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INSTRUMENTED AND COMPUTER INTERFACED SINGLE PUNCH TABLET PRESS FOR THE RAPID EVALUATION OF COMPRESSION AND LUBRICATION BEHAVIOUR

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SUMMARY

A low cost instrumented and computer interfaced single punch tablet press was developed for the rapid data aquisition of compression and lubrication properties of powders and processed materials.

A Manesty type F3 tablet machine has been modified to enable the fitting of piezo electric load cells to both upper and lower punch assemblies. The

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paper describes how the modifications permit interchangability of a range of punch sizes and shapes and yet ensure good accuracy and reproducibility of compression and lubrication data.

The instrumentation is interfaced with a dedicated A.I.M. 65 microcomputer for the rapid conversion of the instrumentation outputs into compression force units and for statistical evaluation. The computer software also incorporates a novel method for the evaluation of lubrication properties from a single or a series of pre-determined compression events, using the same sensitivity for force measurement from the lower punch load cell.

The compression data and the physical properties of the compacts can be stored and retreived as fingerprints using a P.E.T. microcomputer and a digital plotter. A data bank may then be developed for the evaluation of raw materials, product development, monitoring of production performance and trouble shooting.

The paper further describes the evaluation of new lubricants in comparison with magnesium stearate using the instrumentation described.

INTRODUCTION

The instrumented tablet machine has been demonstrated to be an invaluable tool for research and development workers to evaluate compression behaviour.[1, 2,3.] Piezo Electric load cells have been shown to be superior to conventional strain gauge instrumentation in single punch machines, Muller et. al.[4]. They also observed inaccuracies in the measurement of force due to the type of load cell mounting.

A common method for evaluating the transient signals generated by piezo electric load cells conditioned by charge amplifiers is to use an ultra violet oscillograph [5], a recorder with high dynamic fidelity. An oscilloscope may also be used, although this instrument can suffer from poor resolution.

Since the development of the microprocessor however, the anologue signals may be converted into digital form for rapid data manipulation and statistical evaluation by a computer.

The paper describes the instrumentation of a Manesty F reciprocating single punch machine interfaced with a dedicated A.I.M. 65 microcomputer (a low cost microcomputer with a printer and line display on a single board).

The paper further describes the storage and retrieval of compression profiles and how new lubricants may be evaluated using the system.

Although magnesium stearate is an efficient tablet lubricant, the well-known deleterious effects of extended disintegration times and lowering of the crushing force have led researchers to identify suitable alternatives [6,7]. This study optimises the concentration of magnesium stearate and two new lubricants in a placebo base, using both residual area and ejection force measurement. The study then compares each lubricant at optimum concentration and evaluates the effect of the lubricant on tablet properties.

INSTRUMENTATION

The Manesty F3 tablet machine was modified to accept Kistler piezo electric load cells (Type 903A). The modifications to the machine were designed so that the load cells were positioned as close as possible to the force origin for accurate force measurement and still enable rapid interchange of punch and die sets. Figures 1 and 2, a useful facility when a range of pharmaceutical materials are to be evaluated. The design also ensured that the measurement of force was closely related to that seen at the punch face, i.e. no disruption in the force axis such as the punch retaining screw as observed by Muller [4].

Although the piezo electric load cells were pre-calibrated by the manufacturers, this calibration was rechecked using a Dennison Hydraulic press over a range of forces up to 40KN. with the load cells free-standing and assembled in their respective mounting assemblies of the F3.

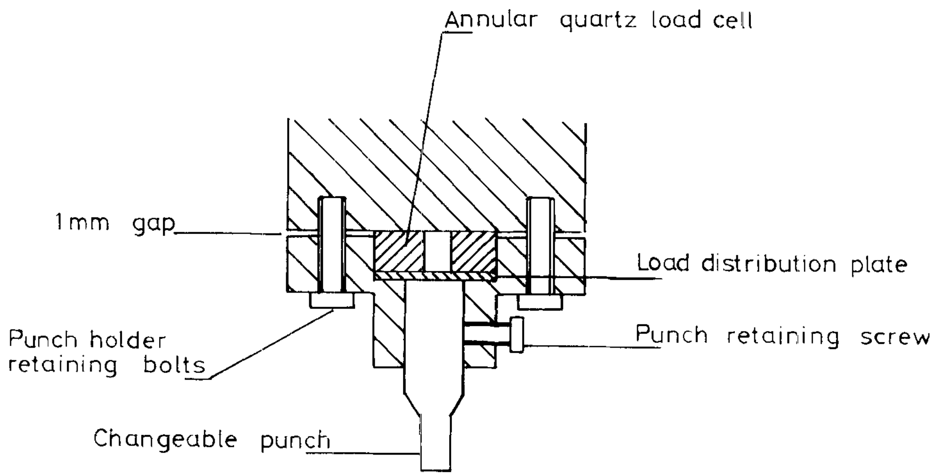

FIGURE 1

UPPER PUNCH HOLDER MODIFICATIONS

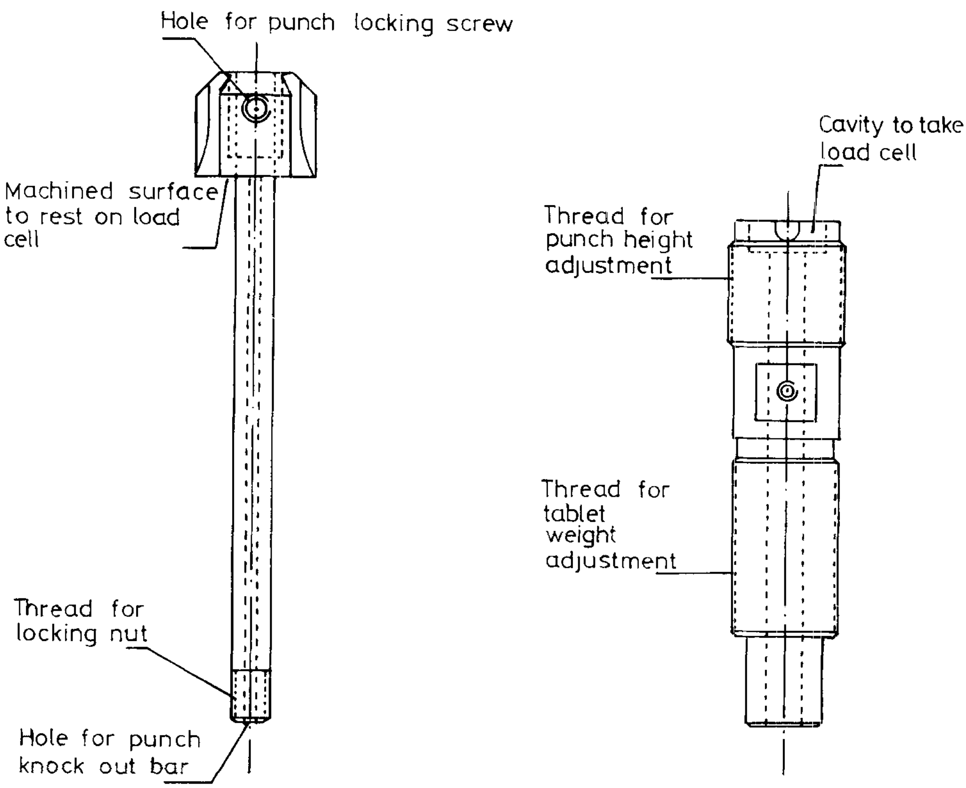

FIGURE 2.

LOWER PUNCH CARRIER MODIFICATIONS

The outputs were recorded on a precalibrated chart recorder. The sensitivity of the upper and lower load cells (free-standing) and the load cell in the modified lower punch holder agreed with makers recommended value Figure 3, 4 and 5. A marginal change in the sensitivity was observed with the upper load cell in its mounting. Figure 6. This error could be corrected by recalibration of the load cell sensitivity and therefore demonstrates the need to validate the load cells within their respective mountings.

The calibrated load cells were then assembled on the tablet machine and validated at normal operating speeds by bringing flat punches together and comparing the outputs from the upper and lower charge amplifiers over a range of forces. Figure 7. This procedure is now carried out as a routine calibration check. The reproducibility of the instrumentation and its calibration is demonstrated by the compressibility profile of a tablet granulation generated from two instrumented Manesty F3 tablet presses. Figure 8.

The electrostatic charges generated by the load cells were conditioned using charge amplifiers (Kistler type 5001) so that a voltage output capable of driving a microcomputer could be obtained. The analogue outputs from the charge amplifiers were converted to digital form using a circuit based on the AD 574 LD (Analog Devices) analogue to digital converter and EQ 7829 (Precision Monolithics) multiplexer [8]

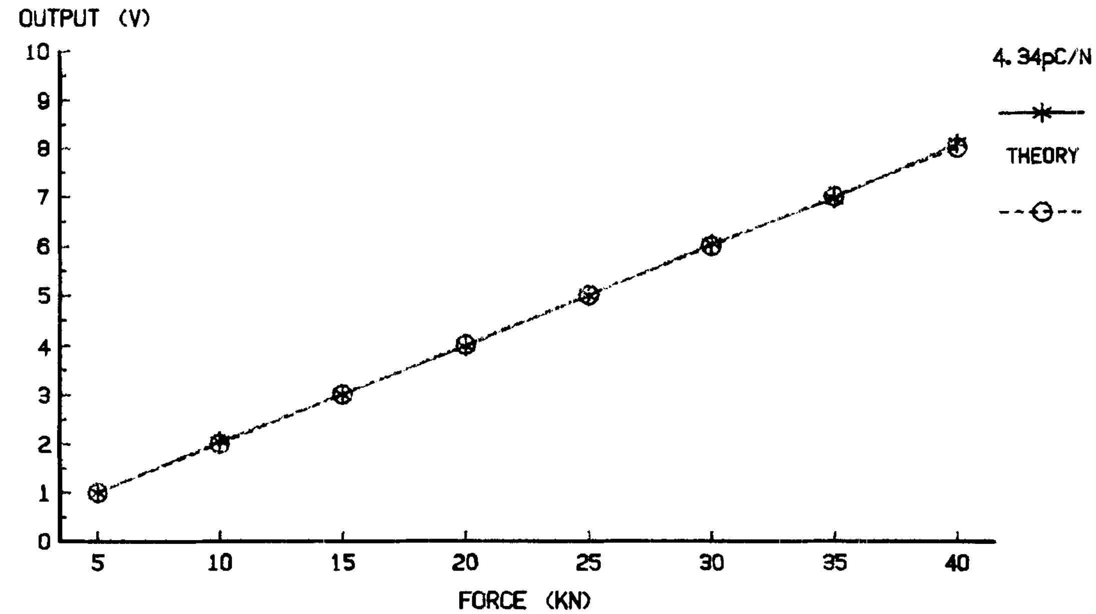

FIGURE 3
UPPER LOAD CELL CALIBRATION
LOAD CELL FREE STANDING

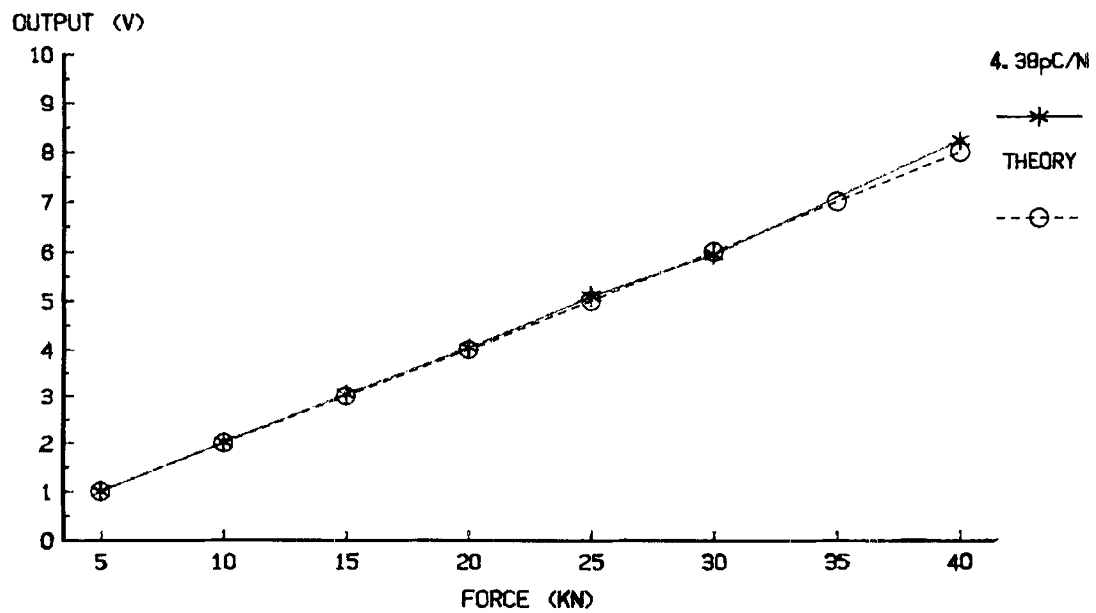

FIGURE 4
LOWER LOAD CELL CALIBRATION
LOAD CELL FREE STANDING

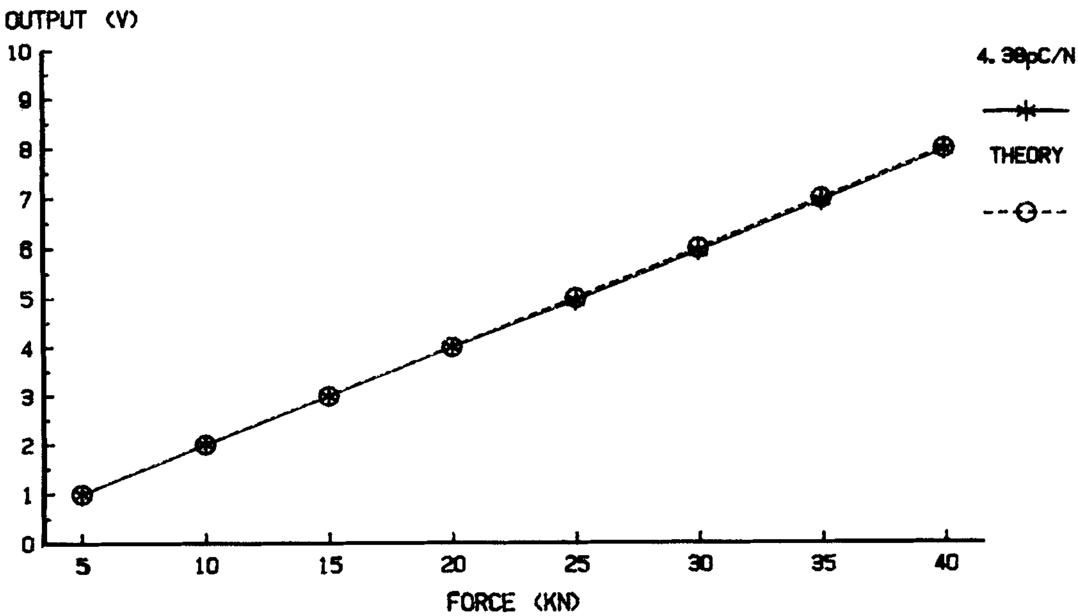

FIGURE 5
LOWER LOAD CELL CALIBRATION
MOUNTED IN PUNCH HOLDER

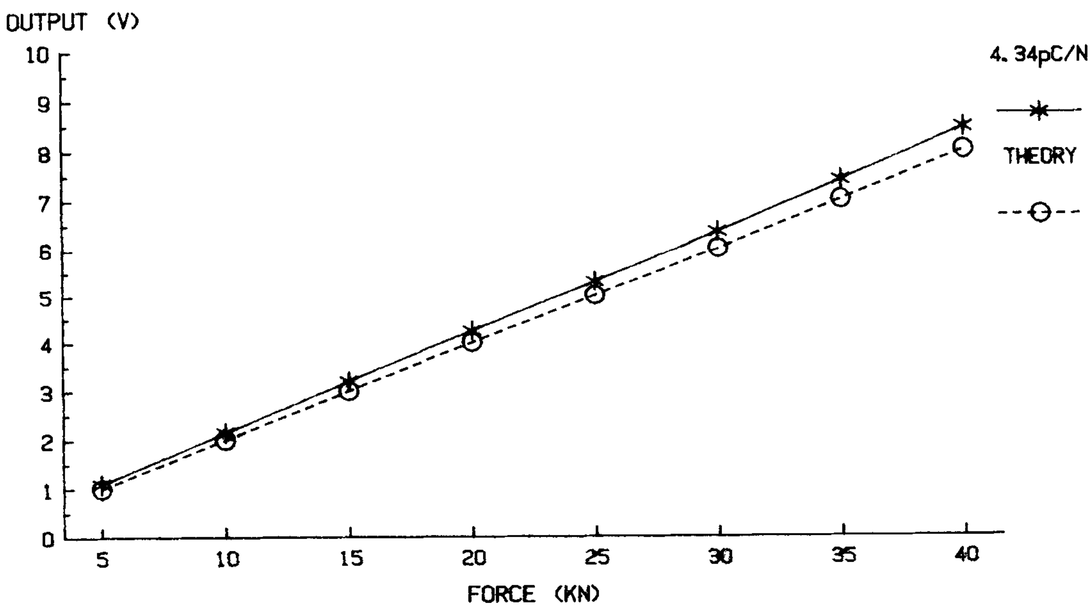

FIGURE 6
UPPER LOAD CELL CALIBRATION
MOUNTED IN PUNCH HOLDER

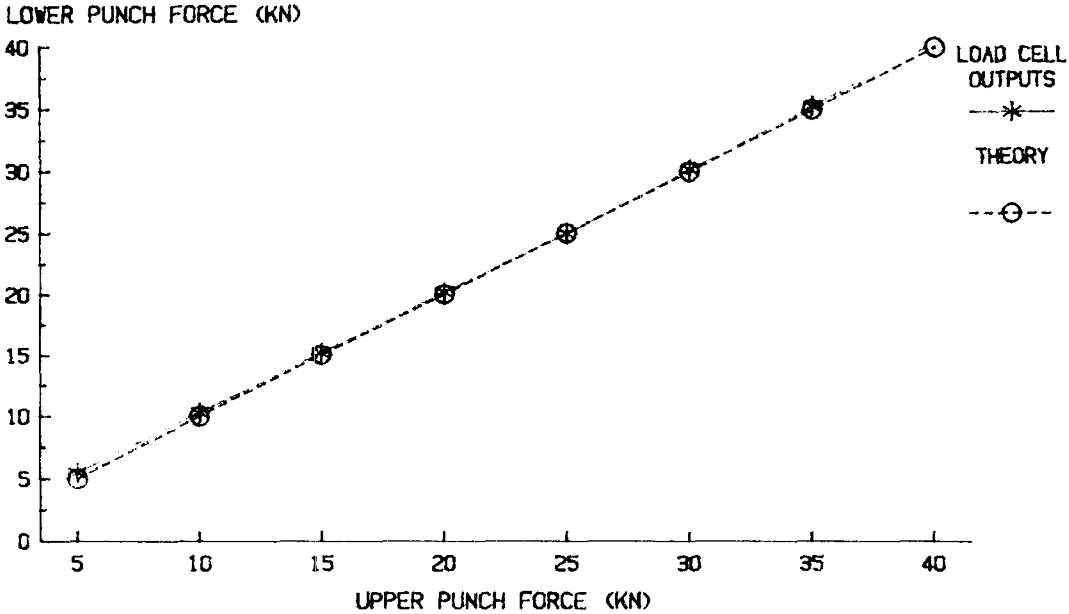

FIGURE 7
DYNAMIC CALIBRATION
60 TABLETS/MINUTE

The digital signals were then manipulated by the AIM 65 microcomputer which outputs the data in engineering units (kg force or K Newtons). To avoid contamination of tapes or floppy discs with powder, the program was burnt onto E.P.R.O.M. and stored within the microcomputer and called into use with a single command. The program was written in two parts, one in B.A.S.I.C., the other in machine code, the latter part of the program being used to access the rapidly changing data from the instrumentation. It is not necessary to be familiar with the language, as the B.A.S.I.C. program uses a structure which prompts the operator to use a series of command letters to enter the

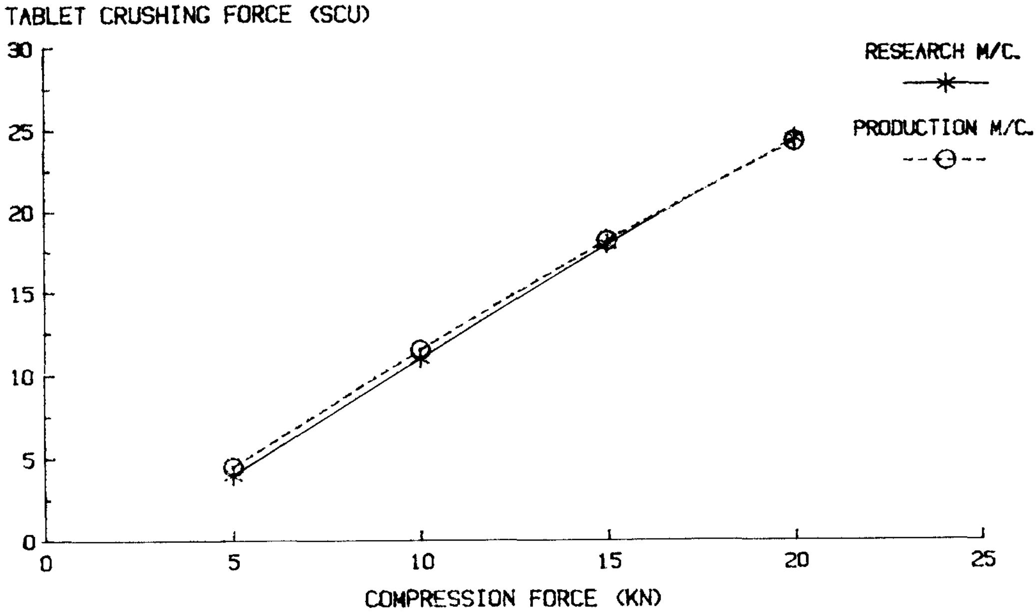

FIGURE 8
COMPARISON OF INSTRUMENTED TABLET PRESSES
COMPRESSIBILITY PROFILE

necessary information for the running of the program and printout.

The program measures the peak force values and integrates the area of both upper and lower force time profiles. It also integrates the displaced area of the lower punch from the baseline during decompression and ejection defined as the residual area. Figure 9.

Literature is controversial as to whether the static (residual) or dynamic (ejection) force is

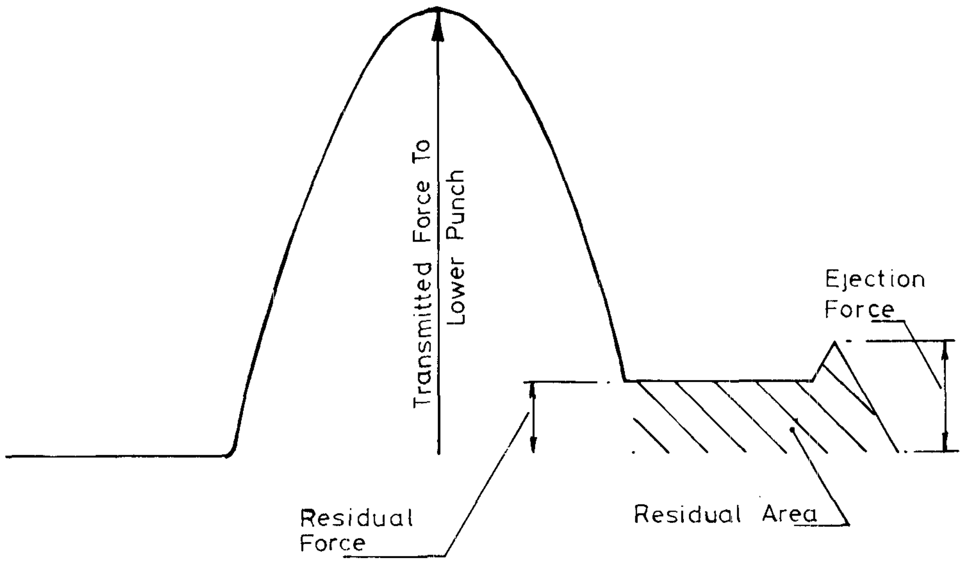

FIGURE 9
RESIDUAL AREA MEASUREMENT

more appropriate for the evaluation of lubrication properties.[4]. It is also suggested that the former is a more suitable parameter for comparing the efficiency of different lubricants while the latter is more suitable for the optimisation of lubricant concentrations. Simultaneous measurements of these lubrication and compression forces are also difficult because of the different magnitude of forces involved. These problems have been overcome by the measurement of residual area which includes both the static residual and dynamic ejection event following compaction.

The data storage and retrieval system was developed from a conventional plotting routine for a P.E.T. microcomputer and Watanabe digital plotter. The

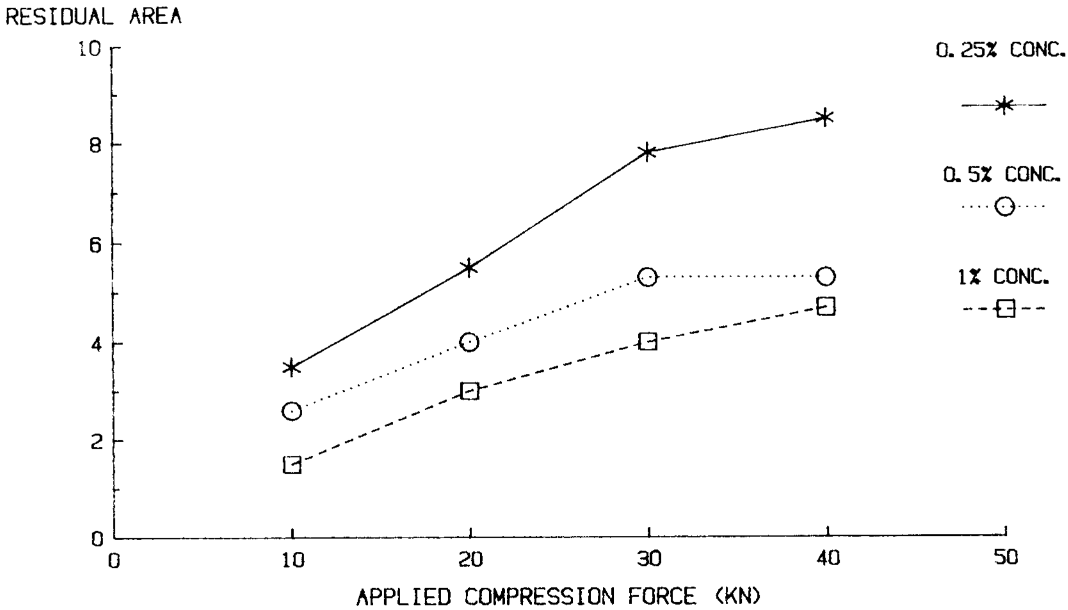

FIGURE 10
LUBRICATION PROFILE
MAGNESIUM STEARATE

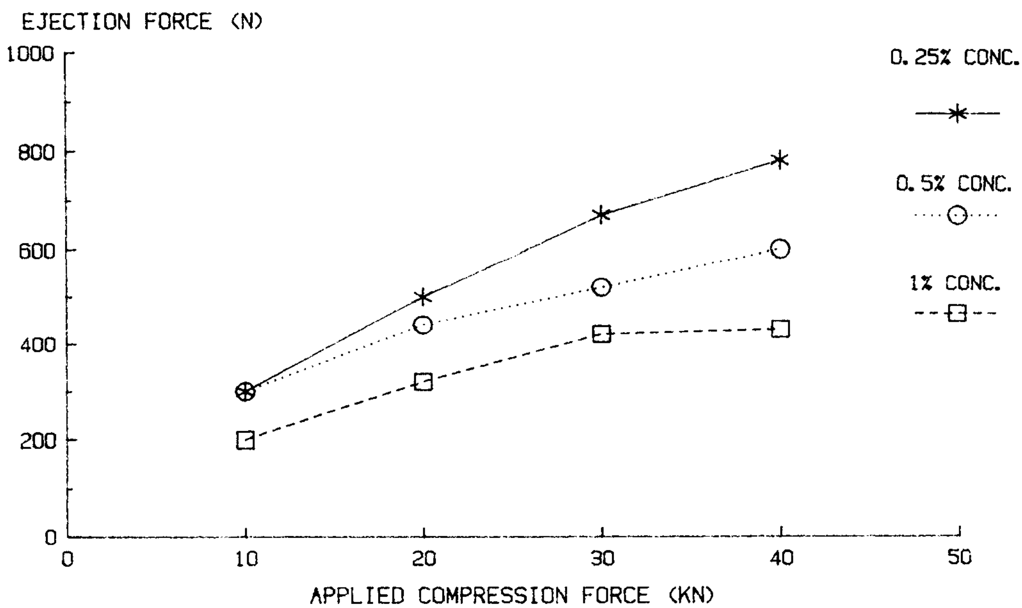

FIGURE 11
LUBRICATION PROFILE
MAGNESIUM STEARATE

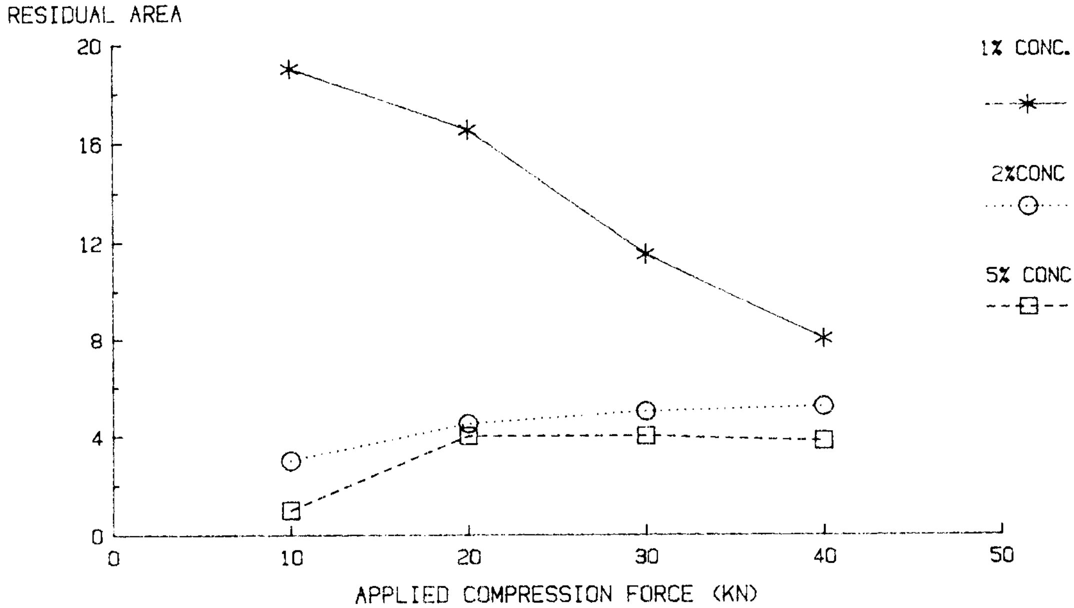

FIGURE 12
LUBRICATION PROFILE
D.K. ESTER

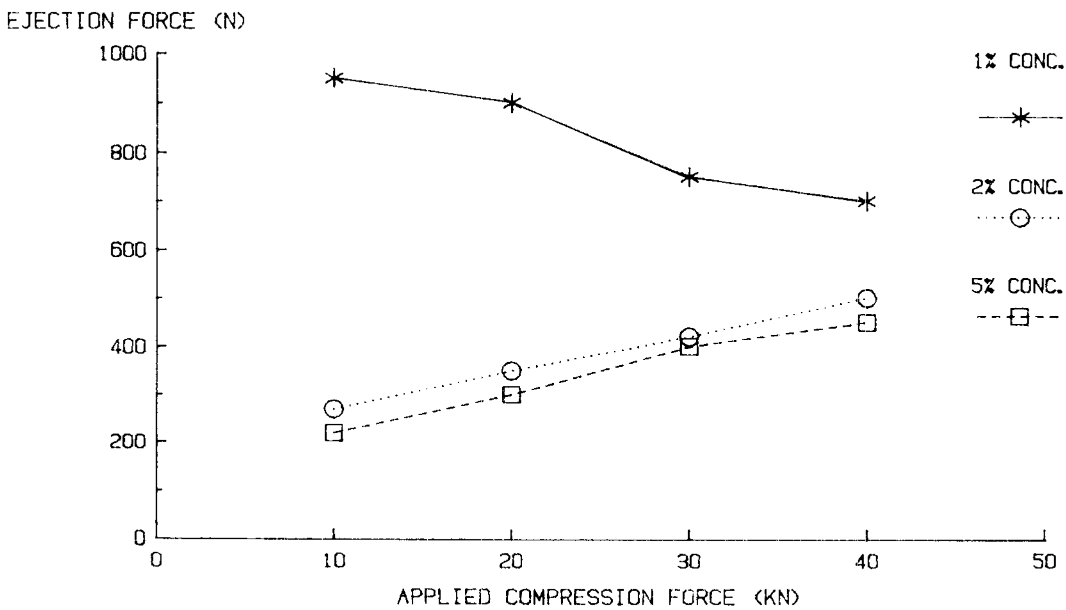

FIGURE 13
LUBRICATION PROFILE
D.K. ESTER

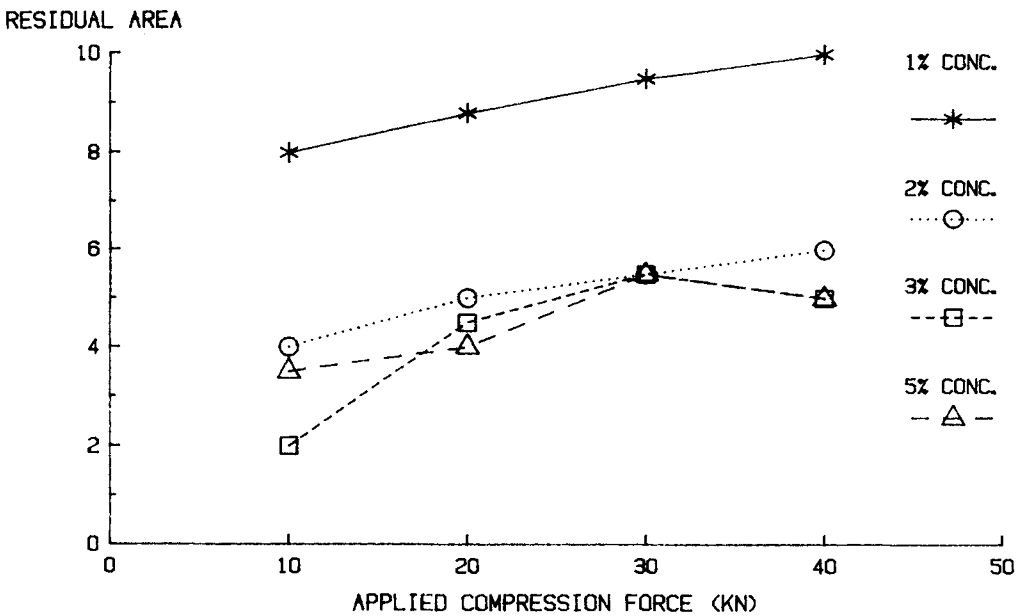

FIGURE 14
LUBRICATION PROFILE
LUBRITAB

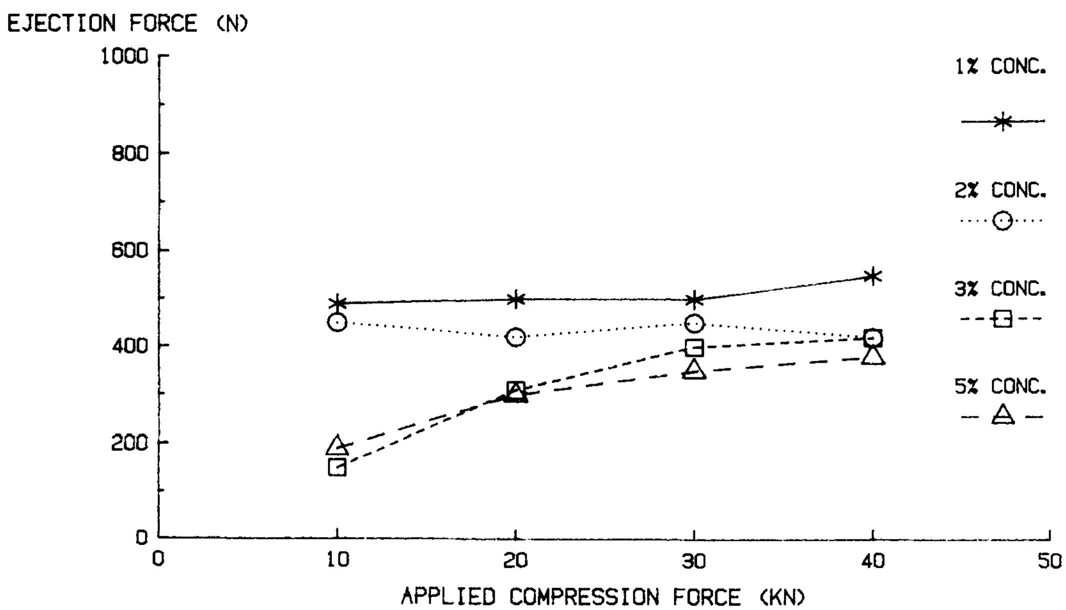

FIGURE 15
LUBRICATION PROFILE
LUBRITAB

system was modified to include the storage of the data points in relative files on 5¼" floppy discs along with a series of standard axes to permit the rapid generation of compression profiles.

With the described instrumentation coupled with the physical properties of the tablets, it is possible to construct compression profiles as fingerprints of the material being assessed Figures 16-19.

MATERIALS AND METHODS

A free-flowing form of lactose, Tablettose EP (Meggle) was selected to evaluate the effectiveness of new lubricants DK Ester F20W (Cairn Chemicals) and Lubritab (Forum Chemicals Ltd) at a concentration of 2-5% compared with magnesium stearate (Durham Chemicals) at 0.25-1% The lactose was passed through a 20 mesh sieve and the lubricants through a 44 mesh sieve. The blending was carried out at each concentration in a Turbula TC2 blender for 10 minutes at a batch size of 500g.

Individual blends were evaluated for their compression behaviour on the Instrumented F3 using 7/16" normal concave tooling at 60 tablets/minute over a range of compression forces. The print-out provides the mean applied compression force and residual area measurement of 20 pre-determined compression cycles. In addition, the ejection forces were measured using an Ultra violet

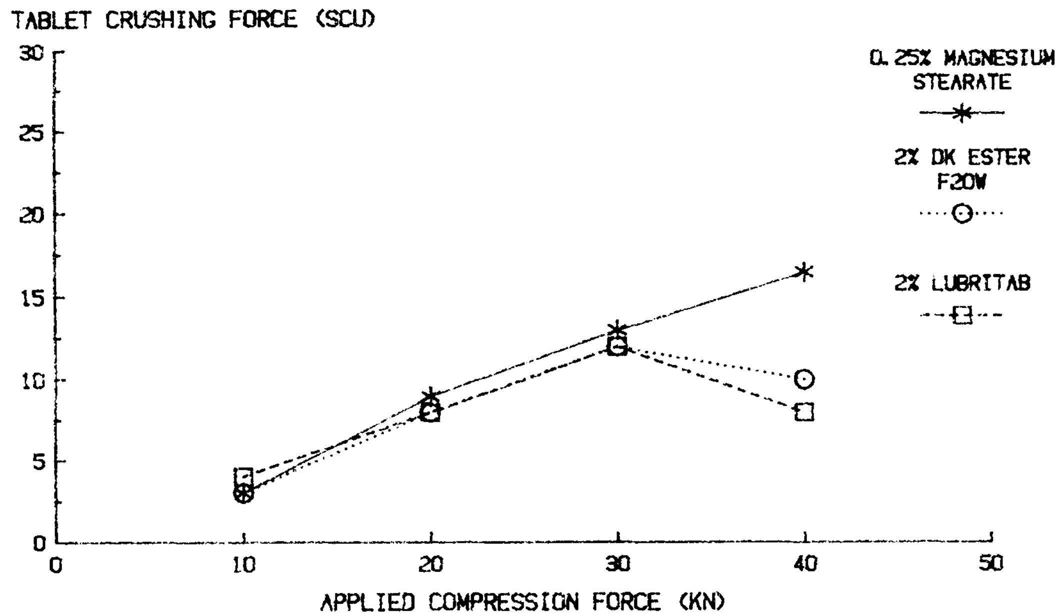

FIGURE 16
LUBRICANT EVALUATION
COMPRESSIBILITY PROFILE

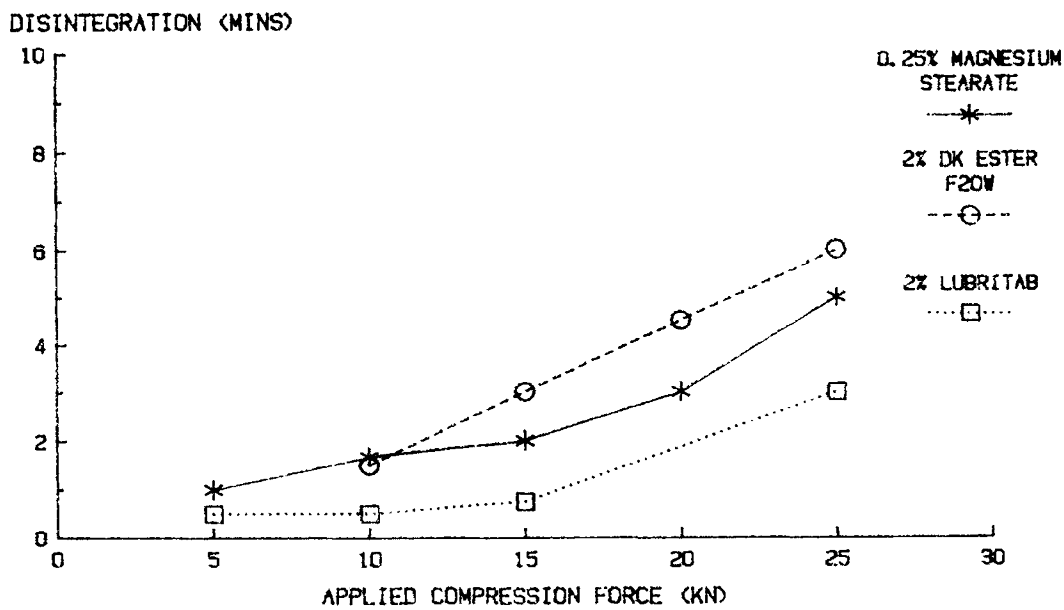

FIGURE 17
LUBRICATION EVALUATION
DISINTEGRATION TIME

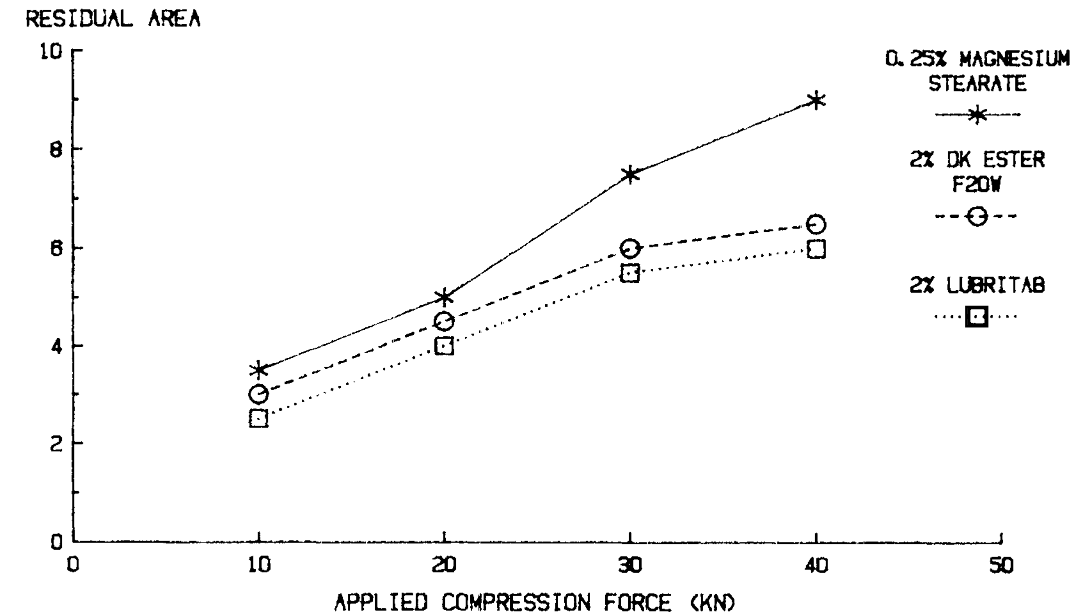

FIGURE 18
LUBRICANT EVALUATION
LUBRICATION PROFILE

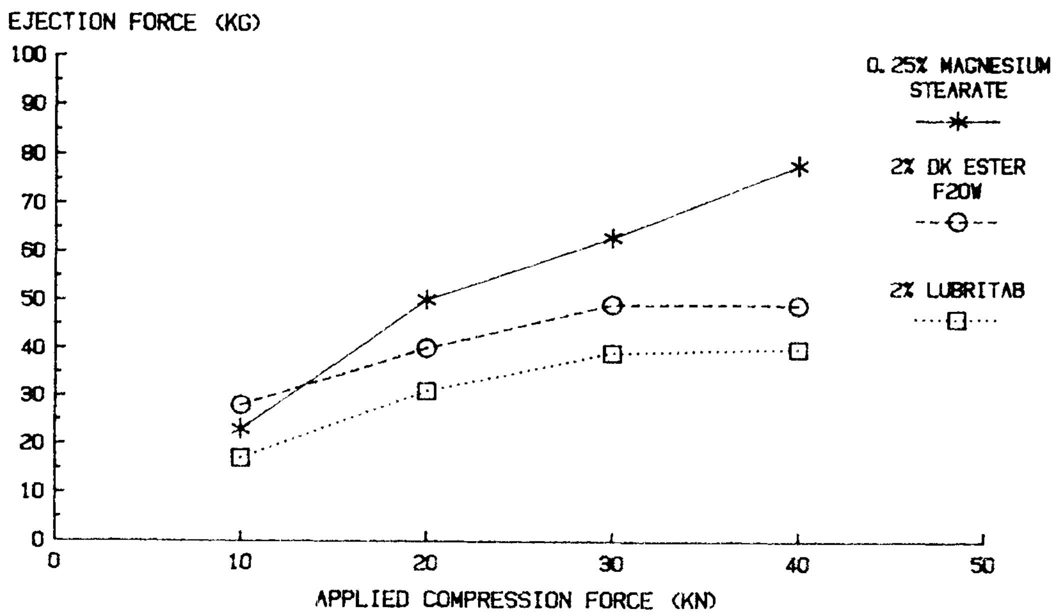

FIGURE 19
LUBRICANT EVALUATION
LUBRICATION PROFILE

oscillograph (Shandon Southern) linked to the charge amplifiers by a galvanometer amplifer. (Kistler Type 5211A) from the same series of compression cycles. Tablet crushing forces (mean of 10) were determined using a Heberlein Tester (Model 2E/205) and disintegration times following the E.P. disintegration method (Erweka ZT2).

RESULTS AND DISCUSSION

Increasing concentrations (0.25%-1%) of magnesium stearate demonstrated improved lubrication properties as observed in both residual area and ejection force profiles Figures 10 and 11 . The lowest concentration of 0.25% still resulted in acceptable lubricity and was considered optimum for comparison with the other lubricants, in order to avoid the detrimental effects of magnesium stearate at higher levels. The data also demonstrates the agreement between the two methods of lubrication assessment.

D.K. Ester exhibited poor lubrication at 1% concentration and although improved, only marginal differences were observed between 2% and 5% levels. Figures 12 and 13. Lubritab also shows little difference at concentrations from 2% to 5%. Residual area in this case appears to discriminate the lowest concentration of 1% at which level the tablets exhibited very poor lubrication properties. Figures 14 and 15.

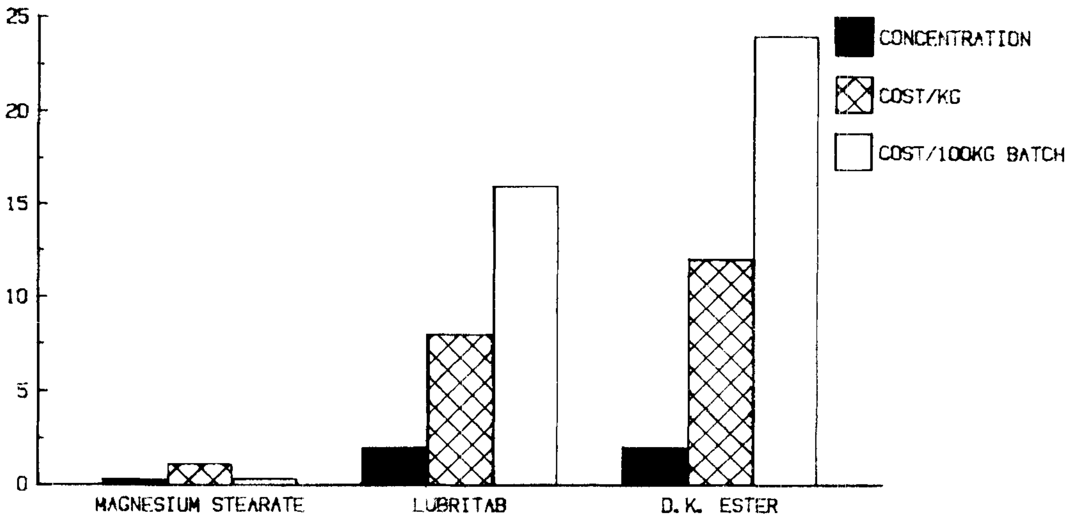

FIGURE 20
RELATIVE COMPARISON OF LUBRICANT CONCENTRATION AND COST

When the physical properties of the tablets were compared at the optimum concentrations of the three lubricants similar compressibility profiles were exhibited, although capping was observed with both the D.K. Ester and Lubritab at higher levels of applied force, Figure 16. Magnesium stearate negatively influenced the disintegration times relative to Lubritab, Figure 17, and demonstrated inferior lubrication properties compared to both lubricants, Figures 18 and 19.

On the basis of the results generated, D. K. Ester and Lubritab appear to be better than magnesium stearate in terms of disintegration and lubricant properties at the selected concentrations offering an alternative to magnesium stearate in lactose based products. However, because of the considerable increase in concentration and net price, the use of the new lubricants would result in a significant increase in cost. Figure 20.

ACKNOWLEDGEMENT

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