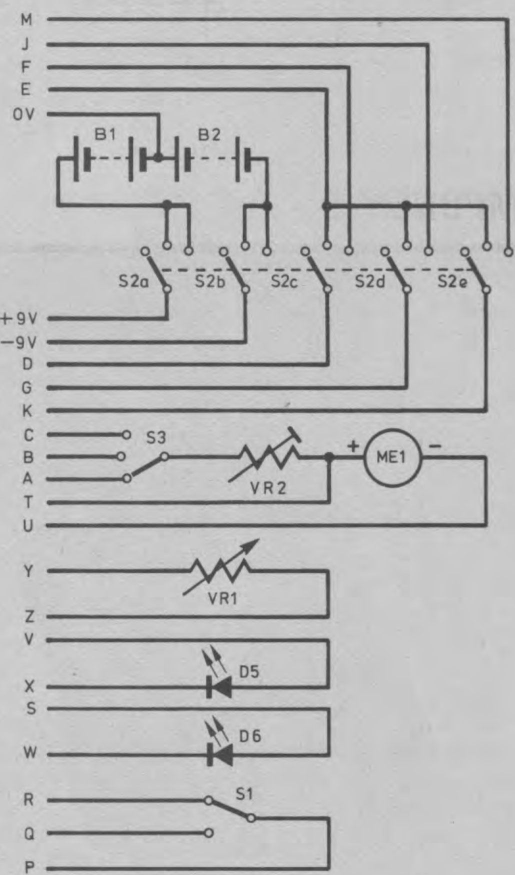
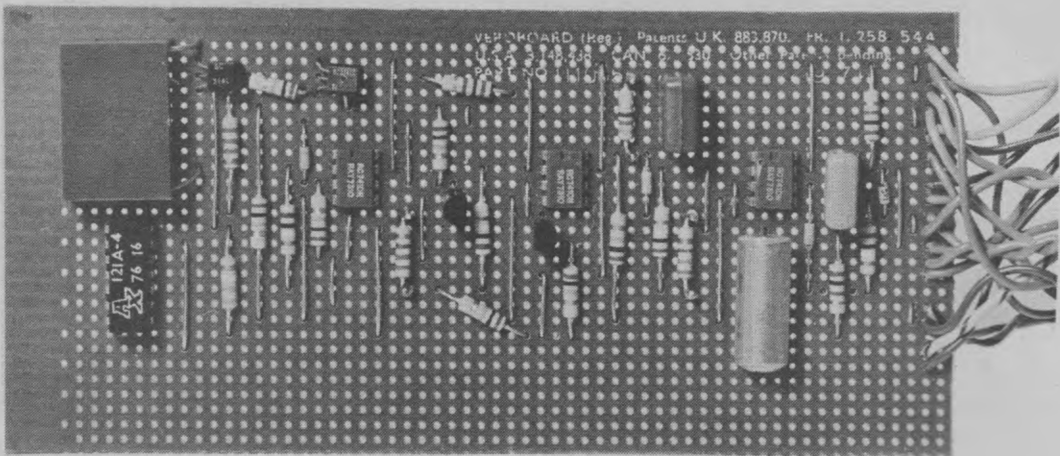
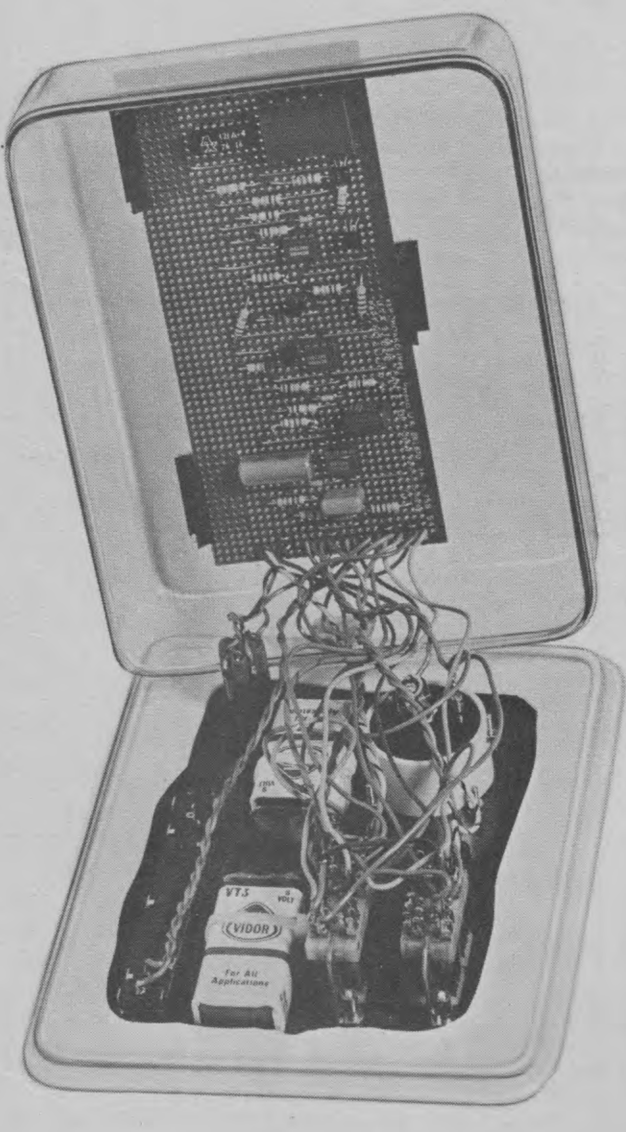


Fig. 4. Control panel wiring to Veroboard





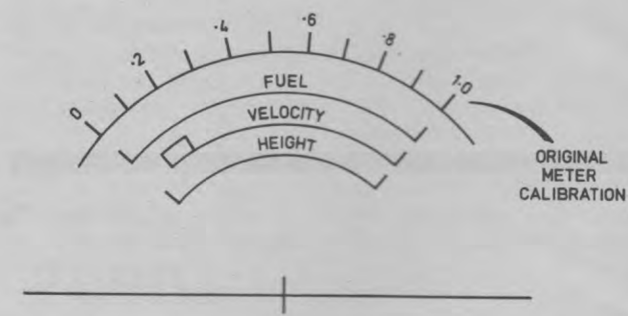


Fig. 5. Rescaling an existing milliammeter

CONSTRUCTION

The Veroboard layout of the *Moon Landing* circuit is shown in Fig. 3 and should present no constructional difficulties. Connections between the Veroboard circuit and the switches, l.e.d.s, etc. are shown in Fig. 4. These components are all mounted on the front panel. A plastic sandwich box was used to house the complete game and the layout chosen for the front panel controls is shown in the photograph.

CALIBRATION

The 1mA meter ME1 requires a new scale. Fig. 5 shows the relationship between the original 0–1mA calibration and the new one for fuel, velocity and height. The new scale may be drawn on plain white paper, cut to shape and glued into position. Take great care not to damage the meter movement while taking it apart.

Use the zero adjusting screw on the meter to set the pointer at zero on the velocity scale with the power off. Adjust VR2 to make the initial values (immediately after "Reset") of fuel, velocity and height agree with the new scale. The meter is now calibrated and landing is for "go". ★