A Study on tht Mechanization of Livestock Production in Developing Countries

開發中國家畜牧生產機械化問題之探討

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中 文 摘 要

本文係著者在一九七八年九月十八日「亞太小農機械化研討會」中宣讀的報告。開發中國家因爲人口增加，國民所得增加等原因，對畜產品的需求量也急劇增加。另一方面因爲畜牧生產有利農地肥力的改善，尤其畜牧經營可以利用低價値或沒有價値的粗草料及農業副產物，將其轉化成爲奶、肉、蛋、皮、毛等高價產品，各國政府都在加强畜牧的發展，而畜牧生產的機械有四大類：一、牧草及飼料作物生產調製用的各類機械，二、畜牧場管理經營用的各類機械，三、收穫畜產品的各種機械，及四、加工畜產品的各種機械等四大類。但是開發中國家機械化的條件較差，例如臺灣每平方公里農地需生產糧食養活1805人 (1976)，這個負擔是荷蘭的8倍，是美國的37倍。而臺灣國民所得1976年是936美元每人，這只是荷蘭的1/6，美國的1/7，農民收入更少、爲發展畜牧機械化而直接「引進」歐美現有機械 (Imported Technology) 應該是不合理的，因此著者提出「最適機械」(Adequate or Intermidiate Technology) 之開發。「最適機械」最主要的指最適本地工業環境生產維護及最適本地農業生產要求的農機。文中以「興大農機」開發的「草料打包機」爲例，探討開發的方法，供各亞太會員國家的參考。

Though the average performance of animals in the developing countries is low in comparation to that in the developed countries there are still a number of factors that favor the further development of animal production in these countries. Among these factors are:

1. Expanding population causes an increasing demand for livestock producrt.
2. Increasing per capita income creates an increasing demand for livestock products.
3. There is still a need of animals as sources of power.
4. Livestock production activities can improve soil fertility
5. The flexibility of animals as converters of agricultural by-products or wastes into valuable products, e. g. fibers, leathers, meat and milk, can be utilized profitably.

On example of Taiwan one can already see the increasing demand for livestock products with the increasing per capita income (Fig. 1).

On the other hand the developing countries need mechanization in the agricuture, because of the following reasons:

1. To increase the productivity of arable land.
2. To ensure the food production despite decreasing available labor in agriculture.
3. To adjust the social image of the agricultural profession.
4. To achieve economic effect in the agricultural production.

one of the usual processes of farm mechanization in developing countries is to import necessary farm machineries from the developed countries. The available machineries for the livestock production in the developed countries can be divided into following categories:

1. Machinery for production of feed.
2. Machinery for management of livestock.
3. Machinery for harvesting of products.
4. Machinery for treatment of products.

The category of machinery for the forage crops production in developed countries for example, may be again divided into:

1. Machineries for field operation, curing and harvestng.
2. Machineries for field handling and transport.
3. Machineries for drying and handling.
4. Machineries for storage.

On the other side, Taiwan is in the group of developing countries. The per capita income in U. S. dollar for several countries is shown in Fig. 2. Taiwan had, in 1976, a per capita income of about 976. This was about 3 times that of Philippines, 1/5 that of Japan, 1/7 that of U. S. A. 1/8 that of Switzerland (Fig 2). It is therefore not possible for Taiwan to aim at a degree of farm mechanization, which is comparable with those in the developed countries like Germany, U. S. A, or Sweden.

In addition to this situation, Taiwan has a population density of 463 persons/km^2, 1805 persons/km^2 arable land (Fig. 3). This situation makes Taiwan one of the worst situated countries for the agricultural production. Taiwan can only afford to supply for her livestock production with the expenssive imported feed stuffs for hog and poultry and with the high yield forage crops and the agricultural by-products and wastes for milk and meat production.

These are, for example, elephant guinea gress, pangola guinea grass, para grass, bahia grass, sugarcane tops, sweet potato vine, peanut vine, soy bean vine, rice straw, cassava, corn stem, chinese milk vetch, banana whole plant, pineapple whole plant, other fruit by-products, cow pea vine and other vegetable by-products. Napier grass has very high yield, namely, up to 200 tons/ha with 11.7% dry matter and 1.1 % protein content. Guinea grass is another kind of native forage. It has about 100 tons/ha yield with 24% dry matter and 1% protein. Pineapple leaf is a kind of agricultural waste aud sweet potato leaf is an agricultural by-product with 9.8% dry matter, 1.5% protein.

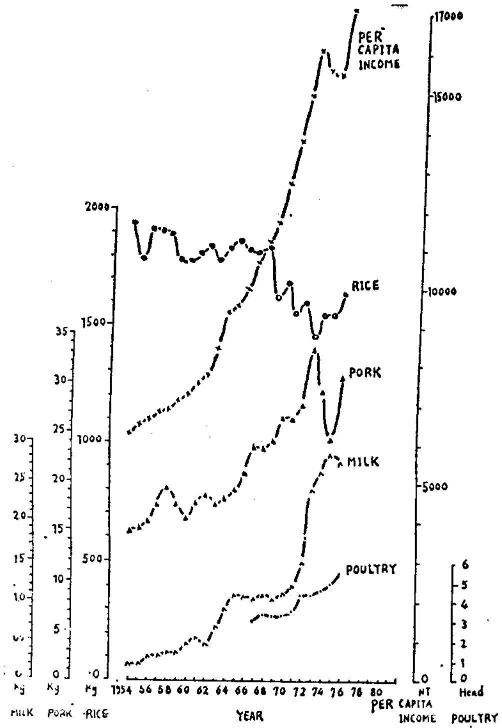

Fig. 1 中華民國國民所得曲線及個人畜產食品之平均食用量

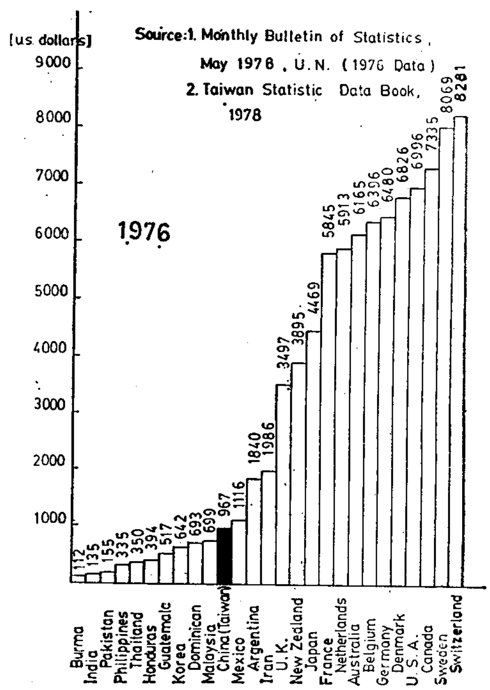

Fig. 2 Per capita Income of several countries

Fig. 3 Population density of several selected countries 1977

Country	Population[1] (A) (million persons)	Area[1] (B) (10000 km²)	Arable Land[2] (C) (1000 km²)	Density (A/B) (persons/km²)	Density (A/C) (persons/km²)
Taiwan	16.7	36	9.2	463	1,805
Korea	36.4	99	20.2	369	1,779
Philippines	45.0	300	104.0	150	433
Thailand	44.1	514	105.8	86	417
Malaysia	12.6	329	182.7	38	69
India	626.8	3,280	634.4	191	987
Burma	31.5	6,376	65.9	47	478
Japan	113.8	372	57.0	306	1,982
Netherlands	13.8	37	21.1	375	656
Belgium	9.8	33	15.6	297	626
Sweden	8.2	450	30.3	18	272
Switzerland	6.3	41	26.0	153	243
Australia	14.1	7,686	110.0	2	128
U. S. A.	217.8	9,363	4,410.0	23	49
Germany, F. R.	61.4	248	134.3	247	457

Source: 1. Monthly Bulletinof Statistics, May 1978, U. N.
2. The Statesman's Year-Book, 1974–1975, Poxton John.

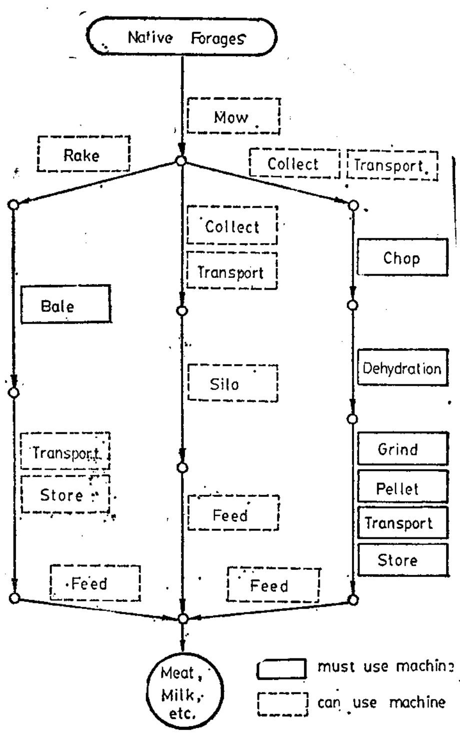

Fig. 4 Flowchart for the Native Forage Activity

Not only Taiwan but also the most of developing countries is different from developed countries in economical and infrastructural aspects. These differences are so great that it is normally impossible to perform the national farm mechanization process simply through the importation of the foreign farm machinery. It is advisable in most casee to develop the "intermediate technology" of farm mechanization for the their own countries. That means to develop machineries whieh use local materials, use native technology for the native market. Because an intermediate technology, not the imported technology is economically and infrastructurally most suitable one for the specific developing country.

A study of forage activities in Taiwan reveals three major processes for her farmers to utilize the native forage. These are namely: (Fig. 4)

1. Dehydration of the forage with very intensive investment of machinenery.
2. Silage making.
3. Hay making.

Dehydrntion means to cut and to transport then to chop the forage before to dry it with very high temperature about 1000 °C for a very short period of several seconds. This is a very expensive method to handle forage because it needs fuel and expensive machinery. But it makes foraga into feed with very good quality in feed structure and with very high animal physiological value.

In Taiwan, the dehydration of napier grass or sugarcane tops is being done, almost without exception from special enterprises for feed exportation.

Silage making uses sugarcane tops or pineapple fruit skin is practiced in several big farms. Silage making in small farms pruved to be not successful in Taiwan because of high cost for silo, because of lack of experience in making silage and because of too high a moisture content in native grasses,

To make the native forage into hay is in Taiwan quite a common practice in big farms as well as in small farms The weather conditions seem to be favorable in most area. But the lack of machinery for hay making prevents the utilization of native forage in such a scale that most agricultural by-products and wasts which are potential for feed, must be left unused in the field.

One of the most important machines in hay making operations is the baler, which compresses the dried grass in to compact form. This makes the transportation, the storage and thus the utilization of agricultural by-products and wastes possible.

An imported automatic baler costs about 250 thousands NT. or about 6000 U.S. dollars. This is a price not acceptable at all for Taiwan farmers. But before to develop an intermediate technology for baling of native forage, we must make a study about the imported technology. The working principle of an automatic baler is quite complicated (Fig. 5). This is especially the case at knot mechanism (Fig. 6). This mechanism when not properly adjusted will cause troubles in operation. And most of all, it is very difficult to repair and to build for the local industry.

Since 1972 there round balers coming into U. S. and European agricultural machinery markets. Some of them work with following principle. Six sets of belts drive the dried grass inside the round baler and compress it into the round bale (Fig. 7).

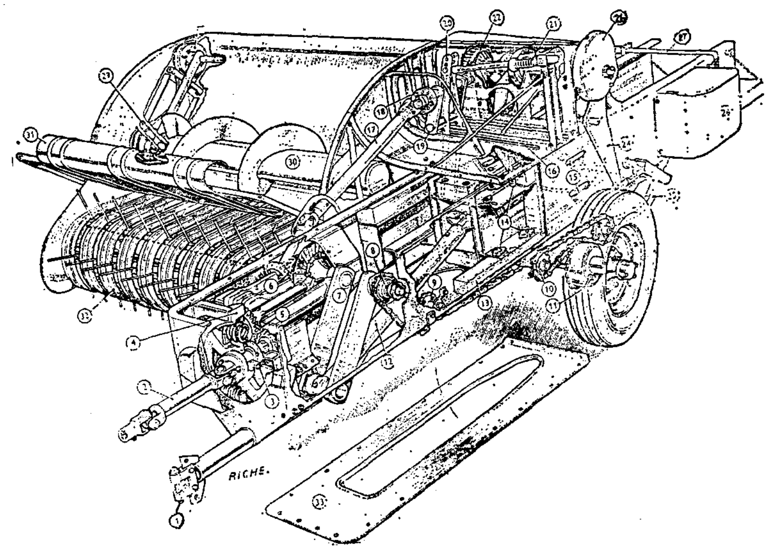

Fig. 5

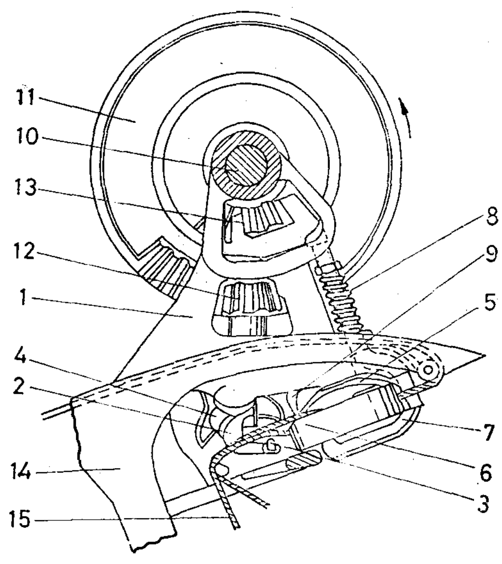

Fig. 6 結繩機構

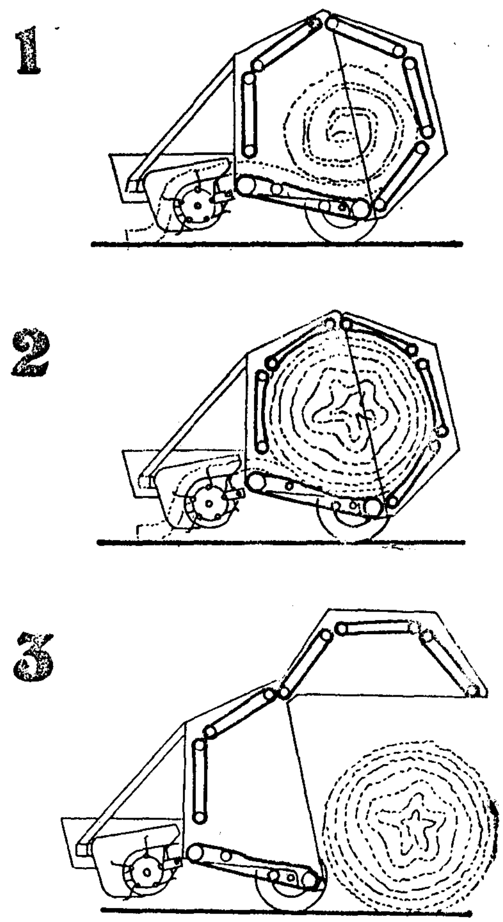

Fig. 7 皮帶壓縮式捲草機原理

Such machineries make bales with a diameter of about 180 cm or about 700 kg while it bales hay.

One of the greatest advantage of such round baler is that it reduces labor into minimum and it has got rid of a knot mechanism. It is also simple and robust in the construction. But the too heavy bale of about 700 kg with all the safety problems related to it such as rolling down the hill, causing turn-over to the tractors, etc. could be considered as disadvantage.

For the design of an intermediate machinery for the forage activities in Taiwan, we have tried to develop a strategy at first with great emphasis on balancing the economical effects with the technical performance. This can be shown in Fig. 8. we find out a likely best concept at first with all means and carry it out. This means we build a concept model to test the function performance of it. user's reaction to it, its compatibility to the local agricultural practice and, most important, to test the economic feasibility of this new idea. We call all these activities "conceptional design". When the concept is proved to be promising, we start the second stadium of the development, namely "engineering analysis", which incorporates with building a test model in addition to a decriptive model (meth matical or simulational). With these two models, we can build a test machine with increasing chance of success to the development work. If the test machine is satisfactory, -- that means a intermediate success both in technical performance and in economical feasibility -- we can hand over the design to production to the local industry with additional to the local industry with additional works in "detail design". The "detail design" means the modification of the test machine in such a way that the machine can also be produced economically and that it will be easier to maintain and to repair.

With this strategy of development for intermediate technology, we began our work in National Chung Hsing University with concept design one year ago. It turns out to be a small size round bales (Fig. 9). The pick-up and transport mechanisms feed In the forage into a baling mechanism, which is constructed with two sets of belts both rotating counter-clockwise so that the dried grass can be rolled into bale against the pressure of springs. The bales can then be thrown out of the machine when it reaches a predesigned diameter, or when a unlocking mechanism is switched. This concept was also developed into a "concept model". This machine can be drawn and powered with a tractor, and bales quite different kinds of local grasses, some of these grasses are impossible to be baled with imported automatic baler. Napier grass, peanut vines, soy bean plant are, for example, some of these plant materials.

For evaluation of the concept model we have tried a grading system (Fig. 10). For the technical performance, we choose some weighed criteria given a grade X between 0.0-1.0. For the economical success we give another grade Y between 0.0-1.0. The geomtric mean (XY) of the two values will be considered as a score S for that machine as intermediate technology (Fig. 11). The improvement of this score S means a balanced improvement both in X and Y. It is of course a great challenge for an engineer to develop a machine with better engineering performance and at the same time with cheaper purchasing and operating cost.

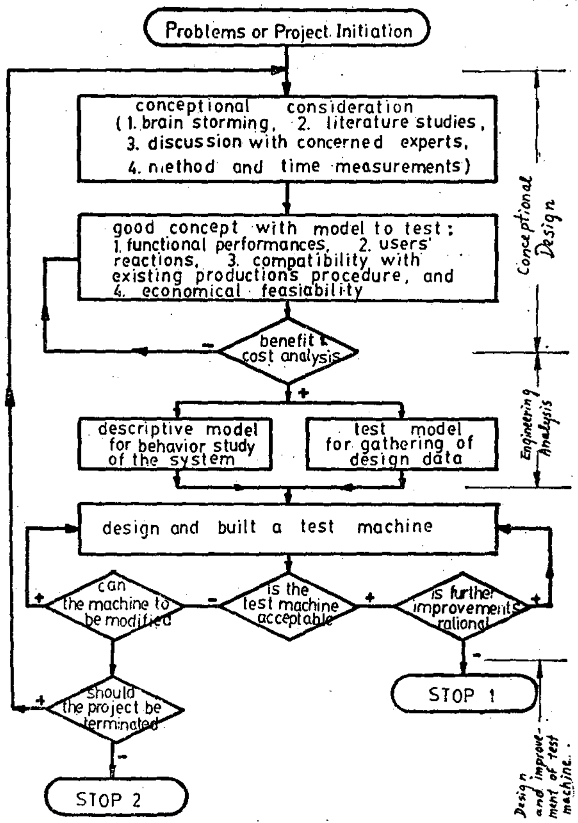

Fig. 8 Design & Evaluatiou at HTAE

Functional criteria of the concept model	Weigh	Baling mechanism		Pick-up mechanism	
		grade	weighed grade	grade	weighed grade
Performance	0.4	0.75	0.30	0.50	0.20
Break downs	0.3	0.75	0.23	0.50	0.15
Weigh & Volume	0.2	0.25	0.05	0.25	0.05
Noise	0.1	0.75	0.08	0.25	0.03
Total grade for the functional criteria (X)			0.66		0.43
grade for economy (Y)			0.75		0.50
grade of the concept model			0.70		0.46

Fig. 10 Grading of a Concept Model

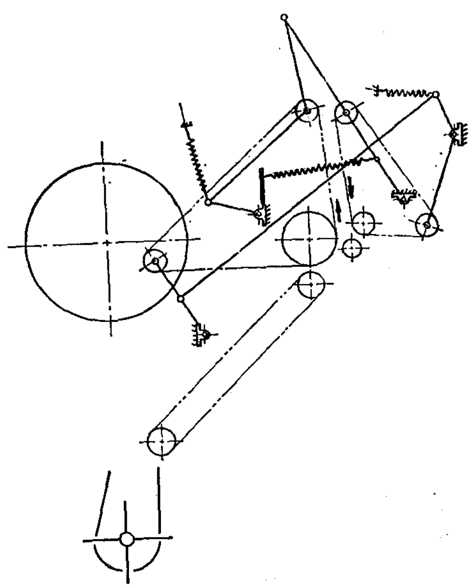

Fig. 9 與大研製之捲草試驗機機構圖

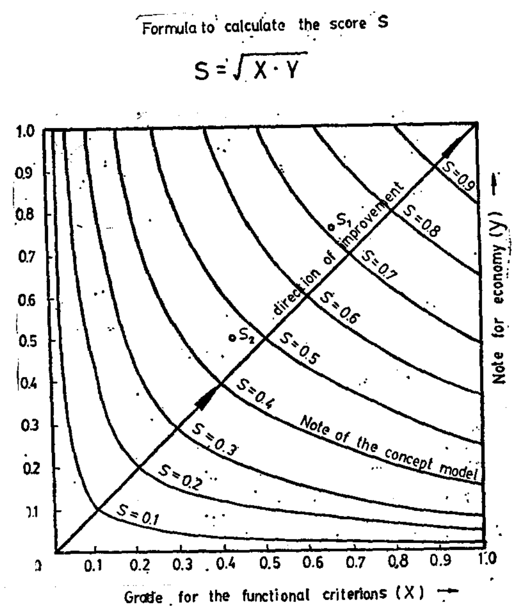

Fig. 11 Intermediate Technology & its improvement

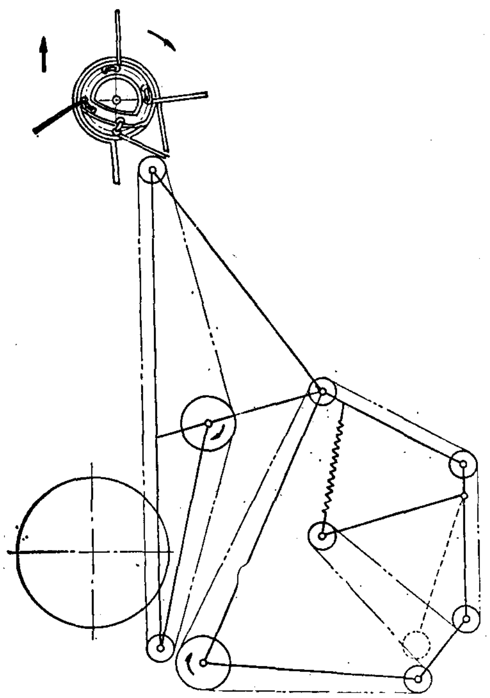

Fig. 12 興大研製之捲草實驗架機構圖

Fig. 13

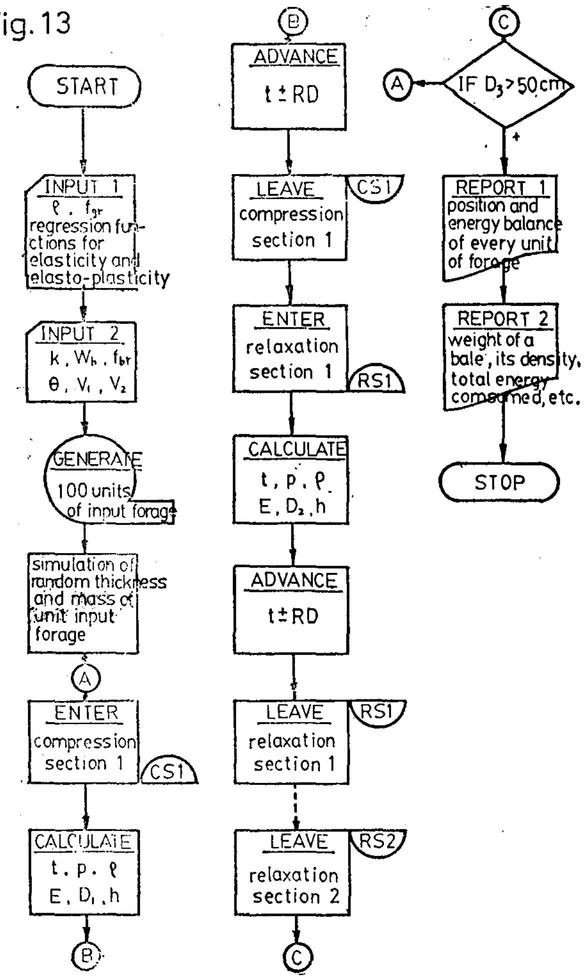

Fig. 13 Simulation of Roll Baling Mechanism with GPSSF Subprogram System

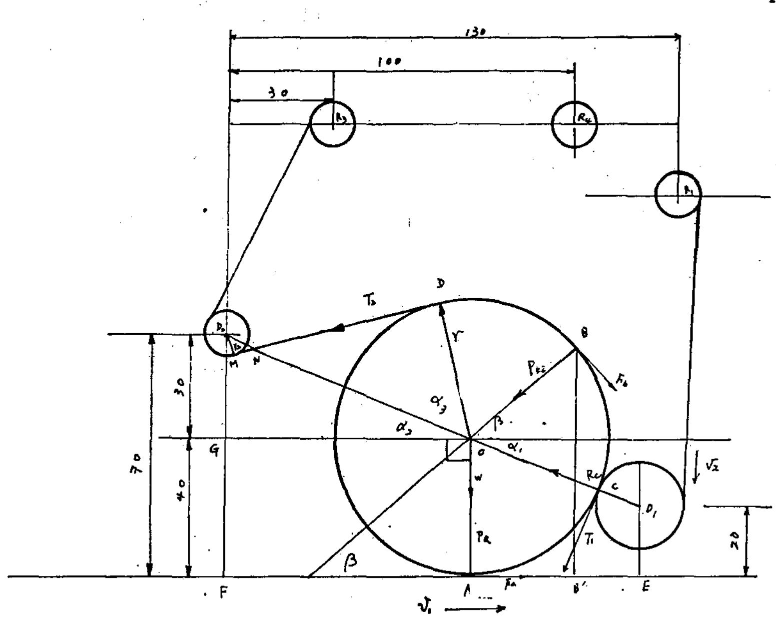

Fig. 14

捲草機構作用圖

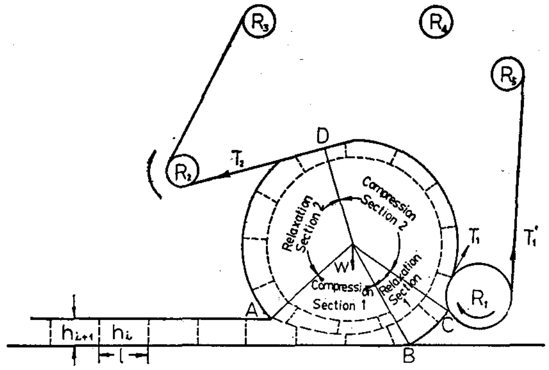

Fig. 15 捲 草 作 用 模 型

To achieve this we need a test model as well as a descriptive model. with both models we can gather enough data for the improvement. The test model (Fig. 12) -- a modified, simplified concept model -- was built for this purpose.

And to this test model, we are in constructing of a descriptive model using GPSSF (General Purposed Simulation Systems on Fortran Basis). GPSSF is a fortran program system developed by Nieme yer (Fig. 13). The main assumptions made in this decriptive model are shown in Fig. 14 and Fig. 15.

This development work is a trial on intermediate technology instead of a imported technology as a solution for farm mechanization in developing countries, especially for their mechanization of the livestock production with main purpose of converting agricultural by-products and wastes into milk and meat.

With the above contribution we hope we can achieve some success in our fight against proverty in developing countries.

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