韓國犂와 Plow의 發達過程 및 犂와 Plow의 各種土壤條件下에서의 耕深과 牽引抵抗에 關한 硏究

A Study Of Development Processes Of Korean and Western Plows and Their Draft Resistances to A Various Plowing Depth and Soil Conditions

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要 約

本論文은 北海道大學審査學位論文으로 總面數 143面인 英文으로 되어있고 圖 48, 表 7, 文獻 66付圖, 付表 20面이있음. Plow는 옛부터 發達한 農具이기 때문에 많은 硏究가 行하여졌지만 複雜한 物理性을 가진 土壤을 對象으로 하는 機械이기 때문에 未解決의 問題도 적지않다. 이牽引抵抗에 對하여 土壤의 種類 및 條件을 變更하면서 實際의 圃場에서 組織的으로 行한 實驗은 極히 적고, 하물며 우리나라의 쟁기에 關한 硏究는 거의없다.

本論文은 쟁기의 特徵을 究明하고, 그의 改良, 發達에 寄與하기 爲한 基礎資料를 獲得코저 實施한 것이다.

1. 쟁기와 플라우의 構造 및 그의 差異 特徵을 明白히하고 犂體에 걸리는 各種의 抵抗의 內容 또는 그 比率等에 對하여 過去의 硏究成果를 紹介하였다.
2. 發達史 ; 플라우는 B.C. 2000年頃에 鹿角, 木枝의 人力用의 耕耘用具에서 發達하고, 東洋犂도 起源은 大體로 같고 發達過程이 다를 뿐이다. 쟁기는 揚子江沿岸에 起源을 가진 支那犂가 新羅와 百濟에 導入되여 次次 發達하고, 地域的인 特徵을 가지게 되었다.
3. 本章은 쟁기의 牽引力에關한 理論的解析을하고, 쟁기의 進行에 依해 層狀으로 剪斷되는 剪斷抵抗을 求하고 쟁기의 表面 및 地側板과 土壤과의 摩擦力, 그리고 土壤의 移動의 慣性力을 쟁기의 牽引抵抗에 關連되는 主要한"힘"으로 생각하고 進行方面, 垂直方面의 힘의 成分의 平衡을 考慮하여 式 10. 12를 유도 하였다.
4. 本章에서는 實驗計劃, 方法 供試機, 供試圃場等을 記錄하고, 畜力用의 쟁기와 플라우를 使用하여 田地 4種 畓 2種의 圃場에서 實驗하는데 牽引力計와 自動耕深測定器를 使用하였다.
5. 實驗結果 및 考察 ; 耕深과 牽引抵抗 D_p와의 關係는 式 10. 12와 같이 表示되고, 實際의 諸値를 代入하여 理論式을 誘導하였드니 直線에 가까운 關係가 있고, 實驗結果는 조금 曲線에 가까워졌다. 그리고, 土壤의 物理性이 牽引力D_p에의 影響을 細密히 檢討하였다.

쟁기의 牽引比抵抗에 있어서도 式 12에서 $K=AT+\frac{B}{T}+C$로 表示할수 있기 때문에 最小値를 表示하는 耕深이 存在하고 이값은 쟁기나 플라우幅의$\frac{1}{2}$即 10cm程度이고 쟁기는 比抵抗이 0.11kg/cm²에서 0.39kg/cm²이였다. 그러나 이 比抵抗도 土壤의 物理性이 많은 影響을 미치고 있다.

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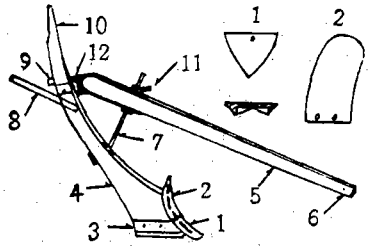
6. 要約 및 結論 ; 以上의 章에서 檢討 考察한 結果만을 記載하고 플라우는 쟁기에 比해 牽引抵抗 및 比抵抗이 논에서나 밭에서 大로 나타난 것이 特異하다.
以上의 內容을 紙面關係로 3回에 거쳐 요약 發表 합니다.

Introduction

Korean Janggi and Western plow are the tillage tools which have been used for operating one of the most difficult and laborious farming works. Janggi and plow devised and turned out in order to substitute the hard manual work for animal work would be the greatest invention at time the when human beings started to cultivate and one of the most basic operating tools in the eyes of the course of agricultural development. Eastern Janggi and Western plow have the different processes of the progress and thus different construction and principal parts, which will be explained in detail. Later, some literatures related to the study of draft resistance of the tillage tools will be reviewed.

1. Principal Parts of Janggi

Janggi was developed in orient(42, 54, 15), and had been used with animal power in the days of Un and Joo (ancient China, B. C. 10-5) for the first time. In the middle of the Yi dynasity Janggi was introduced to the Korean peninsula and has been developed and improved since 1910. Fig. 1 shows the construction of the Korean Janggi. Janggi is constructed so that the plow bottom is in contact with soil. The standard, the brace and the beam are used for pulling the plow bottom. There is also a structural arrangement for steering and lifting works and side handl es. Following is lan outline about how the Janggi is operated.



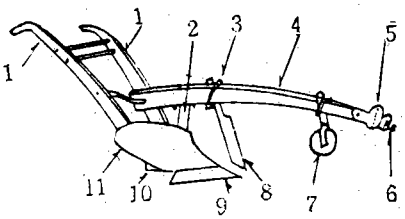
1. share
2. moldboard
3. landside
4. standard
5. Beam
6. Clevis
7. Brace
8. side handle
9. lifting handle
10. main handle
11. depth control nut
12. width control screw

Fig. 1 Construction and name of each parts of Korean plow

Fig. 2 Shapes of the landside

2. Principal Parts of Western Plow

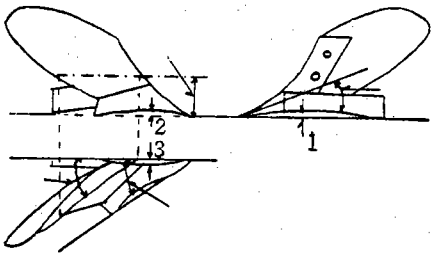
Plow: The plow has been developed in the western countries since the middle of the



1. handle
2. Standard
3. knife clip
4. Beam
5. Clevis
6. hook
7. gauge Wheel
8. knife colter
9. Share
10. landside
11. moldboard

Fig. 3 Plow pulled by animal

19th century as shown in the history of the development of the plow to be set forth nexe (42, 54, 15). The kinds of plows are more numarous than that of Janggi and the shapes are different in different countries. The principal differences between the Janggi and the working-plow pulled by animal power will be explained. The sketch of the plow is shown in Fig. 3.



1. first vertical suction
2. second vertical suction
3. holizontal suction

Fig. 4 Suctions of plow

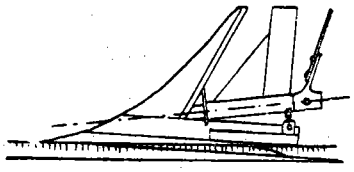


Fig. 5 plow bottom

3. Draft Resistance to the plow and the Janggi.

The resistance acting on the plow which is in operation is indicated by the total resistance or the resistance per equare inch of furrow section. The former is equivalent to the total draft power of the plow and the latter is called "unit draft"' whose unit is kg/Cm².

The total resistance is the result of the many forces acting upon the plow bottom. According (54) to the results of the studies conducted to date it is believed that forces are generally analyzed as follows:

1) Draft due to cutting slice: 50%
2) Darft due to the friction between the bottom and the soil: 25%
3) Draft due to turning furrow slice: 15%
4) Draft of the plow and furrow on the ground: 10%

Dr. Morri analizes (54) the forces that act upon the Janggi as follows:

1) Draft due to the friction between the landside and the soil caused by the weight of the Janggi: 5-8%
2) Draft due tothe friction be tween the landside and the soil caused by the weight of the furrow sliding over the moldboard: 5-8%
3) Draft due to lifting and turning the furrow: 37-46%
4) Draft due to cutting slice by the share: 18-32%
5) Horizontal dynamic pressure acting upon the furrow which slides up the moldboard when Janggi is pulled in a tertain speed, 6-9%

Also, E. V. Collins (54) states in his sests: "The draft of the plow on the ground is 21 %: draft due to turning furrow slice, 34%: draft due to cutting slice, 45%". Thus, it is seen that over 60 percent of the total d.aft of the plow is used in cutting and friction.

Draft power varies on the size of theplow /janggi andthe depth of plowing. In order tocompare the differences of the draft resistance under various conditions of soil and several kinds of the plows unit draft is preferable to draft resistance. If total draft is R (kg), the width of furrow section B (cm) and the depth of the furrow section X (cm), the unit draft, K is R/BX (kg/cm).

The values of unit draft by soil conditions exist within a certain range and the total draft can be estimated on the basis of those values. Unit draft varies according to the depth of the furrow and the speed of the

plow. It is noted that the deeper the depth of the furrow is, the greater the unit draft is relatively and the unit draft is minimized in a certain depth, varying with the soil. The optimum depth to minimize the unit draft is said to be the half width of a furrow. In case of the Janggi the same tendency as the plow is likely to be shown.

The factors influencing draft powor are generally considered to be: 1) the size of the furrow section, 2) the shape of the plow bottom, 3) the speed of a plow, 4) the kinds and conditions of soil, 5) draft conditions. Many results on the study of the relationships between these factors are available in foreign countries but in Korea it is not the case.

4. Reserch Objectives

The objetcves of this study are as follows:

i. To review the constructions and development processes of Korean Janggi and Western plow,

ii. To develop the mathematical model for the draft of the tillage tools for different soil properties and tilling depth, from which to determine the major factors that may affect the draft resistance,

iii. To measure the actual draft of tillage tools by making use of the newly developed draft and depth gauges.

iv. To compare the draft resistance and specific draft resistance between the Korean and western plows for the same soil conditions and also for two different fields, upland and rice paddy,

In carrying out this study, the author is particularly indebted to Dr Okamula Dosid ami, professor of Agricultural Engineering of Hokkaido University in Japan, for helpful suggestions and criticisms and to Dr. Joo ChuChnng, Associate professor in Agricult ural Engineering Deparment of Seoul National Unversity for helpful discussions and carefully reading the manuscript. Special acknowledgment goes the Assistant professor Hyun Kap Song in Choongbuk University and also to Mr. Jong Ho Lee and Mr. Dong Hyeok Keum, the graduate students in the Departm-ent of Agricultural Engineering, Seoul National University for their assistances during the process of this work.

History of the Plow Development

It is an interesting to know how all kinds of plow in the world have been developed and to know how the present type of plow has been improved. The origin of farm farming in the primitive age but it is impossible to know all kind of ancient farm tools complately or we can imagine general types of ancient tool by the many things found in an old mound because we cannot find sufficient records or materials about ancient farm tool.

Only we can imagine that the tool was very simple from judging that ancient farming was very simple and primitive. To the end of 18th centry farming was not so progressive that also farm tool was very poor, all farming work was done by manual power only.

Then, what is the first farm tool used at that time? probably it seems to be origin of present hoe. It the ancientshad planted some flower in the garden without any kind of tool, they could have dug out by hand at soft soil, but they couldn't dig out hard soil trunk or a piece of stone.

Beginning of these days, they used straight wood bar, and they gradually used wood branch instead of it. It was just origin of present hoe.

At old days the ancients at the Swiss lake

side had used an antler and in Egypt they had used Egyptian Sickle which had handle and cutting edge even if all parts were wood. From this time the ancients had used artificial tool suchas above instead of straight wood bar or wood branch.

Gradually they had used cutting edge with shell of schellfish or stone pieces and after that human being had invented iron, they had used iron cutting edge.

Although these progressive course was very different in evevry country, everywhere the ancients had used small tool such as hoe shape for a loug time, and chiefly carried on agriculture by man power.

Since such kind of small tool was not suitable for plowing large area and also working performance was inefficient, the ancients had begun to use plow alike present one.

As this method was initiated, one man held plow vertically and a few people pulled the plow as if now a days animal does. As mentioned above, the origin of plow and it's progress was about the same in the world until the beginning of 19th centry judging from every records and things found in the old mound. However, western countries had used animal power for plowing because their field was very large in size and was used for upland crops. The progress diagram of plow is shown [42] in Fig. 6.

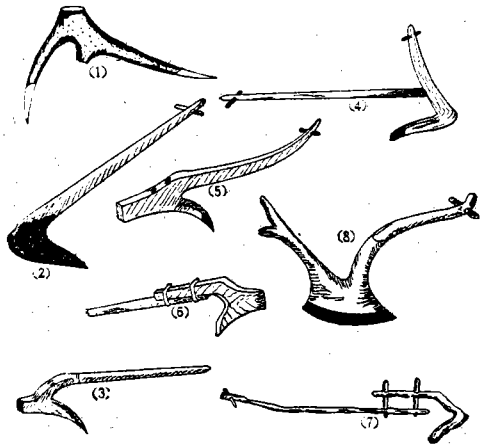


Fig. 6-(a) Development process of western plow

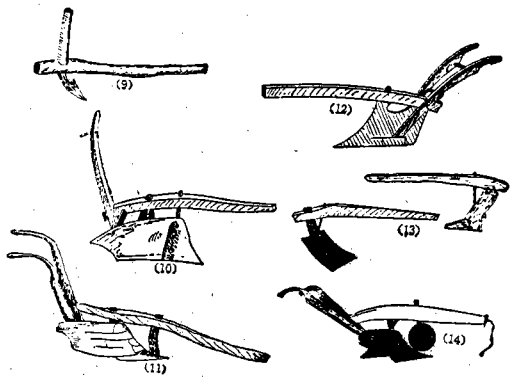


Fig. 6-(b) Development process of plow

1. Development of western plow

In the West, the origin of plow regrards as the time of B. C. 2000. At this time, the plow was a device operated by hand, as shown in the Fig. 6-1, whith was made of antler or wood branch, Egypt regarded as the cradle of plow.

As the human civilization was progressed, bended wooden branch was changed to the cutting edge with stone pieces or iron pieces as seen from Fig. 6-2 to [9]. At the end of 18th centry a little complicated wooden plow was developed. The use of this type was very vigorous and much improved in the America.

Mr. Charles Newbot invented cast iron plow from 1790 to 1796 first time in the west, as shown in Fig. 6-12, and this type had been used for a good while, and again John Deere invented steel plow in 1833 as shown in Fig. 6-14 and then the steel plow had been improved further more.

In 1870, the disc plow was developed. Gradually multifurrow plow for large land in

America was rapidly developed.

2. Development of Oriental plow

Fig. 2 [42] shows the progress diagram of the oriental plow, the origin of which was almost the same time as the western plow, but each developing courses were a little different each other.

The oriental plow has been developed from the long landside plate plow and non landside plate plow crawhich is not in the orient now. Thedle of oriental plowwas the basin of the Yangtse River and this plow was initiated in Korea and also in recent year progressed to the short landside plate plow in Japan. In the oriental tradition plow, similar type of present short landside plate plow had been used bothas paddy field and upland in a plain of the Korea from 1920 to 1935 as Fig. 7-3-c. At this time that was comparably progressed type. Fig.7-3-d

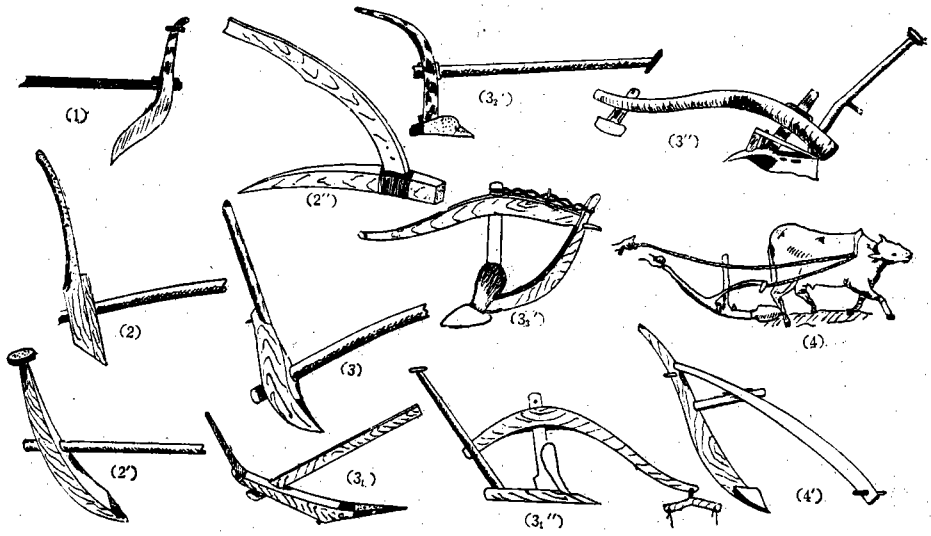


Fig. 7-(a) Development process of oriental plow

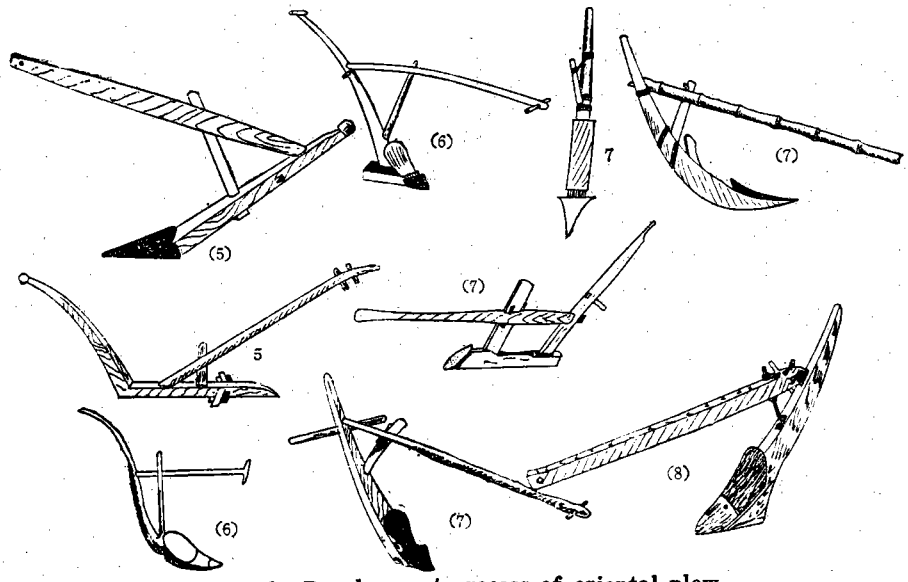


Fig. 7-(b) Development process of oriental plow

was called"long landside plate plow" and this had been used in Formosa and Kyusyu in Japan. Fig. 7-3-c was maturian plow that had been widely used in Manturia and in northern part of Korea also the similar type of this plow called "Pyund Chang" had been used for a good while.

Fig. 7-4 is the non landside plate plow that had been used in China for along time, partially in Korea it had been used at sandy and stony area or on the inclined area. Those plows as shown in Fig. 7-5-7 had been used in the orient until the standard type of plow as called short landside plate as shomn in in Fig. 8 came app-ear.

3. Development of Janggi (Korean plow)

The Janggi came into Baek Je dynasty and Silla dynasty from China, in the northern part of Korea. Manturian plow had been used and developed, after that, this plow had been translated to the Japan.

In Japan this type was used and developed two types that is, lond landside plate plow and non landside plate plow, and Japanese farmer developed those types to the short landside plate plow again the type that was initiated from short plate plow(Japanese plow), was developed and used at some area in Korea.

At that time Janggi was very important tool of Korean Agriculture. The traditional Korean plow was instatle, because it was vertical type. It's production system was not industrial but chiefly all of them were made by each farmer. Also it's structure was a littl edifferent by the area in Korea.

Generally speeking, the bottom of share was wide and plain and mouldboard was directly attached to the share in big plain area. The reason was for compacting after plowing and this type was much used in dry area.

Also in the mountain area and inclined area, Janggi without mouldboard had been much used, because the turning slice by the mouldboard was impossible for those area of sandy, grable, and shallow soil. Another reason was that in an inclined area, it was impossible at the lower part of land to make the turning slice of soil and in this aresmuch more needed to prevent drying of soil. The depth and width of plowing was controlled by the angle of the plow body.

In First plowing one makes plowing width a little narrow and turns over fullow slice on the up plowed land, and after that, in second plowing, one makes plowing with a little wide and same time makes high ridge by turning over furrow slice two times. Generally in this method, plowing depth is not deep and plowing width is not wide.

Plowing performance of this method was a little different according to the skill of operator and soil condition but it was about 60 a/day (8 hrs) in upland, and 40 a/day (8 hrs) in paddy field.

In the traditional plow in Korea, beam leg and share were made by each farmer so, it's shape was not proper type. Therefore plowing method also wasa little di fferent ineach area.

The shapes[42] of each kind of traditional plows are as follow: Fig. 8 had been used in large plain area in Korea and it was pulled by one animal and used in upland and paddy field commonly.

This plow was vertical type and stable as Fig. 7-3-c. The beam was a little bended on center, and attached to the leg and brace.

Those material was pine tree and, share and mouldboard was cast iron. It's structure was similar to the present plow as Fig. 8.

Leg was bended wood, 2" depth, 3" width

and 4. 5-5" length. The length of brace was 95cm, and it's material was rect angular wood bar had 7 cm width. The beam of plow was a little bended rectangular woo den bar 2m long.

It's end size was 7cm width and 8.5cm depth and attached to the crevice. The central part of beam is bigger than other part, and from here brace is attached to upper part of the let.

Share is attached to end of leg, and it's lenght is 40-45cm and, width 24-30cm, also it's cutting edge is very sharp to plow soil easily and then mouldboard turns over the furrow slice. The shear has plain and smooth surface with a small round hole at the center of it and jaw the similar to half-moon on the backside of it, a small round hole is used to fix the shear on the bottom by a spike and the later is used to hold the wooden plow bottom.

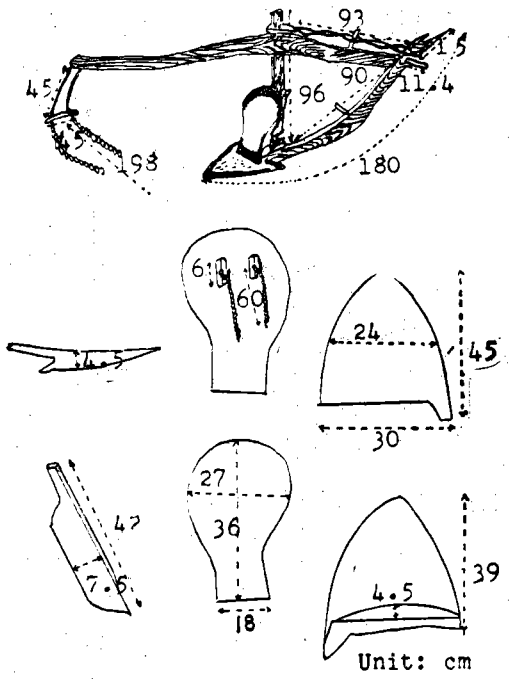


Fig. 8 Traditional Janggi and its detail[22]

The mouldboard which has the smooth curved and twisted surface is connected with the shear to form a plow bottom which has performance to shear the unplowed soil, to rise the soil and to turn over the furrow slice of p. owing soil. The size of it is 38cm length, 27cm width. The degree of the curvature is very important for the turning effect. The surface of the mouldboard is plain the state and smooth but on the backside it has jection, 6cm long, 2cm wide and2cm thick. The turningeffe ct is controlled with changing a proof attachment of the projection. The connecting pin, 3cm diameter and 20-30cm length round wooden bar, fixed verical the end of the beam is connected with the drafting ropes that are fastened with the curved drafting bar.

The neck draft method as shown in Fig. 9, 10 was used mainly to draft the plow (Janggi), since the working cattle was the main power source to draft Janggi.

The working cattile's neck is forced to bend to hold the curved draft bar tthe proper position on the neck, for the purpose of prevention for the draft bar to tilt, the left and right sides, a simple breast band is used.

The best material of the band, 75cm long, 5-6cm wide, was the leather but it was very expensive, therefore the staw belt was used generally. We have to pay attention to make the the band and to attach it to the cattle, if the band were narrow, it would press the cattle on the breast with a concentration force derived from resistance, therefore the band was made of strong, wide and soft material.

Two cattles drafting method is as shown in Fig. 11. In this case, the assistant wood bar put on the left and right sides of the cattle leads the unskilled cattle between these drafting ropes.

And then the draft resistant force is conc-

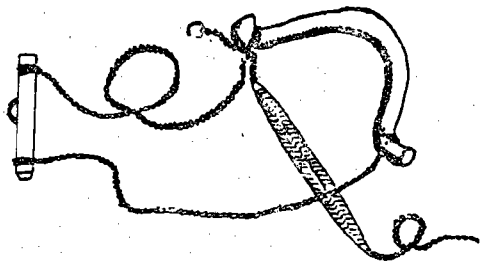


Fig. 9 Drafting ropes and curved bar[22]

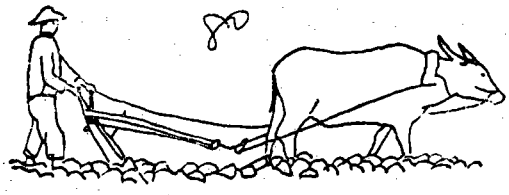


Fig. 10 Plowing mechanism of Janggi drafted by cattle[22]

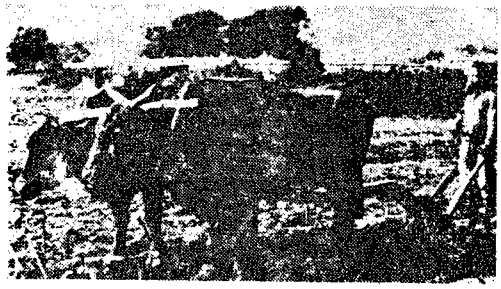


Fig. 11 Two cattles drafting mechanism[22]

entrated on the certain position of the neck, therefore the neck would be damaged very often by the pressure of the draft curved bar, the operator of the cattle has to pay attention for it.

The Janggi as shown in Fig. 12 has been used in the Pyung-An Buk-Do and it is called "Pyung Chang", that is drafted by one cattle and the beam connected directly with the draft curved bar was used insted of the draft rope.

This Jenggi used on field of the mountain and on the sandy field were not able to turn over the furrow slice and it was used to plwo partly the furrow to seed directly there. There was not mouldboard on this Janggi bottom and it's shear plate as same as the other.

The Janggi as shown in Fig. 13 was called "Kekjang" and in had no mouldboard on the bottom, Kekjang attcahed with mouldboard was called "Bow".

It was drafted by two working cattles, that was used on the field and rice paddy but from 1930 it had been used on the field of mountain and on sandy field only and on the reclamation field in the Pyung-An Nam-Do. the Ham-Kyung Nam-Do and Whang-Hea-Do until 1943.

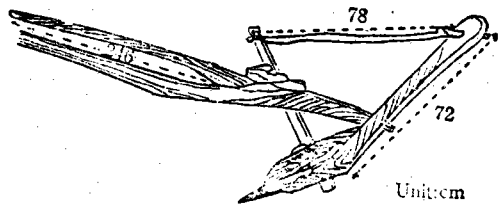


Fig. 12 The old type og Janggi used in Pyung-An Buk-Do[22]

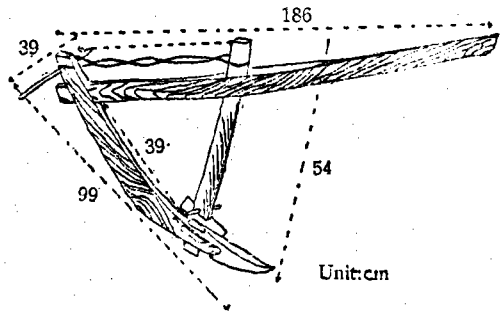


Fig. 13 Janggi by the name of Kokjang[22]

The Janggi as shown in Fig. 14 belongs to the non landside plate Janggi that had not mouldboard and it could not turn over the soill slice therefore it could be used to plow the inclined field in the mountains in the south of Korea.

The Janggi as shown in Fig. 15 had been

used on the field of plain in the Chol-Ra Buk-Do from 1925.

It had been improved from the plow of Japan and the traditional Korean plow, it's curvature of the moldboard was large enough to plow the furrow deeply. As this Janggi was not so bad to form the deep furrow but also the turning effect and the plowing efficiency were very high, from 1935 to 1940 it had been used on the field and paddy of plain area in the Chol-Ra Nam-Do, the Dhung-Cheong Nambuk-Do and the Kyung-Sang Nambuk-Do.

The shear plate and it's moldboard were made of normal cast iron and they were not strong enough to use for one or two years, and so according to the state of the field they were changed once or twice a year.

This Janggi was made of some kind of wood, pine and betula, and cast iron. Besides of the Janggi mentioned above, there was some kind of reclamation plow to cultivate the original unplowed soil.

The reclamation plow drafted by three or four working cattles was weighter than the normal Janggi, it had a strong shear plate, 60cm long and 10cm thick.

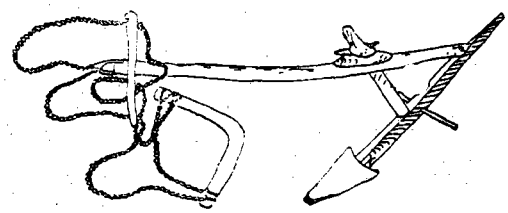


Fig. 14 The old type Janggi usedto plow the mountain field[22]

Fig. 15 The old type Janggi used to plow the field of plain[42]