A Mystery of Ancient China

The Riddle of the South-seeking Chariot

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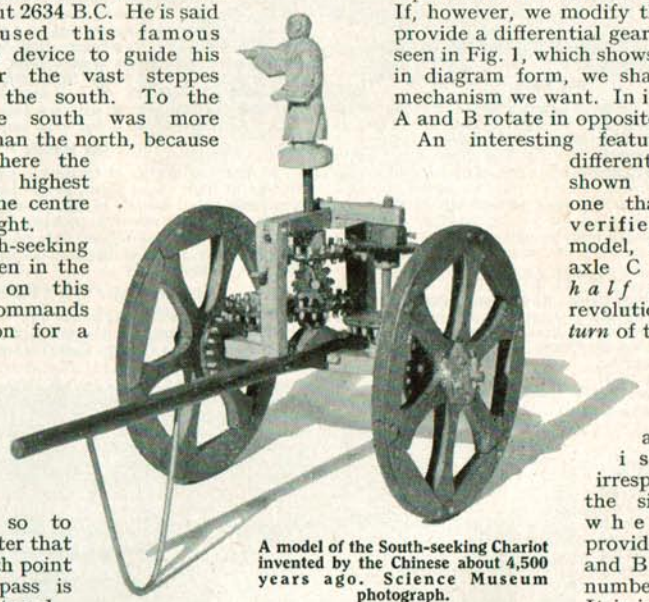
AN interesting model is inconspicuously displayed in the Science Museum's exhibition that treats of the art and principles of navigation. It represents the South-seeking Chariot, which was possibly used by the Yellow Emperor Huang Ti in the 64th year of his reign. The Yellow Emperor was one of three great Chinese Emperors of an almost legendary period and his reign is dated in Chinese story at about 2634 B.C. He is said to have used this famous navigational device to guide his armies over the vast steppes leading to the south. To the Chinese the south was more important than the north, because to them where the Sun stood highest there was the centre of life and light.



A model of the South-seeking Chariot invented by the Chinese about 4,500 years ago. Science Museum photograph.

The South-seeking chariot is seen in the illustration on this page. It commands our attention for a variety of reasons. Firstly, it contains a differential gear that is used ingeniously so to direct a pointer that the true south point of the compass is indicated, irrespective of the way in which the chariot is manœuvred.

Secondly, it discredits the story, presented in so many books and encyclopædia, that the Chinese invented the *magnetic compass* over 4,500 years ago.

Thirdly, it suggests that the Chinese artificers at Huang Ti's court were uncommonly well versed in the art of mechanisms, and that they had usefully employed the differential gear 4,500 years before it was *re-invented* in the West.

Meccano enthusiasts will be familiar with the differential gear, which has its most common use in the back axles of motor vehicles, in which it allows the inner and outer wheels to make a different number of rotations as the vehicle follows a curve in the road. This is necessary to prevent wheel-slip, since the outer wheel has to travel farther than the inner wheel in the same time.

The differential gear used in the rear axle of a car would be of little use to direct a pointer in the South-seeking chariot. If, however, we modify the gear and provide a differential gear of the type seen in Fig. 1, which shows the chariot in diagram form, we shall have the mechanism we want. In it the wheels A and B rotate in opposite directions.

An interesting feature of the differential gear shown in Fig. 1, one that can be verified from a model, is that the axle C makes *one half turn* or revolution for a *full turn* of the wheel A when wheel B is kept stationary. This is true irrespective of the size of the wheels D, provided wheels A and B have equal numbers of teeth. It is important to keep this in mind to appreciate fully the working of the chariot.

The layout of the gears used in the South-seeking chariot is made clear in Figs. 1 and 2, the illustrations on the opposite page. Let us consider these in a little more detail. It will be seen that the pointer P is controlled by the axle C, to which it is rigidly connected by way of a vertical shaft. The differential gear consists of the wheels A and B, and the axle C, with its pair of small wheels, D and D1. The wheels A and B are free running on the axle F. The gear wheels lettered H in

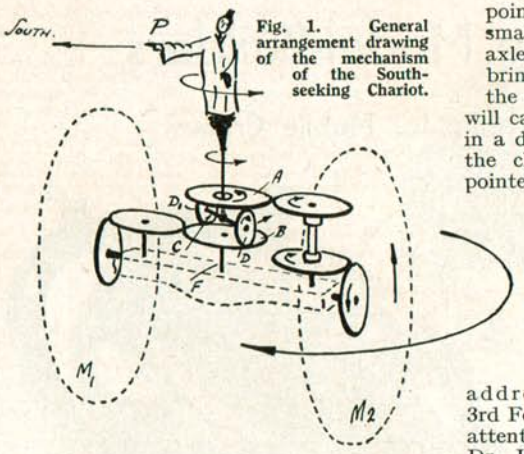


Fig. 1. General arrangement drawing of the mechanism of the South-seeking Chariot.

Fig. 2 have identical numbers of teeth, and this number is the same as the number of teeth of the wheels A and B.

The main road wheels of the chariot, M1 and M2, are spaced apart a distance x, which is made equal to the diameter of the road wheels, as is clearly seen in Fig. 2.

The reason for this equality of the lengths *d* and *x* will be obvious if we consider the main road wheel M1 to be fixed, that is stationary, as indicated in the lettering of Fig. 2, while the chariot is bodily revolved clockwise as seen from above. The chariot's outer wheel M2 then sweeps out a circular track, and will make *two complete rotations on its axle* for one revolution of the chariot in space.

Now the two rotations of main road wheel M2 will cause wheel A to make two rotations and the axle C one revolution, or turn, in a direction opposite to the chariot's direction of turn. In this example the axle C moves counter clockwise as seen from above. Now axle C and pointer P are rigidly connected and pointer P therefore remains fixed in space as the chariot is turned.

It will be appreciated that if the chariot moves forward or backward in a straight line, the main road wheels M1 and M2 will rotate at equal speeds and consequently the wheels A and B of the differential gear will also turn at equal speeds but in *opposite* directions. In these conditions the axle C and the pointer P remain stationary, while the small wheels D and D1 rotate on the axle C. Any turning of the chariot will bring about a difference in the speeds of the two wheels A and B, and thereby will cause axle C to revolve the pointer P in a direction opposite to the direction of the chariot's turn. This will keep the pointer fixed in space on the point to which it was originally set—in this case the south point.

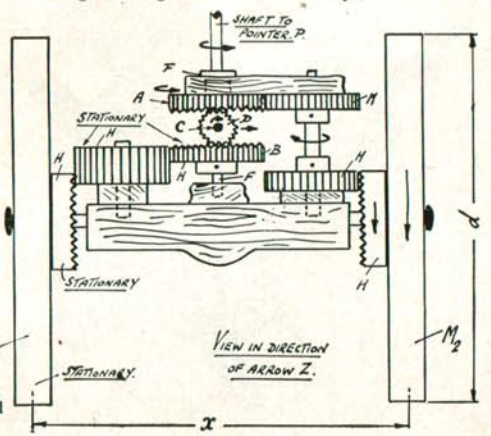


Fig. 2. The gearing of the South-seeking Chariot. The road wheels are spaced apart a distance equal to their diameter.

Now a word about the oft repeated legend of the invention of the magnetic compass by the Chinese.

Mr. George Lanchester, whose solution of the problem of the South-seeking chariot I have presented, delivered a learned address to the China Society on 3rd February 1947. In this he directed the attention of his listeners to a lecture by Dr. J. B. Kramer, an eminent electrical engineer, on the history of magnetism. Dr. Kramer makes this very forceful statement. *"Where are the manuscripts in which the Chinese lay claim to the honour of having discovered the magnet? There are none, and there never existed any writings by the Chinese claiming for themselves that discovery."*

In the course of Dr. Kramer's researches he visited the British Museum and in the Oriental Library there he studied Dr. Herbert A. Giles' historic work *Adversaria Sinica* (Book 11853s) in which he found evidence that the South-seeking chariot was a *mechanical* device and *not magnetic*.

I think you will agree that the model by Mr. George Lanchester and the researches of Dr. Kramer provide a lesson of absorbing interest in the fields of mechanical engineering and the history of science.