To enable static and dynamic checks to be made, trial values are given to the ball problem of Fig. 7.4, as follows: $t_{real} = 1$ sec, $a = -32$ft/sec², $iv = 25$ft/sec, $is = 10$ft, $v = -7$ft/sec, $s = 19$ft, and $\mu/m = 0$. The problem scaling is such that 1 computer volt = 10 units in all cases. For example, 1V = 1 sec for t at the output of OA1 (10 × compute time), and 1·9V = 19ft for s at OA3 output. Calculation from the formula Eq. 7.4 shows that the ball will have travelled just beyond s_{max} after a time of 1 sec, when air resistance is zero.

The next stage is to establish all computer static voltages shown in the Fig. 7.5 symbolised diagram, starting with VS1. Set the dial of the master potentiometer to "10" and patch MP/SK1 to SK4, MP/SK2 to SK3, and MP/SK5 to SK8. Connect RM/SK2 to S1/I1/SK2. Switch on S6, set switch S10 to "null" and adjust VS1 dial for a null meter reading, corresponding to a voltage source output of − 1V. Remove the null input patching lead completely, and use it to link RM/SK1 to OA1/SK13.

With the readout meter on its 1V range, press S7, and trim compute time control VR19 for an integrator output of 1V; this will ensure that the compute interval is exactly 0·1 sec. Set up VS2, VS3, and VS4 check voltages, preferably by nulling with the master potentiometer to avoid loading, and rotate CP1 fully anti-clockwise. Switch off S6 and press S7 to reset the amplifiers. Check that amplifier outputs are zero.

To obtain dynamic check voltages, switch on S6 and press S7, while applying the readout meter to the outputs of OA1, OA2, and OA3 in turn. For greater convenience, three separate voltmeters can be left connected as shown in the patching circuit of Fig. 7.5 to give simultaneous readouts of t, v, and s. Before altering other problem variables, introduce air resistance by means of CP1 and arrest the travel of the ball at selected positions along its path by adjusting the compute time. It is instructive to compare the velocity and distance of the ball when $a = -32$ft/sec² and friction is present, with a ball projected upwards under moon gravity conditions (approximately $a = -5{\cdot}3$ft/sec²) in a vacuum.

The existing scaling of layout Fig. 7.5 will provide the following coverage: VR2 0–±100ft/sec², VR3 0–±100ft/sec, VR4 0–±100ft, with amplifier outputs of OA1 0·1–10sec, OA2 0–±100ft/sec, and OA3 0–±100ft. The coefficient of CP1 covers the range 0–10 for μ/m.

If at any instant during a computer run velocity exceeds 100ft/sec, or distance is greater than 100ft, this will result in amplifier overloading, and a false problem solution. Spot checks of velocity or distance voltage trends can be made at selected compute times, using the single shot facility, and s_{max} will correspond with $v = 0$ at a particular time t. Alternatively, during repetitive integrator switching, an oscilloscope will serve to show amplifier overloads as a flattening or clipping of an output waveform, but this should not be confused with the short "hold" interval which separates the opening and closing of reset and compute switches.

RESCALING PROBLEM EXAMPLE 4

The programme of Problem Example 4 need not be confined to the vertical motion of an object in air, but could equally well apply to movement up and down an inclined plane in water, or else the horizontal progress of a fast wheeled vehicle being decelerated by braking forces, for example.

There are several ways of rescaling Problem Example 4, the most obvious being the adoption of other unit systems, such as miles/hour, centimetres/sec, or even inches/year. Providing that compatible units are employed, and computer voltages are correctly interpreted, there are no serious barriers to unit system rescaling. Probably the most straightforward way of verifying a new problem scaling is to set up a simple check problem, where known values of t, a, v, and s are computed for an object in a vacuum, to establish the relationships between static and dynamic voltages.

Where it is desired to extend the range of an existing unit system, increasing the value of computing capacitors by a factor of ten will reduce real time by ten. Similarly, a tenfold increase in real time is achieved when C_f values are divided by ten.

When employing large computing capacitors at short compute times, always ensure that the reset resistor R_r is small enough to completely discharge C_f during the reset interval. It is also possible to alter the computer voltage scaling so that, for example, 1 computer volt will equal 100 units instead of 10 units, but care should be taken to make sure that *all* voltages and potentiometer settings conform to the new scaling.

Finally, a word or two about variable acceleration. If the input to OA2 is transferred from the VS2 source to the output of OA1, acceleration will then be zero

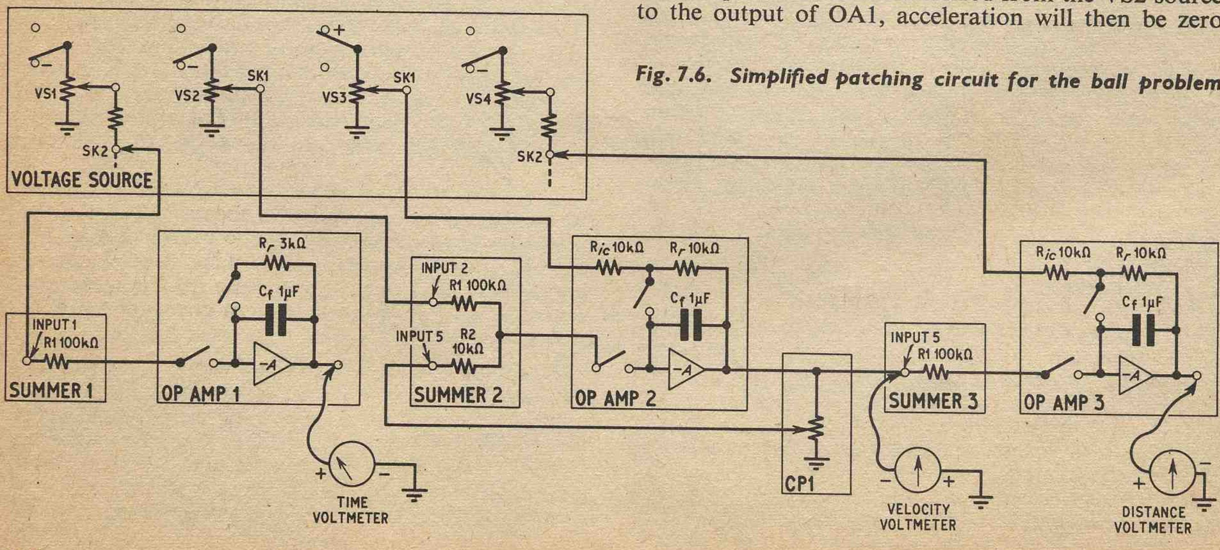

Fig. 7.6. Simplified patching circuit for the ball problem