Development and Performance Evaluation of a Melon Depodding Machine

S. A. Oloko [1] and L. A. S. Agbetoye[2*]

[1]Department of Agricultural Engineering, Federal Polytechnic, P. M. B. 5351, Ado-Ekiti, Ekiti State, Nigeria.

[2]Department of Agricultural Engineering, Federal University of Technology, P. M. B. 704, Akure, Ondo State, Nigeria.

***Corresponding Author**: *lasagbetoye@yahoo.com*

ABSTRACT

Manual depodding of melon pods for the purpose of extracting the edible seeds is a time consuming and tedious operation. A melon depodding machine was therefore designed, fabricated and evaluated for performance. The major components of the machine are the frame, hopper, depodding chamber and discharge outlet. The machine is powered by a 1.5 kW, 1420 rpm single-phase electric motor. All materials used for fabricating the components were sourced locally.

The performance characteristics of the machine, including Depodding Efficiency, Material Discharge Efficiency (product of Seed Discharge Efficiency and Pulp Discharge Efficiency) and Overall Efficiency, were evaluated at six operating speeds (200 rpm, 250 rpm, 300 rpm, 350 rpm, 367 rpm and 400 rpm) and one clearance setting (10 mm) between the spiked-screw conveyor and the cylinder wall. The Depodding Efficiency varies between 31.8% and 62.1% while Seed Discharge Efficiency varies between 29.7% and 74.4%. The Pulp Discharge Efficiency varies between 38.9% and 82.4%, while the Overall Efficiency varies between 13.1% and 68.8%.

Key words: Melon, depodding, melon depodding machine, development, efficiency, Nigeria

1. INTRODUCTION

The origin of melon is Africa and Asia (Douglas, 1982) and areas where it is widely cultivated include the Caribbean, Indonesia and Africa. In Nigeria, the existence of melon dates back to the 17th century. Egusi melon is a popular fruit in Nigeria because of the edible seeds which are commonly used in the preparation of local soup or stew and snacks such as fried melon seed ball known as “Robo” in South - Western Nigeria. Recent statistics shows that 100,000 and 488,000 metric tons of melon were produced in Nigeria in 1992 and 1997 respectively (Federal Office of Statistics, 1998). In the East, the seeds are sometimes boiled and eaten as snacks too. The seeds are rich in oil (30 – 50 percent) which is comparable to other oil plants (Omidiji, 1977) and the oil contains a high level of saturated fatty acids (Adeniran and Wilson, 1981). Egusi melon is also an important component of the traditional cropping system usually interplanted with such staple crops as cassava, maize, sorghum, etc. (Omidiji *et al*., 1985)

Two major seed types of egusi melon (*Citrullus lanatus*) "Bara" and "Serewe" are common in Nigeria. Survey and evaluation trials conducted by Lanre and Adeniran (1989) showed definite geographical distribution and differences in the performance of the two types. The 'Bara' has the widest distribution. The geographical distribution can be attributed to consumers' preference rather than physiological adaptation of the crop. The cross-ability between egusi melon and water melon has been exploited by NIHORT to produce new cultivars with edible seeds (NIHORT, 1986). Studies by researchers indicate that egusi melon pods has an almost spheroidal external shape and an ellipsoidal seed cavity (Ramaligam *et al., 1977;* Nwosu, 1988; Chen *et al*., 1996; Akubuo and Odigboh, 1999). Furthermore, the elastic modulus increases significantly from the inner part to the rind. It has a sphericity of 1.03, average density of 0.87 g/cm^3 and seed content of 3.5% by weight.

The transverse and longitudinal sections of egusi melon fruit is shown in Figure 1 (Akubuo and Odigboh, 1999). The epicarp (A) is a thick and tough outer coat strongly attached to the much softer fleshy mesocarp (B) to form what is jointly referred to as the rind. The epicarp does not decompose easily and cracking is necessary to initiate decomposition. The endocarp (D) is segmented and separated from each other by the septum (C). Within the segments are the seeds (F).

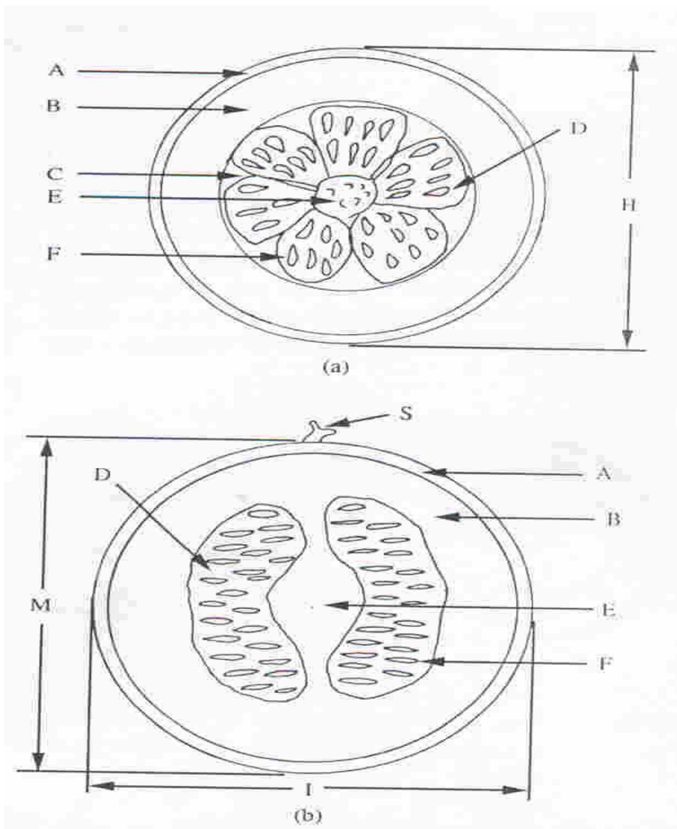


Figure 1: Transverse and longitudinal sections of an melon fruit; *(a) Transverse section; (b) Longitudinal section; A, epicarp; B, mesocarp; C, septum; D, endocarp; E, central septum; E, melon seed; H, minor diameter; I, Intermediate diameter; M, major diameter; S, stalk.*

Source: Akubuo and Odigboh (1999)

Processing of melon involves depodding, fermentation, washing, drying, cleaning and shelling. Kushwaha *et al.* (2005) reported the development and performance evaluation of an okro seed extractor. However, this machine can not be used for melon depodding because of the differences in morphological characteristics of the two crops. A coring machine was designed by Akubuo and Odigboh (1999) and used to remove the seed-bearing pulp of the fruit core to accelerate decomposition of the mesocarp and endocarp. A melon washing machine has been developed by Oloko *et al.* (2002) to reduce the drudgery involved in the traditional method of washing melon after fermentation and depodding. The process of breaking melon pods to remove seeds from the pods is known as melon depodding.

In Nigeria, farmers still perform melon depodding manually with stick. Inadequate or improper depodding of melon pods can cause problem in other processing stages such as separation of seeds from the pods. It is therefore very important to properly depod melon pods to enhance the removal of seeds from the pods. In the study presented, a melon depodding machine was developed and evaluated for performance. It is expected that the development of this machine will not only alleviate the drudgery involved in manual depodding of melon, but also enhance further processing stages.

2. METHODOLOGY

2.1 Description of Machine Components

The melon depodding machine (Figure 2) consists of four major components which are the frame, hopper, depodding chamber and discharge outlet. The hopper is pyramidal in shape and situated at the left top hand side of the machine. It is the inlet in which the fermented melon pods are admitted into the depodding chamber. The hopper is fabricated from 2mm thick galvanized metal sheet of dimension 300 mm x 200 mm x 250 mm. The depodding chamber consists the parts that break open the melon pods to release the seeds. The depodding unit consists basically of a screw conveyor on a horizontal shaft driven through a belt drive by a 1.5 kW, 1440 rpm single-phase electric motor. The spikes are attached to the shaft at 90^o and are pointedly positioned within a cylindrical chamber of 2 mm thickness and of external and internal diameters of 340 mm and 300 mm respectively.

The discharge outlet (containing two separate units) is the point where the seeds and chaffs from the depodding chamber are collected separately. The frame is the mounting support for all the components of the machine. While it was desirable to minimize the weight of the frame, it was necessary that it was sufficiently strong and rigid.

2.2 Design Considerations

The mechanics of melon depodding include compression, shearing and impact. The developed machine utilizes the principle of impact force and this was chosen because it has been utilized in the design of machines for coarse, medium and fine grinding materials.

The following factors were considered in the design of the melon depodding machine.

i. Materials of adequate strength and stability were used for fabrication (i. e. mild steel);

ii. The machine was designed to have a maximum capacity of 86.4 kg of melon per batch so that machine could be affordable for small scale farmers;

iii. The materials that are available locally were used in the fabrication of the components;

Consideration was given to the cost of items and materials for fabrication with the ultimate aim of utilizing the cheapest available materials, yet satisfying all strength requirements.

2.3 Design of Melon Depodding Machine

The relevant physical and mechanical properties of melon required as basic design data were obtained (Makanjuola, 1972). Basic considerations were given to the design for the size/dimension and capacity of components, including the belt pulley system, the speed of operation, machine power rating of shaft, spiked screw conveyor and the bearing. The PSG (1982) design guide and specifications was used for belt and pulley drive design. The diameter of shaft and the specifications of screw conveyor were calculated using standard procedures (Hall *et al*., 1980). The RHP Bearings (1992) design and guide and specification was used for selecting bearings.

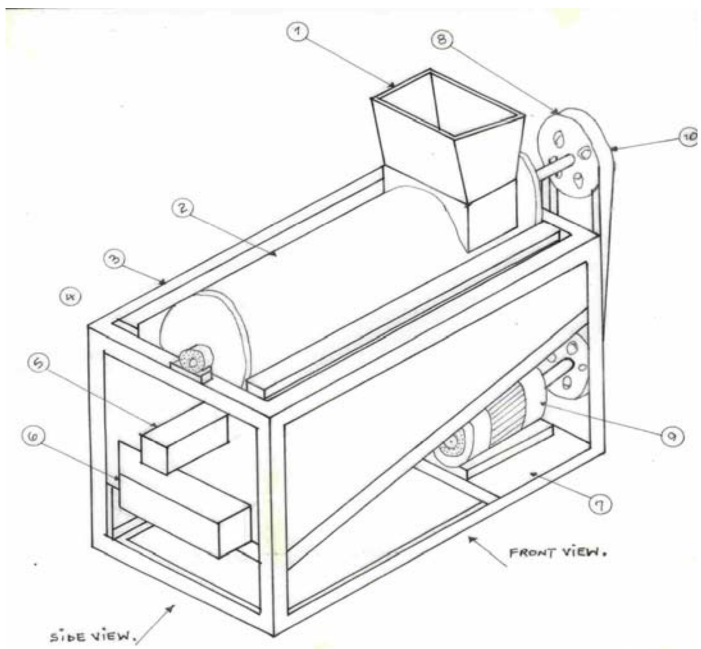
2.4 Operation of the Melon Depodding Machine

The main function of the melon-depodding machine is to break the melon pod and separate the seeds from the pod and the pulp. The hopper serves as the feeding mechanism through which the melon pod is fed into the machine. The spike, through their impact force breaks the pod and the melon seeds, are separated from the pod and are subsequently collected through the outlets. The screw conveyor containing spikes conveys both the depodded melon pulp and seeds into the discharge outlets (Figure 2).

2.5 Performance Tests

The “bara” type of egusi melon grown locally in the area was used for the performance tests of the machine. The moisture content of the melon pods was determined by gravimetric method and was found to be 19.72% (wet basis). Tests were conducted using fermented melon pods. This was done by feeding 5 kg of fermented melon pods into the machine, and then operating the machine for a period of three to six minutes. Tests were conducted at six different speeds of the machine ranging from 200 rpm to 400 rpm. Speed variation was achieved by changing the diameter of the driven pulley. Clearance setting between the auger and screen was maintained at 10 mm. After each run, materials were collected from the discharge outlet and weighed accordingly. Symbols used for the different parts of melon are given below:

(a)



(b)

Legend:

1. Hopper	7. Motor base
2. Cylindrical drum	8. Vee belt
3. Frame support	9. Electric motor
4. Bearing Mounting	10. Vee pulley
5. Upper outlet	11. Bearing
6. Lower outlet	12. Shaft

Figure 2: Photograph (a) and schematic diagram (b) of the melon depodding machine

M_1 = mass of melon pods fed into machine, kg

M_2 = mass of seed and pulp depodded and discharge, kg

M_3 = mass of seeds in mixture depodded and discharged, kg

M_4 = Mass of pulp in mixture depodded and discharged, kg

M_5 = mass of materials depodded and left inside machine

(Excluding undepodded ones), kg

M_6 =mass of seeds depodded and left inside machine, kg

M_7 = mass of pulp inside machine, kg

M_8 = mass of undepodded melon pods inside machine, kg

In order to calculate the performance efficiency of depodding melon, it was necessary to determine the ratio or the percentage of extractable seeds per given mass of melon pods. This was determined by manually extracting seeds contained in 5 kg of fermented melon pods, and thereafter measuring its mass using an electronic balance. The ratio of extractable seeds from melon pod, ***i*** was calculated using equation 1 stated below;

$$i = \left[\frac{M_e}{M_p}\right] x100\% \qquad (1)$$

Where,

M_e = Mass of seed manually extracted from pod, g

M_p = Mass of whole fermented pods, g

The value of ***i*** obtained was 0.13 or 13%. This means that the melon pods used for the tests had 13% seeds by mass.

The Depodding Efficiency, E_d of the machine was defined as the mass of extracted seeds expressed as a percentage of extractable seeds contained in the melon pods fed into the machine (Equation 2);

$$E_d = \left[\frac{M_3 + M_6}{M_1.i}\right] x100\% \qquad (2)$$

The Material Discharge Efficiency, $\boldsymbol{E_{md}}$ was defined as the mass of materials that were discharged out of the machine expressed as a percentage of material fed into the machine and was calculated using equation 3;

$$E_{md} = E_s + E_p = \left[\frac{M_2}{M_1}\right] x100\% \qquad (3)$$

Where;

M_1 = Mass of melon pods fed into machine

M_2 = Mass of mixture (seeds and pulp) depodded and discharged

$$E_s = \left[\frac{M_3}{M_1 . i}\right] x100\% \tag{4}$$

$$E_p = \left[\frac{M_4}{M_1 - M_1 . i}\right] x100\% \tag{5}$$

The Seed Discharge Efficiency, E_s was defined as the mass of seeds depodded and discharged expressed as a percentage of the mass of extractable seeds, and was calculated using equation 4.

The Pulp discharge Efficiency, E_p is defined as the mass of unwanted materials discharged expressed as a percentage of the mass of unwanted material fed into machine, and was calculated using equation 5. The Overall Efficiency, $\boldsymbol{E_o}$ of the machine was defined as the product of Ed and E*md*, and was deduced by equation 6.

$$E_o = E_d x E_{md} \tag{6}$$

3. RESULTS AND DISCUSSION

Data obtained from the tests were also subjected to analysis of variance (ANOVA) and test of significance using Duncan's Multiple Range Tests. Results of the analyses carried out indicate that there were significance differences in the magnitudes of depodding efficiency (E_d), seed discharge efficiency (E_s) and overall efficiency (E_o) at all speeds tested. However, there were no significant differences in the E_p and material discharge efficiency at speeds tested except Pulp at speed S_6 (400 rpm).

3.1 Depodding Efficiency

Preliminary tests with unfermented melon pods confirmed that because of the firm attachment of seeds to the pulp, it was practically impossible to depod without initial fermentation. Depodding of the fermented pods was achieved with the machine, and it was required to observe time between 2 and 10 minutes per run of machine at all the speeds of operation. The fermented pods were easily shattered under the pressure of the auger as it rotates within the depodding chamber. The average depodding efficiency was observed to range from 65.6% at speed 200 rpm to optimum level of 82.1% at speed 300 rpm before reducing gradually to 31.8% at speed 400 rpm (Figure 3). The increase in depodding efficiency from speed 200 rpm to speed 300 rpm was probably due to the greater impact energy induced on the pods. Beyond 300 rpm speed, the depodding efficiency reduced probably because the melon pods were driven so fast on the spikes of the auger that they escaped undepoded

3.2 Material Discharge Efficiency and Overall Efficiency

Both the seed discharge and pulp discharge efficiencies increased from speeds 200 rpm up to a maximum at speed 300 rpm, and then reduced to lowest at speed 400 rpm. The corresponding values of the seed discharge efficiency; pulp discharge efficiency and therefore material discharge efficiency are 74.4%, 8.1% and 82.4% respectively (Figure 4). In terms of the overall efficiency of the depodding machine, the speed of 300 rpm gave the best value, equivalent to 68.8%. Below and above speed of 300 rpm, the overall efficiency is reduced (Figure 5).

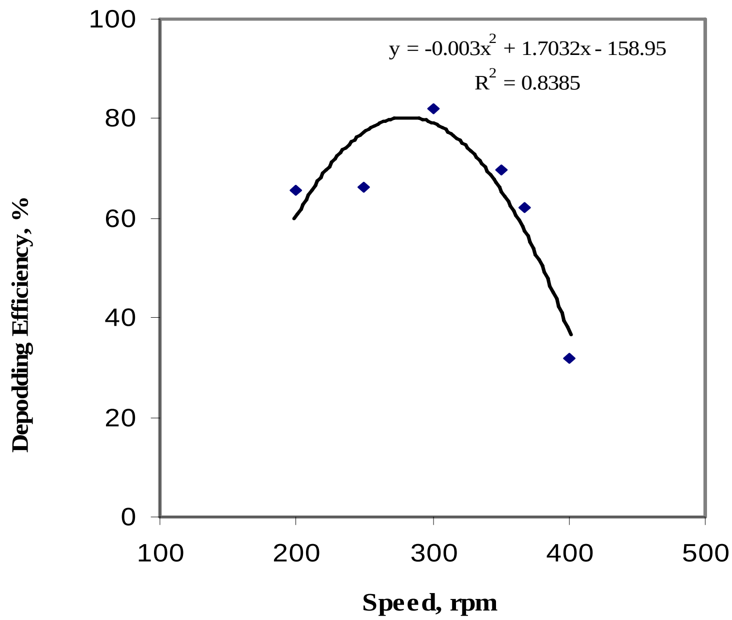


Figure 3: Effect of machine speed on depodding efficiency

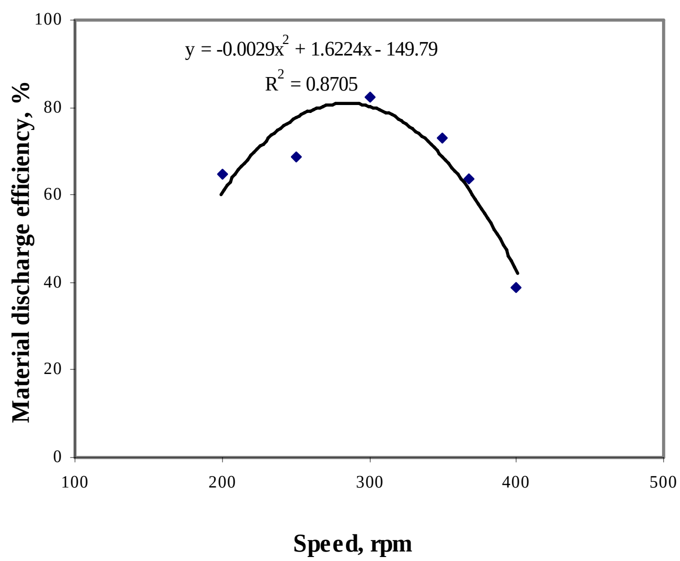


Figure 4: Effect of machine speed on material discharge efficiency

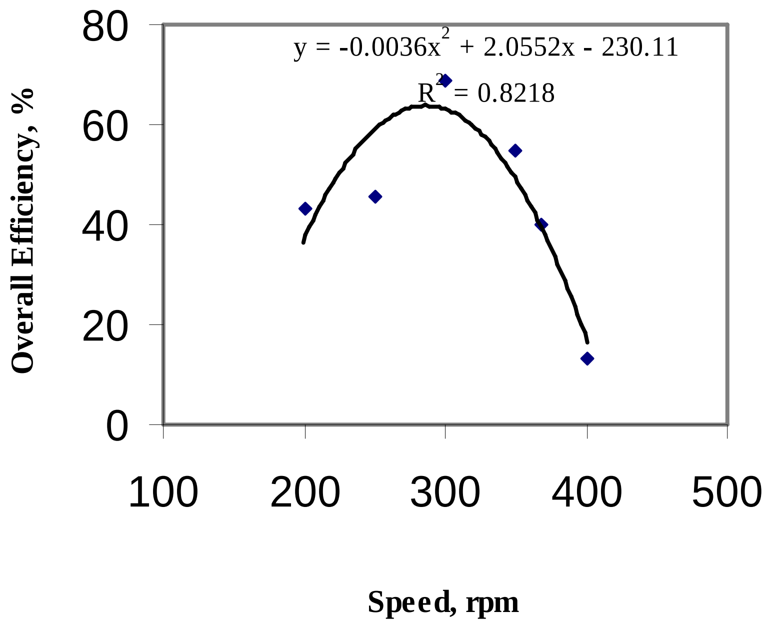


Figure 5: Effect of machine speed on overall efficiency

4. CONCLUSIONS

A machine for depodding fermented melon pod has been designed, fabricated and evaluated for performance. The depodding efficiency of the machine varies from 31.9 percent to 82.1 percent while the overall efficiency varies between 13.1 percent and 68.8 percent. At operating speed of 300 rpm, the overall efficiency of the machine is high (68.8%). The machine performed smoothly during the period of operation. All materials used for fabricating the machine were obtained locally.

5. REFERENCES

Akubuo, C.O. and Odigboh, E.U. 1999. Egusi fruit coring machine. *Journal of Agricultural Engineering Research*, 74: 121-126

Adeniran, M.O. and Wilson, G.F. 1981. Seed Type Classification of Egusi Melon in Nigeria. Paper presented at the 6th African Horticultural Symposium, University of Ibadan, 9th – 25th July, 1981.

Chen, H.; Baerdemaeker, J. De; and Bellon, V. 1996. Finite Element Study of the Melon for Non-destructive Sensing of Firmness. *Transactions of the American Society of Agricultural Engineers*, 39 (3): 1057 – 1065.

Douglas, M. C. and Glenn, D. 1982. Foods and Food Production Encyclopedia. Van Reinho. D, New York.

Federal Office of Statistics (1998). Annual Abstract of Statistics: 260-262.

Hall, A. S.; Holowenko, A. R; and Laughlin, H. G. 1980. Theory and Problems of Machine Design S. I. (Metric) Edition, Schaum's Outline Series. McGraw–Hill Book Company, New-York, America: 113-130.

Kushwaha, H.L.; Strivastava, A. P. and Singh, H. 2005. Development and Performance Evaluation of an Okra Seed Extractor. Agricultural Engineering International: the CIGR Ejournal. PM 05 001, Vol. VII, December (Article 52).

Lanre, D. and Adeniran, M. O. 1989. Geographical Distribution and Performance of the Major Seed types of Egusi Melon (*Citrullus lamatus*) in Nigeria. National Horticultural Research Institute, Idi-Ishin, Ibadan Occasional Paper No. 15, Pp. 1-12

Makanjuola, G.A. 1972. Study on Some of the Physical Properties of Melon Seed. *Journal of Agricultural Engineering Research*. 17 (1): 128 – 137

NIHORT. 1986. Advances in Fruits and Vegetable Research (1976–1986). National Horticultural Research Institute Ibadan : 20 – 27.

Oloko, S. A; Agun, B. J. and Jimoh, A. A. 2002. Design and Fabrication of Melon Washing Machine. *World Journal of Biotechnology,* 3 (2): 481 – 486.

Omidiji, M. O. 1997. Tropical Cucurbitaceous Oil Plants of Nigeria. Vegetables for the Humid Tropics. A Newsletter and Annual Communication among Research Workers. No 2: 37 – 39.

Omidiji, M.O; Oyedokun, J.B; Akinlosotu, T.A; Ogunfowora, A.O and Oputa, C.O 1985. Exploratory Survey on Cropping Systems and Related Activities at Ilugun Local Government Area, Ogun State. In: Farming Systems Research in Nigeria; Diagnostic Surveys, edited by Omodiji *et al.*

Nwosu, R.C. 1988. Engineering Properties of Egusi Fruit and the Design of Egusi Seeds Extraction Equipment. B.Eng. Project Report, Department of Agricultural Engineering, University of Nigeria, Nsukka. June

PSG. 1992. Design Data. Complied by Faculty of Mechanical Engineering, PSG College of Technology, Coinbatore 641004, India.

Ramalingam, S.T.; Pereira, S. and Pereira C.I. 1977. Modern Biology for Secondary Schools, FEP International Limited, Singapore.

R.H.P. 1992. RHP Bearing Technical Hand book. Published by RHP Bearings Industrial, P. O. Box 18, Newark, Notts England NG 24 2JF: 125-135