Report NYO 10.606

"STUDY ON THE MECHANICAL WORKING CONDITIONS OF NUCLEAR MATERIALS AS RELATED TO ROLLING"

Second Quaterly Report

C. A. Martínez Vidal
J. A. Sabato

September 1962
Comisión Nacional de Energía Atómica
Buenos Aires
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to

U.S. Atomic Energy Commission

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TABLE OF CONTENTS

Abstract

This report covers: a) the design, construction and adjustement of a Ford plane-strain compression die, to be used in the determination of constrained yield stress curves, and b) the design and construction of a load cell with strain gauges to be used in the measurement of the rolling load during rolling.-

1.- INTRODUCTION

In the First Quaterly Report NYO 9843, was indicated that the results obtained with the Ford die were not satisfactory. The die was repeared, but even so, it was not possible to obtain reliable results. It was decided then to build a new die, where various improvements -respect to the old one- were introduced, as it is described in 2.1.1.

The determination of the actual rolling loads -by mean of the measurement of the forces acting on the left and right upper bearing-holder- was necesary to correlate them with the values obtained with the Ford die.-

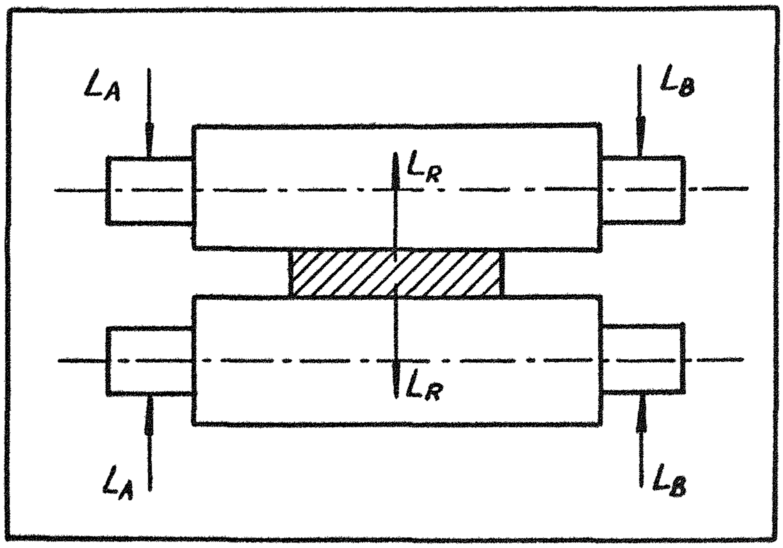
2.- EXPERIMENTAL PROCEDURES

2.1 Apparatus

2.1.1 Ford compression die: In the First Quaterly Report we have given the general description of the Ford compression die. In the new Ford die, the four columns were eliminated and the tool-dies were modified in order to obtain a compact body with only two windows to put in and to take out the samples. Fig. 1 is a drawing of the die and Fig. 2 (Plate I) shows the actual die (1,2,3,4).

Two sets of tool-dies made of special tool steel were built. Their dimensions are 2 x 50 mm and 5 x 50 mm.

2.1.2 Load cell: If we considered perfect alignement in the rolling mill and non-flatteness of the rolls (5,6), the rolling load, as it is shown in Fig. 3, can be divided in two forces, L_A and L_B, that



L_R - Rolling load

L_A and L_B - Measured loads

$L_R = L_A + L_B$

Fig. 3 - Rolling load in the rolling mill

could be measured with load cells (7) situated in the bearing-holders. These load cells should operate without interfering with the eventual raising and lowering of the rolls (Fig. 4).

The upper plate has an spherical seat in which the screw down is applied and two threaded rods keep the plate tight in position.

The body of the load cell has four strain gauges, two actives

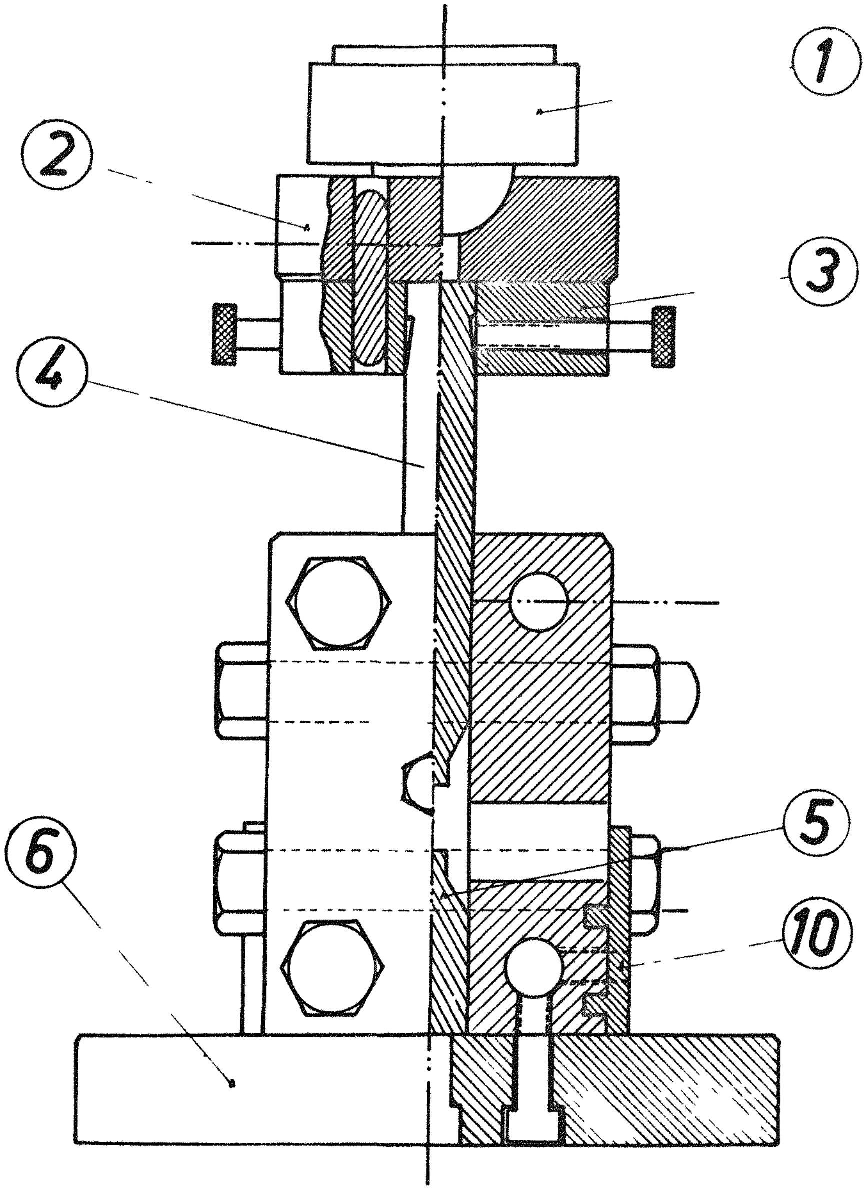


Fig. 1 - Plane-strain compression Ford die

1) 2) 3) : Upper die shank with a spheric seat
4) : Top die
5) : Bottom die
6) : Backing-plate for the whole die
10) : Guide for centering the specimens

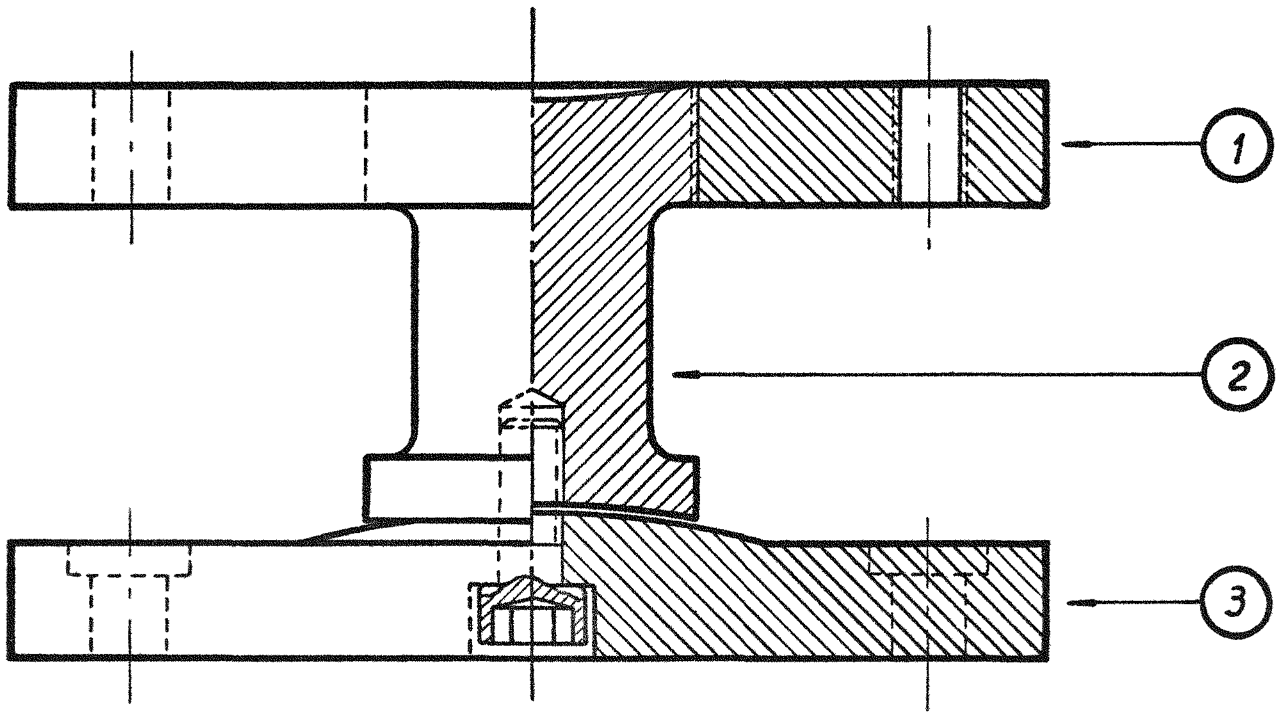


Fig 4 - Load cell

1) Upper plate
2) Body of the load cell
3) Lower plate

and two dummies for temperature compensation. Through an spherical surface the load cell body seats in the lower plate, and an allen screw joins the lower plate to the body.

The lower plate is fixed with four screws to the upper bearing-holder. Fig. 5 shows a load cell in the rolling mill.

The cross-section of the body was calculated in order to be able to produce 0.2 °/o strain with the maximun rolling load of the rolling mill (35 tons):

stress $\sigma = \varepsilon E = 0.002 \times 21{,}000 \text{ kg/mm}^2 = 42 \text{ kg/mm}^2$

cross-section $A = L/\sigma = 35{,}000 \text{ kg}/42 \text{ kg/mm}^2 = 835 \text{ mm}^2$

the final diameter was fixed in 32 mm.-

2.2 Materials

The material used in the Ford compression test was fully annealed electrolytic copper strips.

Chemical composition: Si $<$ 0.01 ; Ni - 0.01 ; Fe - 0.01 ;
Ag $<$ 0.1 ; Al $<$ 0.01 ; Mg $<$ 0.001

2.3 General Methods

2.3.1 Ford compression die: The specimen are copper strips of 49 mm wide and 5 mm thickness. The die is fixed with a small load and the change in the dial gage is measured for every ton of load. The elastic recovery is measured by discharging the load suddenly. With the measured values, the conventional strain and the constrained yield stress are calculated:

conventional strain $e = \Delta h/h_o$

constrained yiel stress $$\text{CYS} = \frac{\text{load}}{\text{area of identation}}$$

2.3.2 Rolling load measurement: Fig. 6 shows the electric circuit used. Two half strain gauges bridges are measured with two suitable

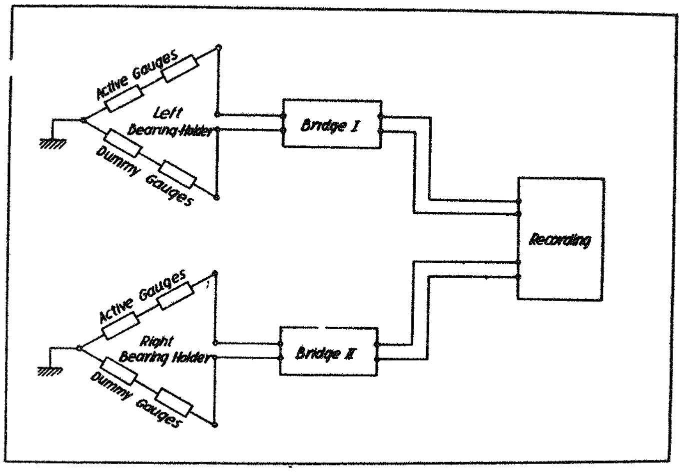


Fig. 6 - Rolling load measuring circuit

instruments and the output registered in a two channel high speed recorder (oscilograph type).
Previously, the whole assembly is calibrated in a universal testing machine.-

3.- EXPERIMENTAL RESULTS

One group of ten copper strips samples of 5 mm thickness and another group of ten copper strip samples of 2 mm thickness have been tested. As the dies have 2 mm and 5 mm wide, the thickness chosen in every group of samples is such that the same relation

$$t/b = \frac{\text{thickness of sample}}{\text{wide of the die}} = 1$$

is mantained. The dies were lubricated with molybdenun bisulphide and colloidal graphite suspended in alcohol.

In all the tests a strain-rate less than 0.1 °/o per sec. was maintained. The results are diagrammed in Fig. 7 and compared with the original Ford results in Table I (4).

Fig. 8 (Plate II) shows four specimen tested with the die of 5 mm wide.-

4.- DISCUSSION AND CONCLUSIONS

In our First Quaterly Report, it was mentioned that the non-axiality between the dies in that first Ford die, was one of the principal problems to be solved and Fig. 9 (Plate II) shows some tested samples where bending -due to non-axiality- is quite remarkable in the compression zone.

If Fig. 9 (Plate II) in compared with Fig. 8 (Plate II) -specimens deformed with the new designed Ford die- the differences between both groups of samples can be appreciated; with the new Ford die perfect axiality is maintained even for reductions as high as 95 °/o.

In Fig. 7 and in Table I, we compare the results obtained in four different samples (in two of them the relation t/b = 1 is maintaines) with the original results obtained by Watts and Ford (4).

There is remarkable agreement between both groups of experimental values, and so it can be said that the new Ford plane-strain compression die provides results with very good reproducibility and little scattering.

Furthermore, the whole assembly for measuring the rolling load is ready for calibration and so, sistematic determinations of the true yield stress, constrained yield stress and specific rolling pressure in the chosen metals can be now carried out.-

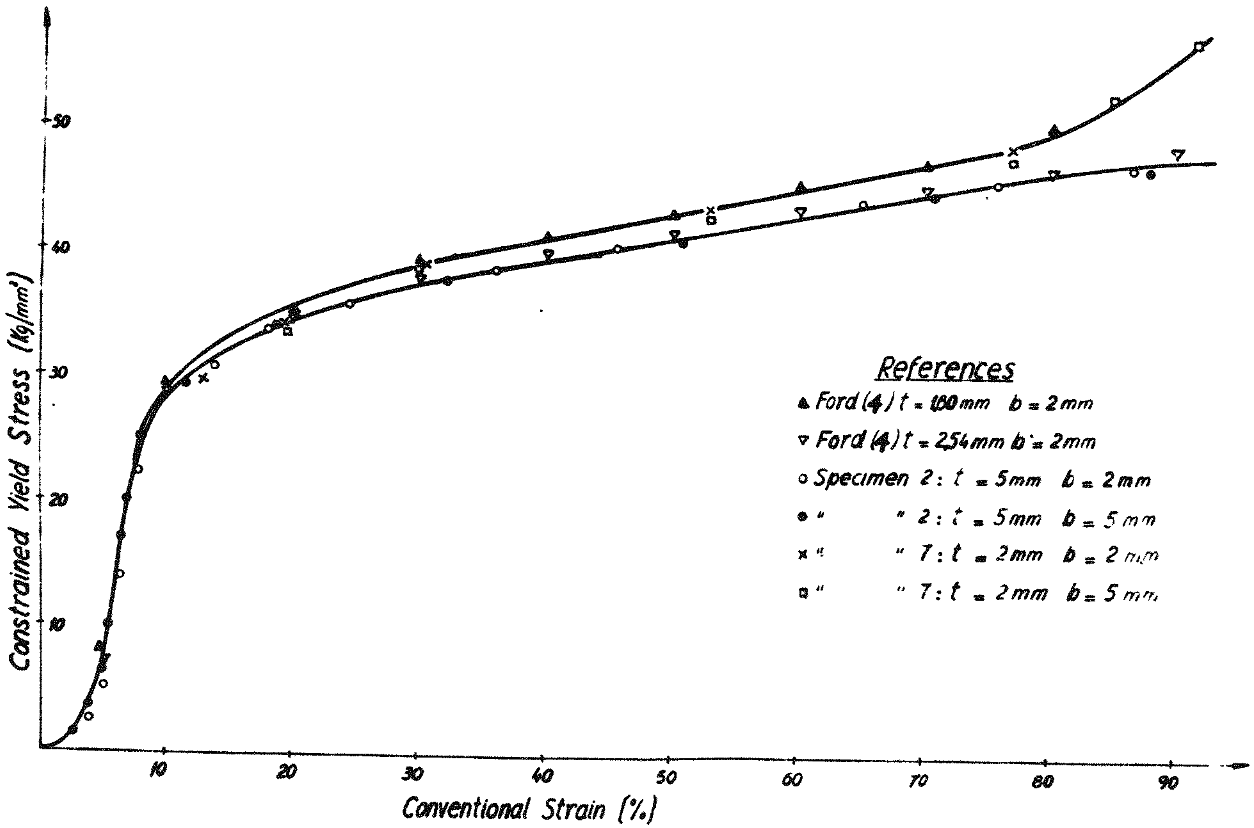


Fig. 7 _ Constrained Yield Stress For Copper _

Table I

COMPARATIVE CONSTRAINED YIELD STRESS VALUES OF COPPER

References	Conventional Deformation (o/o)								
	10	20	30	40	50	60	70	80	90
Ford (4) a	28.7	35.5	39.0	41.3	43.2	45.5	47.3	50.4	63.0
Present work b	28.7	35.6	38.8	41.1	43.1	45.2	47.3	50.0	56.1
Ford (4) c	29.2	34.4	37.8	39.8	41.6	43.2	45.0	46.4	48.2
Present work d	28.2	34.2	37.4	39.3	41.1	43.0	44.8	46.7	47.9

a : t = 1.80 mm , b = 2 mm , t/b = 0.90

b : t = 2.00 mm , b = 2 mm , t/b = 1.00

c : t = 2.54 mm , b = 2 mm , t/b = 1.27

d : t = 5.00 mm , b = 2 mm , t/b = 2.50

Plate I

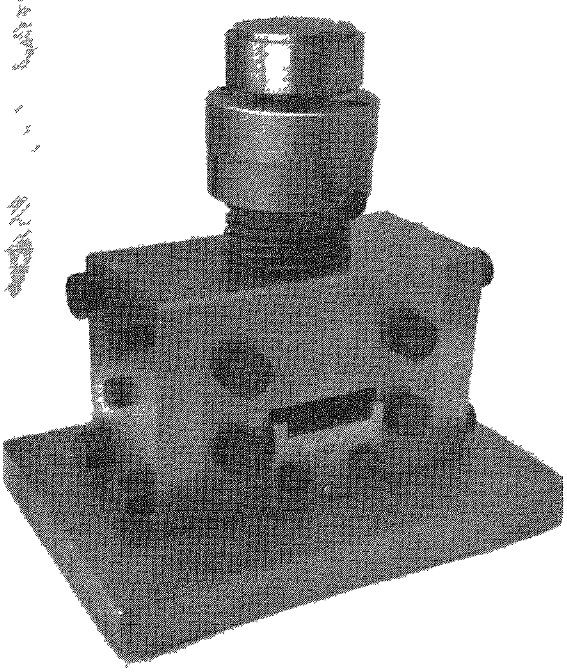


Fig 2 Assembly of the Ford plane-strain compression die

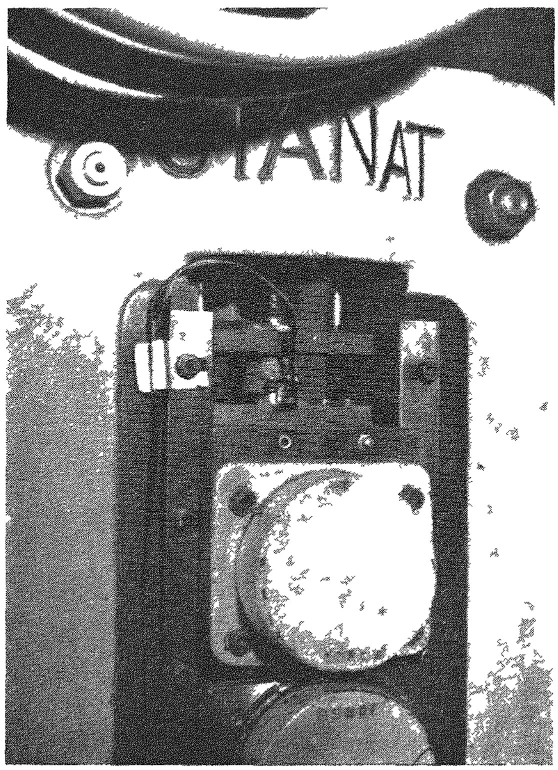


Fig 5 Load cell in the working position in the rolling mill

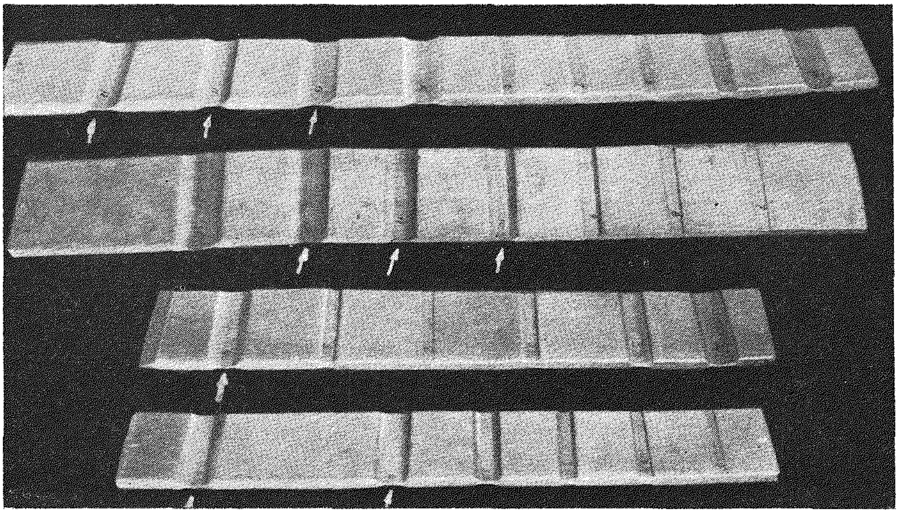


Fig. 8 - Specimens tested with the new Ford die (5 mm thickness, idented with a die 5 mm wide)

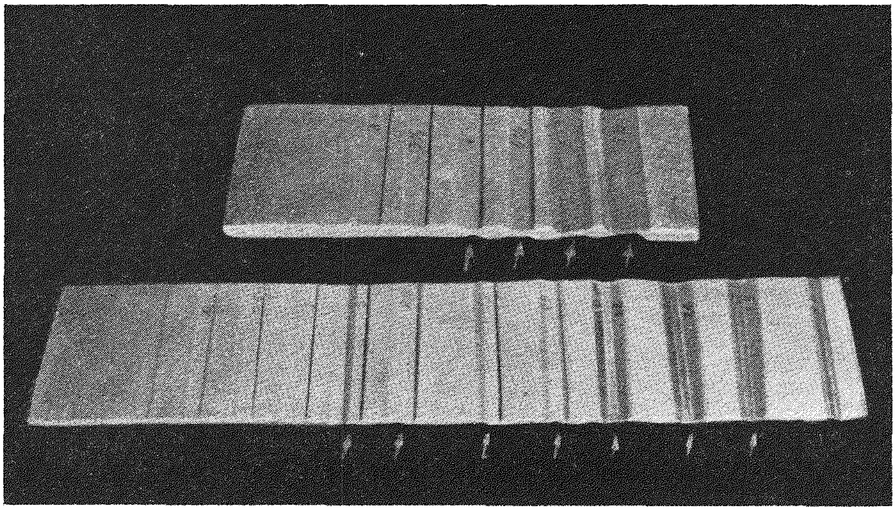


Fig. 9 - Specimens tested with the old Ford die, showing the non axiality

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