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A SIMPLE DIGITAL SYSTEM DRIVE FOR SMALL TELESCOPES

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ABSTRACT

A variable stable frequency source employing a crystal oscillator and a programmable digital divider chain is described. The system offers an ideal arrangement for controlling tracking rates of small and medium size telescopes by which limitations due to mechanical imperfections can almost be completely eliminated.

Key words: digital drive—variable rate generator

In small and medium size telescopes with aperture less than 1m, the need for a versatile drive control unit is frequently felt. In photometry, a very accurate drive enables the observer to cut down the diaphragm size to almost the seeing diameter limit, thereby vastly increasing the signal-to-noise ratio. With the conventional spectrographs, a precise control of the drift rate can be obtained by off-setting the tracking speed by small controlled amounts, resulting in uniform spectra, to be recorded. In older instruments this has been attempted by choosing a crystal controlled oscillator very close to a frequency which is an integral multiple of driving frequency of a synchronous motor with accurate gear reduction system. A fixed divider was normally employed to scale down the frequency to the synchronous value. For variable speed drive, a separate oscillator with less stability was used.

The arrangement works very satisfactorily for tracking the telescope near the zenith, where the refraction and mechanical corrections are almost non-existent; but at lower elevation the tracking is not so satisfactory. In photometry experiments, this calls for the use of a larger diaphragm with consequent deterioration of the signal-to-noise ratio. The variable oscillator, because of its lower stability, cannot be used to compensate for these errors, even if these were previously determined with desired accuracy. Above all the requirement of mechanical precision is rather high and choice of the natural crystal frequency becomes a bit rigid. Sometimes, these factors pose considerable difficulties.

In the present paper we describe a digital system where the majority of these limitations have been removed. Basically this employs a stable crystal controlled oscillator with a digital variable divider chain, whose scale factor can be precisely set or altered according to any pre-arranged pattern. The arrangement is versatile catering to a variety of synchronous driving systems with equal precision. This removes the stringent restrictions imposed on mechanical design and if required permits quick alteration of driving rate.

The basic arrangements of the variable rate generation system is shown in Figure 1. A stable frequency is generated by a crystal controlled oscillator which regulates the pulse generation rate of a schmidt trigger circuit. The pulses are scaled by a chain of counters, but unlike a normal scaling arrangement the scaled final pulses are not utilised. Instead, the counters are wired to a series of gate circuit chips, whose other input is selected by a series of thumbwheel switches. The coincidence circuit generates a pulse as soon as the total count reaches the value set by the thumbwheel switches. This pulse operates a flip-flop besides resetting the complete counter chain, when the whole operation starts all over again. The output of the flip-flop thus generates a square wave whose frequency, besides being very stable, can be accurately controlled by the thumbwheel setting. The square wave is next converted into its fundamental sinusoidal component by filtering, which drives the final power amplifier supplying

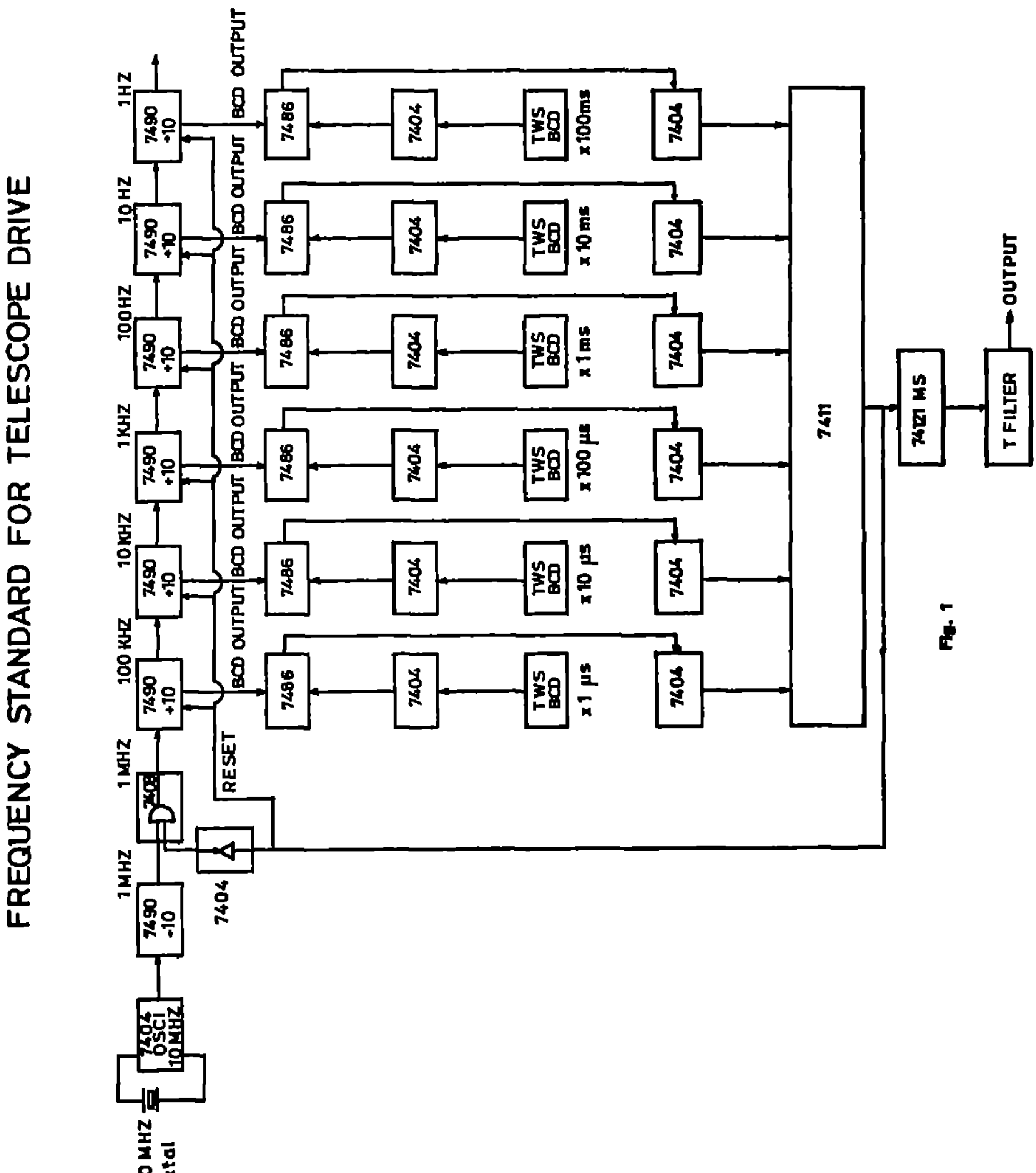
FREQUENCY STANDARD FOR TELESCOPE DRIVE
10 MHZ xtal
7404 OSCI 10 MHZ
7490 ÷10
1 MHZ
7408
7404
RESET
100 KHZ
10 KHZ
1 KHZ
100HZ
10 HZ
1HZ
BCD OUTPUT
7486
7404
TWS BCD
x 1 µs
x 10 µs
x 100 µs
x 1 ms
x 10 ms
x 100ms
7411
74121 MS
T FILTER
OUTPUT

Fig. 1

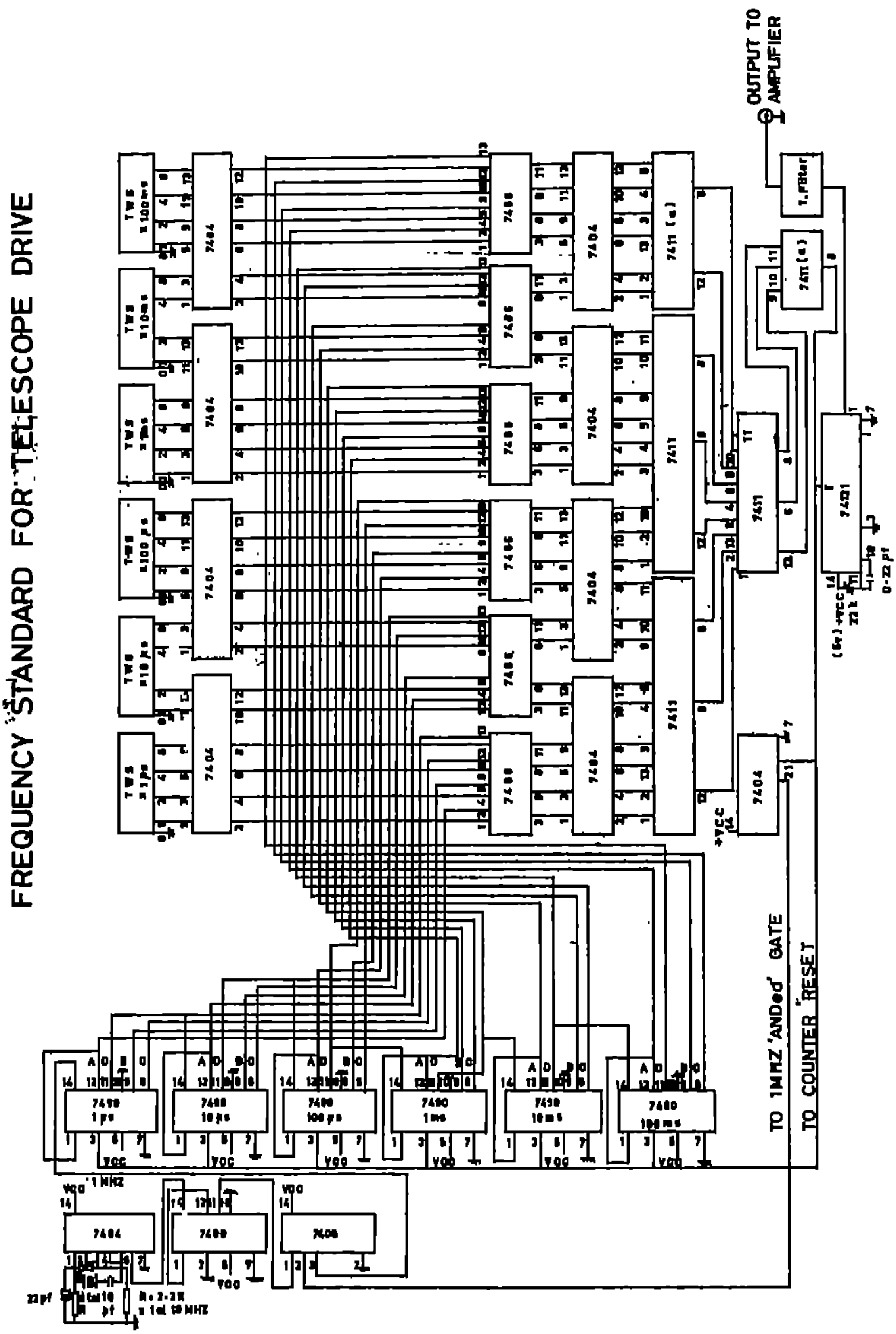
FREQUENCY STANDARD FOR TELESCOPE DRIVE
OUTPUT TO AMPLIFIER
TO 1MHZ 'ANDed' GATE
TO COUNTER RESET
7404
7486
7411
7490
74121
1MHZ
VCC

Fig. 2

power to synchronous motor drive. The complete circuit is fabricated by using about thirty digital I.C. chips of the 7400 series and is contained in two cards of 11 x 17 cm. Figure 2 shows the details of the chips and their arrangement. Figure 3 shows a photograph of the two cards, containing the entire digital system.

This digital system has been put into operation in the 38 cm photometric telescope at Kavalur and has proved its capability by actual performance. The required thumbwheel settings could be determined quite precisely by trial and error; during the trial runs, the programme star could be contained in a diaphragm of 30 arc sec for more than two hours. Small periodic errors were, however, found to exist whose origin can be traced to imperfections in the mechanical parts of the driving system. These errors in the Kavalur 38 cm telescope are of the order of 10 arc sec thereby limiting the choice of very small diaphragms; but for most of the observational programmes this is found to be a limitation of little significance.

For the total solar eclipse experiments in India, on February 16, 1980, a battery of these digital control systems were employed to provide adjustable rates for coelostat drives in different experiments. The precision and adaptability of the devices were found to be of a very high order, meeting the long overdue requirements of the experimental astrophysicists.

An extension of the present system in which the thumbwheel switches are to be replaced by shift registers, controlled by a keyboard, with provisions to programme the rate of drive compensating for flexure, mechanical and refraction errors is being worked out This may ultimately provide an inexpensive precise drive system for small and medium sized optical telescopes.