TIDAL PREDICTIONS FOR SOUTH AFRICAN WATERS

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The increasing use of the secondary and minor ports along the South African seaboard, and the ever-increasing tempo of oceanographical, tidal and fishery research have, for a considerable time, rendered desirable more frequent analyses and more accurate predictions than are at the moment available.

The current practice is for analyses for the standard ports Cape Town and Durban to be done every ten years by the Liverpool Tidal Institute, the results obtained being used for yearly predictions. Secondary ports are dealt with in Admiralty Tide Tables through time and height differences applied to the nearest standard-port prediction. Some of this information is based on data of some antiquity and doubtful accuracy which urgently require revision.

A great impetus was given to tidal research in South Africa through participation in the IGY, during which 8 tide gauges were installed in secondary ports and the records analysed for MSL computations. This accumulation of accurate and reliable data is now available for use in the computation of the tidal constants for the ports concerned.

Following the announcement at the IHB Conference of the production of a 12-component portable predictor designed by Dr. Doodson and manufactured by Messrs. Légé, it was decided, after suitable enquiry as to the suitability of the machine for the work envisaged, to acquire one for the S.A. Naval Hydrographic Office with the object of predicting tides for the more important of the secondary ports. An order was accordingly placed, the following components being specified :

		Values of Constants at Robben Island	
Diurnal Tides :		*Amplitude in ft*	*Phase Lag*
K_1	Lunar declinational constituents	.167	072°.0
O_1	Lunar declinational constituents	.028	281°.8
Q_1	Constituents due to changing parallax of the moon	.010	014°.7
J_1	Constituents due to changing parallax of the moon	.015	324°.4
P_1	Solar diurnal declinational term	.062	022°.6

		Values of Constants at Robben Island	
Semi-diurnal Tides :		*Amplitude in ft*	*Phase Lag*
μ_2	Lunar elliptic constituents	.061	357°.5
N_2	Lunar elliptic constituents	.396	056°.6
M_2	Principal lunar constituent	1.679	303°.5
K_2	Luni-solar declinational constituent	.153	120°.0
S_2	Principal solar semi-diurnal constituent	.708	246°.6
Quarter diurnals (Shallow-water constituents) :			
M_4	derivative of $2M_2$	.026	243°.0
MS_4	derivative of M_2 plus S_2	.008	095°.4

Whilst awaiting delivery, the Office staff was familiarized with the method of analysis of 29 days' observations devised by Dr. Doodson and published in the I.H. Review, May 1954, and suitable pro formas were prepared. Confining the analysis to the constituents specified for the predictor and correcting these as necessary for minor constituent as laid down in tables VIII and IX of the method, it was found that an analysis takes some 4 days' computing time including the checking at every stage by an independent computer (*). An electric computing machine is of course essential for this work.

Following the arrival of the machine, predictions were done using the constants obtained from an analysis of 29 days' records from the Robben Island gauge. These were then compared with the heights actually observed. In no case did the discrepancy exceed ± 0.2 feet, a most gratifying result. The machine was then run for a period of three months without any loss of accuracy.

For the benefit of other hydrographic offices contemplating a similar programme and possibly like ourselves without a trained tidal specialist, the following remarks concerning the predictor are offered.

As is well known, the height of the tide at any moment above a datum can be expressed by the following formula :

$$h = Z_0 + \Sigma f H \cos (V_0 + u - g + nt)$$

where

$Z_0 =$ the mean height of the tide above the datum used for prediction

$H =$ mean amplitude of the constituent

$f =$ the factor for reducing the mean amplitude H of a constituent to the year of prediction

$V_0 + u =$ value of the equilibrium argument of the constituent when $t = 0$, viz. the phase of the equilibrium tidal constituent

$g =$ the phase lag or epoch of the constituent computed for Greenwich meridian

$n =$ the constituent speed in degrees per hour

$t =$ No. of hours elapsed since the beginning of the epoch.

At the beginning of the epoch, when $t = 0$, the angle of each constituent tide simplifies to $(V_0 + u - g)$ which is the phase of the equilibrium

(*) When more familiarity with the computation is acquired it is anticipated this time will be reduced to 2 ½-3 working days.

constituent tide minus the phase lag g. Thereafter the angle increases in proportion to nt, the height changing accordingly.

To predict accurately a tidal curve therefore it is necessary to :

(*i*) set the initial height of mean sea level above chart datum;

(*ii*) add to this height by hand setting the height contribution of each constituent at time $t = 0$, viz. $f\mathrm{H} \cos (\mathrm{V}_0 + u - g)$;

(*iii*) record further changes in height of each constituent as the phase increases in proportion to nt, viz. $f\mathrm{H} \cos (\mathrm{V}_0 + u - g + nt)$ and sum and apply them automatically to height dial.

We will now see how the predictor satisfies these requirements. The predictor consists of :

(*i*) a height scale on which the Z_0 is set by hand as the initial setting. All other settings must be zero.

(*ii*) a time unit. Zero hour is set by moving the operating handwheel forward. The correct day is set by rotating setting wheels until the wanted number is reached, e.g. 2 January = 2.

(*iii*) dials which simulate the harmonic motion of the 12 constituent tides. These are operated by hand as regards the initial setting and subsequently by gears worked by the main driving shaft which is operated by a central handwheel. This latter turns 360° for one hour on the time scale and precise gearing ensures that the dials revolve at their correct constituent speed of n° per hour.

Setting the amplitude $f\mathrm{H}$ adjusts the length of a radial arm on the back of each dial. At the end of this arm is a pin engaging in a slot in the face of an associated pulley which is free to move only in a vertical direction. The initial amplitude setting with angle 0° lifts the pulley through a distance $f\mathrm{H}$ and, as the dial revolves, the pulley rises and falls automatically, the heights of the constituent at any moment t being equal to $f\mathrm{H} \cos (\mathrm{V}_0 + u - g + nt)$. See sketch No. 1.

These vertical motions are summed and applied simultaneously to the height dial by means of a tape under tension fixed at one end, led over each pulley and then around the height-dial drum. With this arrangement any vertical movement of a constituent pulley causes the height drum to revolve a proportional amount, the composite h-value being read against a fixed scale. The height scale therefore reflects at any moment t the height of the tide above chart datum, viz. $\mathrm{Z}_0 + f\mathrm{H} \cos (\mathrm{V}_0 + u + nt - g)$. See sketch No. 2. To read hourly heights a stop to the handwheel is provided which engages after one complete turn (one hour on the time scale). To read times and heights of high and low waters this stop is disconnected and the handwheel revolved until maximum and minimum heights are registered on the height scale. The times are then read off the time scale.

It is the intention of this Office to issue monthly tide tables in respect of the following ports : Walvis Bay, Port Nolloth, Luderitz Bay, East London, Hermanus, Simons Bay, St. Helena Bay, Port Elizabeth and Mossel Bay. The operative factor of course will be the question of the analyses — once these are done the rest will follow quite easily. All officers on the staff (three in number — vide I.H. Review, November 1958) will help in this, after which it is hoped that the Tidal Officer with one new assistant will be able to deal with predictions and publications of the tables in addition

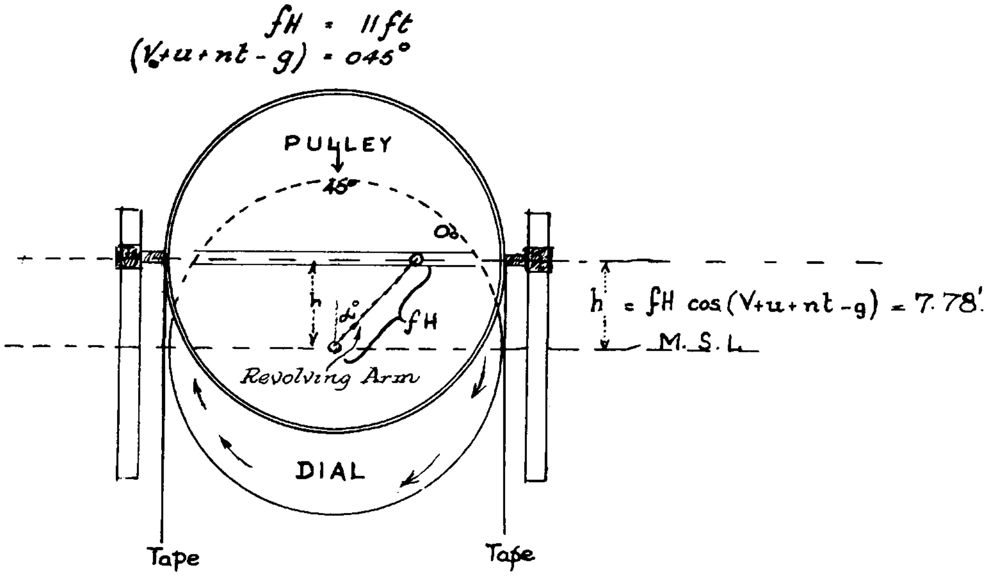


FIG. 1. — Harmonic motion.

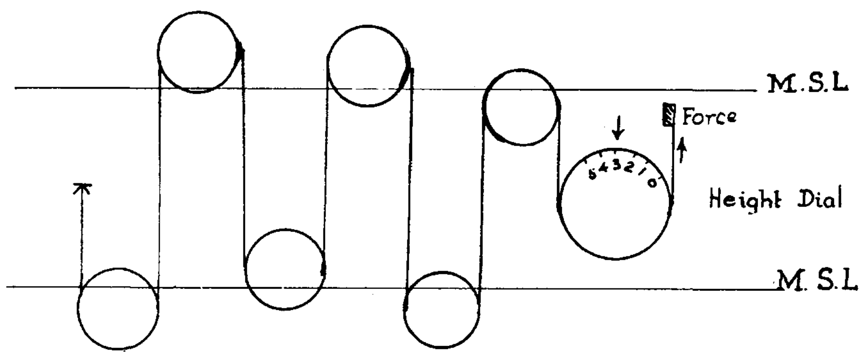
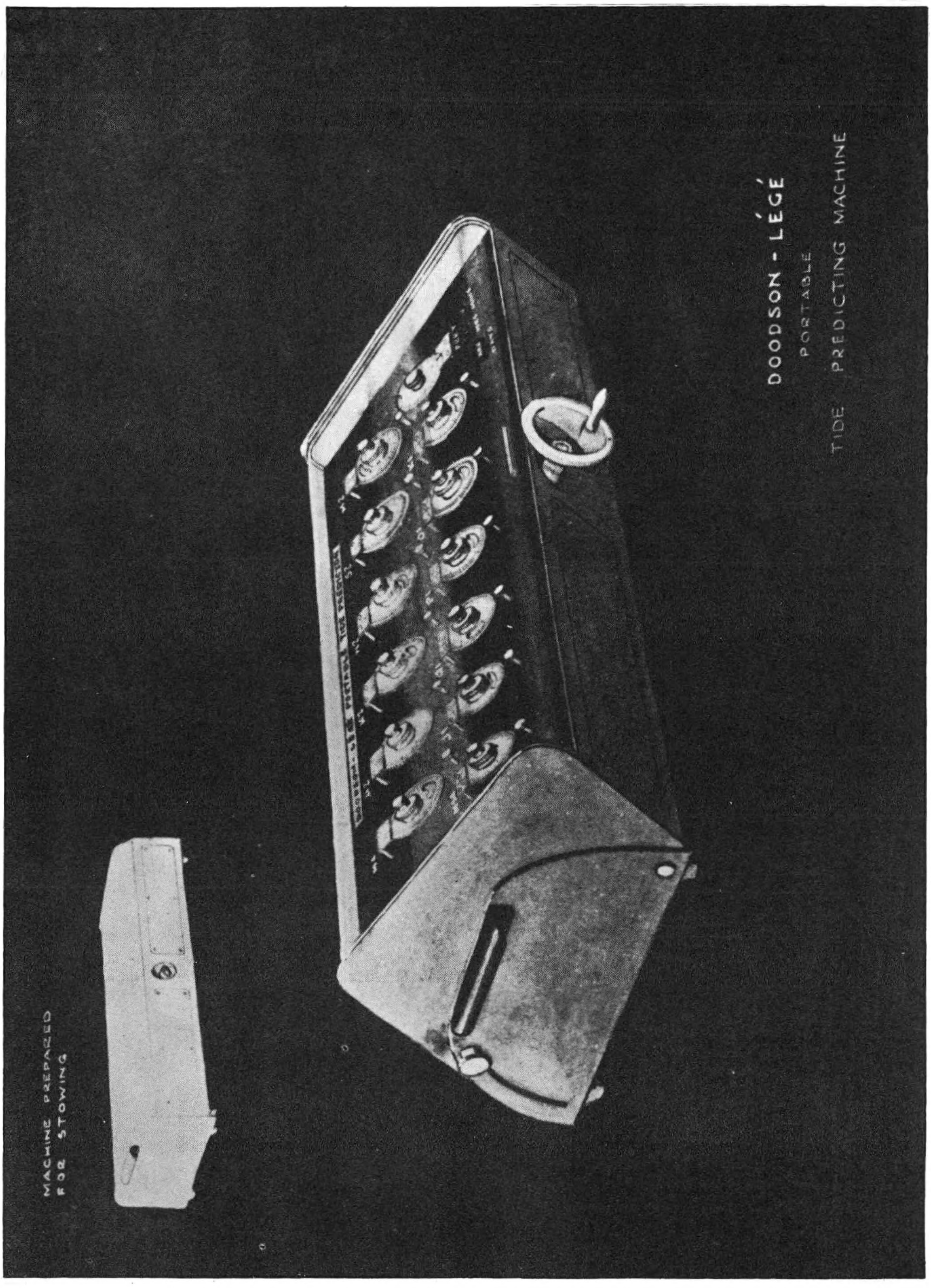


FIG. 2. — Summation of motions.

to MSL computation by integrimeter and the maintenance and periodical calibration of the tide gauges.

The predictor has incidentally aroused much interest in South African academic and scientific circles, to which we have promised any assistance it will enable us to offer.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TIDE PREDICTING MACHINE
MACHINE PREPARED
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