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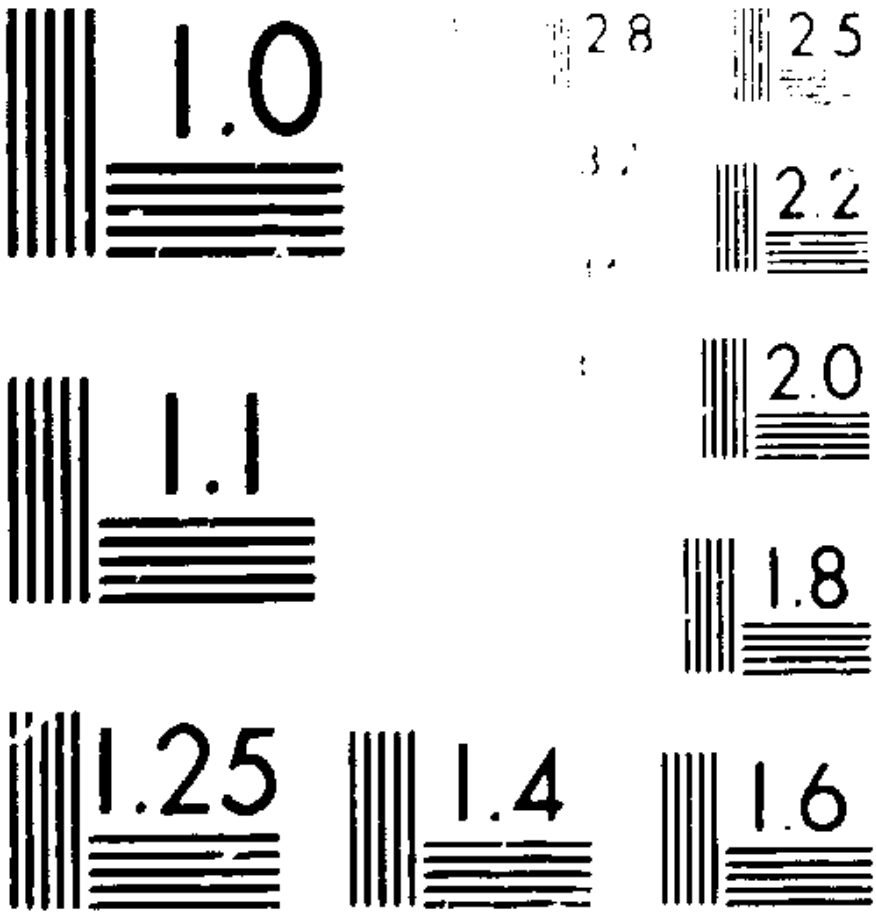
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Harare, Zimbabwe

WORKSHOP ON DESIGN AND DEVELOPMENT
OF AGRICULTURAL EQUIPMENT IN AFRICA

EXPERIENCES IN ZIMBABWE. (Agricultural equipment)

CAIRO 17TH OCTOBER - 28TH OCTOBER, 1982

BY

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MINISTRY OF AGRICULTURE
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WORKSHOP ON DESIGN AND DEVELOPMENT OF
AGRICULTURAL EQUIPMENT IN AFRICA

Cairo - 25 September to 8 October 1982

Presented by A.J. SPEAR
Chief Engineer,
Head of the Institute of Agricultural Engineering,
Zimbabwe.

INTRODUCTION:

Zimbabwe is a country situated on the central plateau of Southern Africa. The country lies between 17° and 23° south of the equator. Most of the country lies at a reasonable altitude above sea level varying in the main between 500 and 1 400 metres. It is for this reason that the rigours of a tropical climate are less harsh for, despite being in the tropics, the climate generally is closer to sub-tropical.

Zimbabwe is a land-locked country of some 39 000 km^2 in extent. The nearest outlet to the sea is the port of Beira in Mozambique which is over 200 km in the east. There is a period of four months from November to February when there is strong solar heating of the atmosphere. Rain falls from November to mid March in the northern half of the country and from late November to early March in the areas of lower altitudes to the South. Rain falls generally in relatively intense storms, usually after midday, and there are fairly long, hot, dry sunny days between storms. The prevailing wind throughout the year is from the east and the warm waters of the Mozambique Channel form an important source of moisture. Another source of moisture is the so-called Congo Air which is formed in the south east Atlantic and when this air meets colder air from the south east rain due to this convergence can give whole days or longer of continuous precipitation. This rainfall rarely moves to the south of the main watershed which runs from the south west to the north east. October, before the start of the rains, is the hottest month. In this month the mean temperature at Buffalo Range (420m) is about 32,5°C whilst that at Inyanga (1 870 m) is 21,7°C. Thus altitude has a considerable effect on the temperature.

CAIRO, A.J. SPEAR, ZIMBABWE.

The industry in Zimbabwe is relatively sophisticated compared with most countries in Eastern and Southern Africa. Zimbabwe is fortunate in having ample supplies of iron ore, coal, electricity, and steel is comparatively cheap and in plentiful supply.

Local industry is capable of producing good quality engineering products, but generally most manufacturers do not have the facilities for research and development of agricultural machinery. It is therefore important that the engineers available at The Institute of Agricultural Engineering and the manufacturers work as a team, and this has been the policy of the Institute and many of the manufacturers for the past 15 years. Currently the Institute has a very good working relationship with manufacturers and several of the experimental machines developed at the Institute related to Tillage Systems have been in local production almost as soon as the development work has been completed. On other occasions where the manufacturers have had past experience, they have produced proto-types of machinery which the Institute have tested. Another method which was a follow-up of a detailed ox cart survey (see appendix) was an invitation to local manufacturers of ox carts to submit them for a competitive test on certain performance criteria. The results of these tests are shown in the appendix. The ultimate result of the ox cart project was not as successful as it should have been mainly due to factors related to unsuitable sales and service facilities together with a lack of manufacturing facilities in rural areas by the local "Blacksmith" type of organisation.

A further approach which has been successful when enough information is known about particular requirements of a specific operation is a competition with detailed performance specifications, when manufacturers are invited to produce samples of their designs which are then tested competitively to ascertain which machine is of the most satisfactory design. The winner of this competition is then presented with a silver or gold medal together with appropriate publicity which is a major sales promotion aid. This system has worked successfully with ox-ploughs, ox-rippers, and tractor reversible disc ploughs.

All these methods of developing new machinery in Zimbabwe have merit, e.g. the Commercial incentive method generally works with the commercial sector,

and the "Medal" approach where the manufacturer hopes that the publicity accompanying the award will ensure commercial viability, which of course is essential for their survival. However, as the machinery gets more sophisticated more problems arise, e.g. in the case of the planter competition we could not get a really cheap and efficient unit because production of several thousand units would have to be assured before the investment necessary could be justified, and in Zimbabwe alone this figure would not be reached for some considerable time. The solution to this type of problem is much more difficult to solve, possibly some form of regional or international competition with some arrangement to supply kits in different stages depending on the country requiring planters. As far as Zimbabwe is concerned we would only need possibly the planter plates or other precision mass produced components.

Generally new types of equipment and systems for the commercial sector are implemented far quicker than on the peasant sector where considerable extension effort is necessary to get even a moderate response, e.g. within 3 years of finalising the reversible disc plough competition 40% of the land on commercial farms was ploughed with Reversible disc ploughs. Although there was only one winner of the competition there were 3 local entrants who are now all in production and, with the improvements of the non winners, they are all very competitive with the winning plough which has also had several design improvements over the past few years.

The effect on crop production, particularly in the peasant sector with utilization of improved and efficient labour saving techniques, together with the equipment to enable a farmer to utilize these techniques has been very beneficial and in some areas the average yield has been increased by over 100% from an average of 1 tonne per hectare to over 2 tonnes per hectare, and this is with very little or no more, physical effort than previously. However, the development of techniques and the production of machinery is only part of this development and it must be accompanied by major extension effort to be effective, particularly in peasant areas.

DISCUSSION

It may seem that a competition for a particular piece of machinery is an easy way to produce it, but in fact a considerable amount of work needs to be done before the competition can be launched and a considerable

amount more needs to be done during the testing programme. However, it does mean that the Manufacturer/Designer is also working under pressure to obtain the winning machine. The final result is therefore likely to be more satisfactory than trying to design, develop and get manufactured a piece of machinery at a reasonable price than trying to do it as a Government project, and then get it made on a contract basis. One of the problems trying to get a specific design manufactured is that some local manufacturers may have good foundry facilities and others may have good pressing facilities and the most economic design would therefore depend on the facilities that a particular manufacturer has.

Whichever method is chosen to stimulate the manufacture of Agricultural Machinery in Africa, success will depend to a large extent on the enthusiasm and both quality and quantity of effort the Engineers and Technicians are able to provide.

Details of the various competitions and investigations are shown in the appendix as follows:-

1) Report on Investigations on ox carts in peasant areas.
2) Photostat copy of the Silver Medal Competition 31st March, 1970.
3) Photostat copy of the Silver Medal Single Furrow Ox Plough competition June, 1971.
4) Introduction to test Programme
5) Test Results.
6) Competition for Tractor Drawn Reversible Disc Plough 31st March, 1973
7) Test Results and Silver Medal Winner.
8) The Whitsun Cold Medal Competition for an improved animal drawn planter fertilizer unit. (Photostated).
9) Test Results of above.

APPENDIX I

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Ref: F/7/11

CONEX FARM MACHINERY TRAINING CENTRE,
DOMBOSHAWA,
P.O. BAG 1,
BORROWDALE.

17th January, 1970

District Commissioner (Marketing),
Ministry of Internal Affairs,
P.Bag 702,
CAUSEWAY.

REPORT ON INVESTIGATION ON SCOTCH CARTS IN AFRICAN AREAS

1. Aim

To find out (at the request of the Ministry of Internal Affairs) the major weaknesses of scotchcarts (particularly professionally manufactured ones) and how these can be most easily overcome.

2. Method of Investigation

(a) A survey was conducted by the E/A's manning mobile ox-drawn Training Units in the 5 Provinces, Mashonaland North and South, Victoria, Matabeleland, Midlands, in Tribal Trust Areas.

Over a period of 2½ months a questionnaire was completed for each group (roughly 12) attending a training course. The farmers' complaints, comments and suggestions were also asked for.

(b) Various carts, including two designed and built at Domboshawa, in the light of the results of the survey, were subjected to a road test.

(c) Carts which proved satisfactory on the road test are sent out to our Field Training Units for field evaluation.

3. Results of Survey

A table of results Province by Province is attached. (See Appendix A.)

The following summary of this table indicates some interesting information:

TOTAL FARMERS QUESTIONED	NUMBER OF CARTS OWNED	PERCENTAGE HOME BUILT	PERCENTAGE WITH PNEUMATIC TYRES	PERCENTAGE OF ½ TON CAPACITY	PERCENTAGE OF 1 TON CAPACITY
1,412	687	48	67	45	48

The main complaints were:

(a) On carts with plain wheel bearings these bearings wore very quickly to the point where there was sufficient slack to allow the wheel to scrape the sides of the cart.

(b) "U" bolts fastening body to axle were constantly working loose and breaking.

(c) Some makers used soft wood for the bodywork.

(d) Some carts were mounted on old car axles which ran on 19" wheels and these tyres were very difficult to obtain.

There were many more complaints which occurred less frequently throughout the survey, for example:

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Disselboom (drawbar) connection to body too weak.
Brakes did not work.
Spokes of steel wheels break, usually at the weld.
Too low a clearance under axles.
Welding insufficiently strong.
Some bodies were too shallow.
Tyre levers, spanners etc. were not supplied with the cart.

4. Discussion of Results

The table in Section 3 above shows that almost 50% of the farmers questioned were owners of carts and also nearly 50% of the carts were home built.

Assuming that the results of the survey can be taken as representing the situation in the whole country then roughly 200,000 carts are in use at the present time. The remaining 200,000 plotholders who do not own carts are probably using sleighs for a lot of their transport.

Of the 200,000 carts in use, approximately 100,000 have been locally built in the Tribal Areas.

The working life of a scotchcart is in the region of 5 to 10 years, before replacement is necessary. This means that 10,000 to 20,000 carts are built locally every year.

At an average figure of £30 per cart, the result is a £300,000 to £600,000 home industry.

Considering population increase and the fact that there are still about 50% non owners, this can only be an expanding industry.

5. Discussion of Complaints

On the Harold Poole carts, with plain wheel bearings, there is available, at a cost of 6/-, a bush for the wheel. The makers offer to fit these bushes at no charge to the owner for labour. Remoteness and difficulty of transport preclude many owners from taking advantage of this service, but it seems that very few of them are even aware that bushes are available.

If these bushes were renewed when necessary the biggest complaint about these carts would be removed. The manufacturers press the bushes in and out, but if a correctly matching drift were supplied with each cart the farmer could then do the job himself - or certainly the local garage could do it, provided the drift. (The establishment of reliable local agents would help to provide a more easily available servicing and spares organisation).

It would seem from the data collected that a satisfactory scotch-cart should consist of :

Enclosed bearings.
A deep body.
Hard wood construction.
Standard size pneumatic tyres (or semi solid type).
A simple and effective braking mechanism.
A good ground clearance.

With special attention during construction being paid to :

Disselboom fastening.
Body to axle clamping bolts.
Welding.

And the provision of sufficient tools and accessories to maintain the unit.

..3/..

6. Performance Criteria

The following standards are assumed:

(a) The cart should last the equivalent of at least one year without failure due to normal wear and tear, (at an estimated 1000 miles/year).

(b) It should carry a load of 1000 lbs. minimum.

(c) It should be satisfactory for use on tarred roads as well as unmade roads.

7. Details of Road Test

The test consists of running the carts over typical T.T.L. roads loaded with a minimum of 1000 lbs. of bagged sand.

Oxen are used when possible, also a tractor running at 2 m.p.h. pulling two carts at once.

A constant check is made on mileage and time taken, and notes are made of any failures or changes as they occur. The manufacturer is informed of any breakdown or weakness as it occurs.

8. Performance and Specification of Individual Carts (For summary see Appendix C)

(i) 'Earthwork Contractors' prototype: (Plate 1)

Specification:

Deck & Sides : 5' x 4' pressed steel 16 gauge unit construction 18" deep, hinged tail gate.

Wheels & Axles: Wheels, fabricated rubber tyres on spoked hubs. Bearings plain steel, steel in wood, and ball bearing at various times.

Retail price : £20

Performance:

The road test started on July 11th with steel axles and plain steel hubs on both wheels, one greased and one ungreased.

The un-greased axle lasted only 16 miles before it was too worn to continue using, and was replaced by an identical bearing which was given one hand greasing only for the duration of the test. This bearing began to wear rapidly after 80 miles, but the tyre failed before the bearing was quite useless.

A wooden bush on a steel axle with initial greasing only was beginning to show slight wear after 30 miles. The wear rate was very slow up to 74 miles when the tyre failed, stopping the test. Given adequate greasing this wooden bush would last quite well.

Sixty miles after starting the test the axle ends, outside the box mountings, had began to bend upwards.

The limiting factor up to now, apart from plain steel axles and hubs which will be unsatisfactory unless constant lubrication is ensured, has been the tyres, and since these are an integral part of the wheel and hub, it is impossible to continue testing once they fail.

It is my opinion that as it stands at present this cart is not yet a sound proposition, certainly no better and probably worse than existing available carts. With the right modifications it could, however, prove to be very worthwhile.

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Modifications should include:

Satisfactory wheel bearings.
Stronger axle.
Heavier gauge floor sheeting.
Improved tyres.

(ii) Domboshawa prototype: (Plate 2)

Specification:

Deck	:	6' x 4' steel-over-wood, 2" x 2" x 3/16" angle iron frame.
Sides	:	Wooden, 3" x 1" saligna planks, 15" high, staked into deck pockets, completely and individually removable.
Axle & Wheels	:	Car front stub axles, connected by angle iron (or pipe) axle, welded, conventional pneumatic tyres 590 x 15.
Cost of materials only	:	£19 - all materials costed at full retail price.

Performance:

This cart is running on second-hand car front stub axles and ordinary car tyres.

No failures have occurred to date after 210 miles on the road test.

This cart has now been sent into Chinamora T.T.L. for use by a plotholder as part of its field testing.

(iii) 'Plant Maintenance' - Gwanda : (Plate 3)

Specification:

Deck & Sides	:	4' x 3'5" x 14" unit construction, sheet steel on 1" x 1" angle iron frame.
Wheels & Axles:		14" x 4'8" (wheelbarrow) wheels, needle roller bearings.
Retail price	:	£30

Performance:

This is a production model as far as I can make out, and the manufacturers have informed me that it was designed to carry 1000 lbs.

After 10 miles on the road test the tyres (solid rubber on split rims) were noticed to have become loose fitting on the rims. This condition progressed fairly rapidly.

One wheel rim came apart completely at 36 miles. Panel beating and welding was necessary to get it back on the road.

Dunlops maximum load rating for this 14" by 4.8 tyre is slightly over 400 lbs.

At 42 miles the body work began to crack at stress points.

Road testing was stopped at 49 miles.

This cart is not suitable for carrying 1000 lbs. and certainly not for rough roads. No doubt it has an application for much lighter

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loads on reasonable road surfaces.

(iv) Purcell Engineering - prototype : (Plate 4)

Specification:

Deck & Sides : 5' x 4' x 12½"
4" Wood (pine) planks in 2" angle iron frame unit construction. Removable tail gate.

Wheels & Axle : Steel spoked wheels 30" diam. 4" width
Nylon bushes on steel axle.

Performance:

This cart has completed 320 miles on the road test satisfactorily and the test is continuing but with 25% increase in load for a period of 100 miles; if still satisfactory an additional 25% increase will be made for a further 100 miles.

Some minor breakages, include the hitching eye on the end of the dissleboom and the floor bracing which required strengthening.

The wooden floor is not metal covered and this would inevitably fail in practice.

The sides are bolted to the angle iron frame so are not easily removed.

The main feature of this cart is the type of bearing which if proved satisfactory will be a promising substitute for the manually lubricated plain or roller bearing.

The makers are modifying the steel wheels, making a curved instead of a flat tyre.

(v) Nimac Engineers (Plats 5, 6 and 7)

These carts were inspected independently in Fort Victoria by the Senior Agricultural Engineer whose report is quoted in full:

"The range of Ox Carts produced by Nimac Engineering as shown in the attached leaflet, and the smaller one known as the 'slay slay' as shown in the attached photographs. All the cheaper range have plain wheel bearings and need to be lubricated. Experience has shown on the tests that we have carried out at Domboshawa that ordinary plain bearings, as fitted to these machines, are not satisfactory and without care will last for only a few hundred miles. In fact, some of the ox carts with plain bearings have already been returned to Nimac Engineering with bearings that were beyond repair. It is, of course, impossible to estimate the mileage that their carts have performed, but there is no reason to suppose that this would be any greater than that experienced by ourselves with similar bearings."

None of these carts have been tested at Domboshawa.

9. Conclusions:

1. The most satisfactory new bearing so far is the Purcell Engineering type. Although old car bearings if well adjusted, sealed and greased initially are quite satisfactory.

2. Body size of 5' x 4' is ample for the 5 bag cart. Sides, of the removable type, are preferred. A steel covered deck will last better and give less trouble than a wooden deck.

3. Provided the draught is taken from the axle, body-to-axle mountings should give no trouble.

4. Investigation into alternative tyre equipment to 2nd hand car tyres continues. Enquiries have been and are still being made with overseas tyre and foam filling manufacturers, but as yet no reliable alternative has been brought to our attention.

5. The plain steel bushed type of bearing is unsatisfactory, particularly if left unsealed.

6. This type of testing and development work is necessarily a fairly slow process and is impossible to speed up to any great extent without it becoming unrealistic.

G. OLIVER
Extension Officer - Farm Machinery Training
for: Director of Conservation and Extension

ENG/55/CO/CS/20B/26/1/70-COPY

PRELIMINARY SURVEY OF SCOTCH CARTS IN AFRICAN AREAS

% of Tot.	21%	8.7%	1.5%	48%	16%	5.1%	48%		29%	67%	4.1%	45%	48%	6.1%				
PROVINCE	Harold Poole	Mash. Coach	Nimack Eng.	Home Built	Unknown make	MISC. Make	TOTAL Home Built	TOTAL	Steel Wheels	Pneumatic	Wooden	½ Ton	1 Ton	1½ Ton	2 Ton	Number of Farmers	% of Tot. Who are Owners	No. of Groups Constituted
Mashonaland South	9	3	-	111	23	19	67%	165	33	127	-	108	47	5	-	401	40%	22
Mashonaland North	84	7	-	69	75	-	29%	235	72	146	17	97	128	11	-	315	75%	13
Victoria	17	5	10	8	2	2	18%	44	30	14	-	16	23	5	-	87	51%	7
Matabeleland	1			21	6	14	50%	42	3	39	-	24	18	-	-	55	76%	4
Midlands	33	45		122	1		61%	201	58	132	11	64	114	21	-	554	36%	8
TOTAL	144	60	10	331	107	35	48%	687	196	458	28	309	330	42	-	1412	49%	

Conducted by Conex Engineering Branch Mobile Training Units - July/August, 1968

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APPENDIX C

REPORT ON INVESTIGATION INTO SCOTCH CARTS IN AFRICAN AREAS

SUMMARY OF RESULTS OF ROAD TESTS

CART	TOTAL MILES COVERED	TYRES	BEARINGS	BODY	GENERAL
Dombotshawa Prototype	210	2nd hand car tyres. No trouble	2nd hand car stub axles. No trouble	Steel decked. Wooden sides. No trouble Rather heavy and large.	The body need not be so large for a 5 bag capacity. Generally satisfactory. Sent for field testing.
Earth work Contractors	134	Fabricated tyre sections. Unsatisfactory	3 types tested. Plain steel bush - unsatisfactory. Wooden bush) Test in-complete. Ball bearings) due to tyre failure.	Pressed steel Floor should be heavier Sides should be re-movable.	Needs major modification.
Plant Maintenance	49	Inadequate for load. Wheelbarrow Wheels.	Roller bearings. No trouble.	Sheet metal on angle iron. Not strong enough.	Designed for donkey draught. May be suitable on good roads with lighter loads.
Purcell Engineering	320	Steel wheels 30" diam. 4" wide No trouble so far.	No trouble so far. Noisy.	Wood in angle iron frame Bottom needs strengthening.	Generally satisfactory Needs minor modifi-cation. Test continues.

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