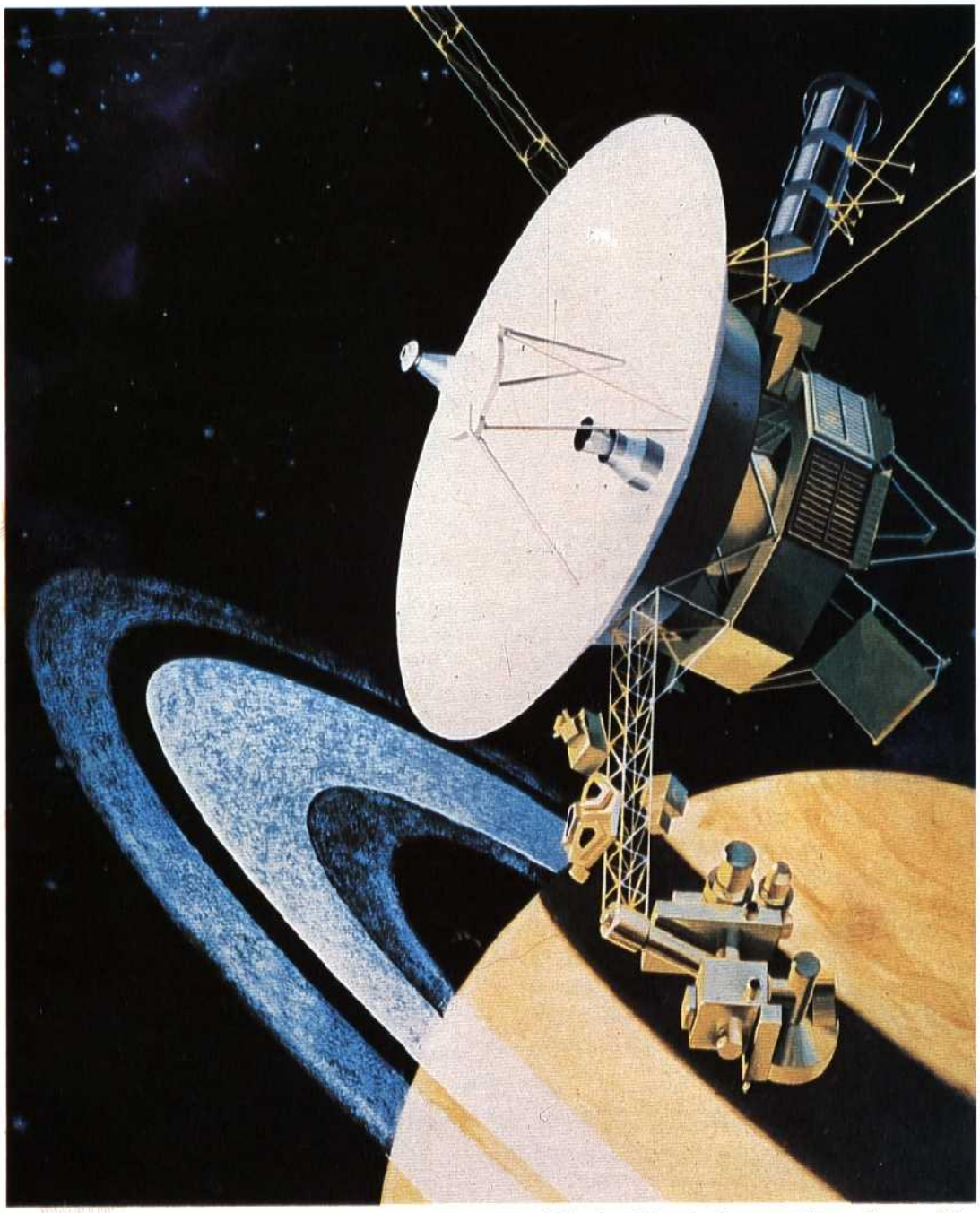
When Minus Equals Plus

Computers like their circuits simple and so must employ a clever trick to perform subtraction by means of addition



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Voyager 2

The spectacular Voyager was the first space explorer to go beyond our solar system. It travelled through space, taking pictures and gathering information, while the on-board computer converted the data into binary digits. The data were sent back to earth at the staggering rate of 115,000 bits per second. They were then processed by the NASA computer in Houston, Texas

In the first part of this series, we discovered that binary digits could be used to represent any decimal number. Binary numbers have the disadvantage of being longer than their decimal equivalent, but are convenient for the computer as the zeros and ones may be represented by zero and positive voltages. We also saw that binary numbers can be added together very simply.

On paper, binary numbers can be subtracted as easily as decimal numbers, following the same rules used in decimal subtraction. Computer designers realised long ago, however, that adding circuits (electronic circuits that perform addition) could both add and subtract without the need for special subtraction circuits. We shall find out how this is done.

Two's Complement

One method of representing negative numbers in computers is known as 'Two's Complement'. With this the process of subtraction appears as just another part of the addition. Consider the following arithmetical problem:

$$16 - 12 = 4$$

or $16 + (-12) = 4$