FINAL REPORT

TRAINING IN JAPAN

JICA

AGRICULTURAL MECHANIZATION

CLAUDIO ALBERTO BENTO FRANZ

may/27 - july/27 - 1996

FINAL REPORT

This final report is about training in agricultural mechanization in Japan. This training include general knowledge about the agriculture and mechanization situation in Japan and specific study in tillage of soil implements available and instrumentation for this.

This training is enclosed in JICA/EMBRAPA-CPAC project, Japan/Brazil, for a Sustainable Agricultural Exploration in Brazil Cerrados Region.

There are three different chapter in this report:

1 - About the general knowledge agricultural mechanization in Japan.

2 - About The seminary, Brazil and Cerrados Region - Agriculture and Mechanization.

3 - Training in NARC-National Agriculture Research Center-Upland Farm Mechanization Laboratory.

Brazilian Researcher - Claudio Alberto Bento Franz - EMBRAPA-CPAC (Brazilian Agricultural Research Enterprise - Cerrados Agricultural Research Center).

CHAPTER 1

General knowledge about agricultural mechanization in Japan and technical visits.

- National Agriculture Research Center(NARC) - Upland Farm Mechanization Laboratory - Dept. of Mechanization. Specific individual training (03-06-96/24-06-96).
- Ministry of Agriculture, Forestry and Fisheries (30-05-96).
- Tokyo International Center (JICA/TIC).
- Japan Agricultural, Mechanization Association (31-05-96).
- Japan Farm Machinery Manufacturer's Association(31-05-96).
- JICA Head Office(30-05-96).
- Tsukuba International Center (TBIC).
- National Institute of Agro-Enviromental Sciences (NIAES) (27-06-96).
- Shikoku National Agricultural Experiment Station (03-07-96/05-07-96).
- Hokkaido National Agricultural Experiment Station, Sapporo and Memuro city (18-07-96/25-07-96).
- Attend the meeting of the Agricultural Working Society in Shikoku (04-07-96).
- Attend the meeting of the Agricultural Machinery Society in the Bibai city and University (23-07-96/24-07-96).

CHAPTER 2

SEMINARY

BRAZIL AND CERRADOS REGION

AGRICULTURE AND MECHANIZATION

MINISTRY OF AGRICULTURE, SUPPLY AND LAND REFORM

Embrapa

BRAZILIAN AGRICULTURAL RESEARCH ENTERPRISE
CERRADOS AGRICULTURAL RESEARCH CENTER – CPAC

Brazil covers an area of 8,511,996 Km^2, ranging from near 4° N to 33° S latitude and 36° to 72° longitude. The country is divided into 5 major regions (Figure 1) as follows:

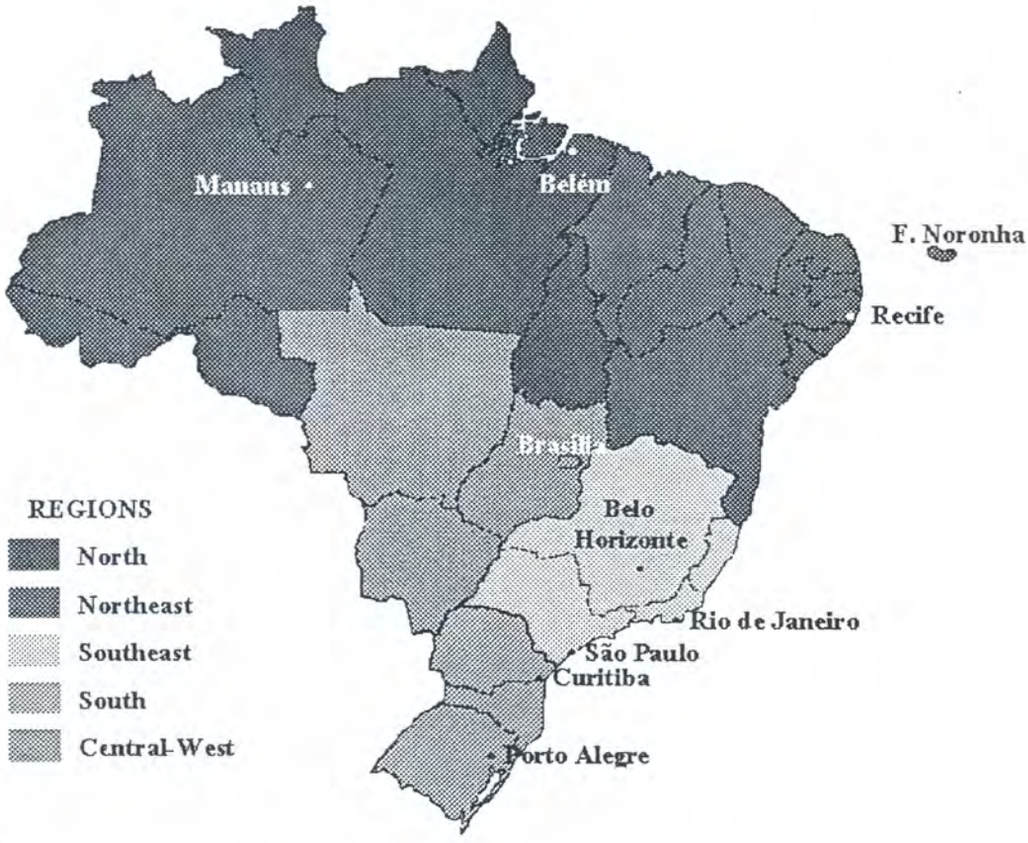


Figure 1 - Brazil, Geo-Economic Regions
Source: Anuário Estatístico do Brasil 1994

Table 1 - Climatic Parameters in Various Brazilian State Capitals - 1993

City	Average Temperatures °C		Annual Rainfall	Relative Humidity
	warm	cold	mm	%
Manaus (AM)	31.2	23.0	2,523	82
Belém (PA)	31.3	22.8	3,189	86
Recife (PE)	29.6	22.4	1,331	78
Rio de Janeiro (RJ)	27.3	21.0	1,414	79
Belo Horizonte (MG)	26.1	17.8	1,698	69
São Paulo (SP)	25.4	15.7	1,583	74
Curitiba (PR)	23.2	13.0	1,120	82
Porto Alegre (RS)	25.0	14.9	1,495	79
Brasilia (DF)	26.7	16.6	1,319	63

Source: Anuário Estatístico do Brasil 1994

GEOGRAPHICAL CHARACTERISTICS

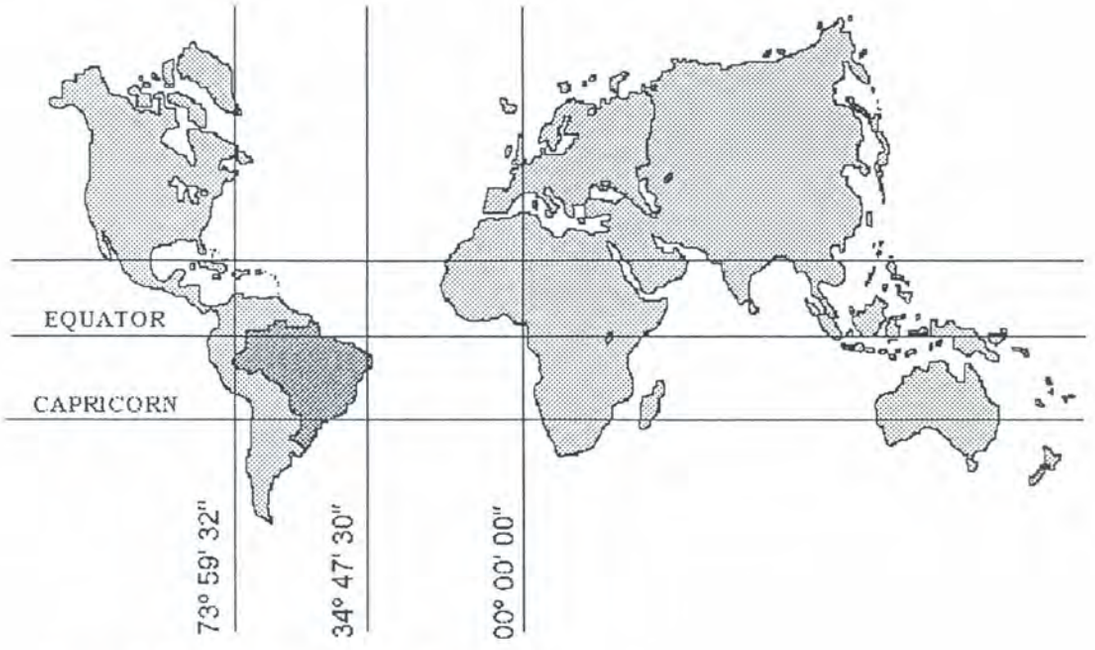


Figure 2. Brazil, Geographic Location

Figure 3 - "Continental" Size of Brazil

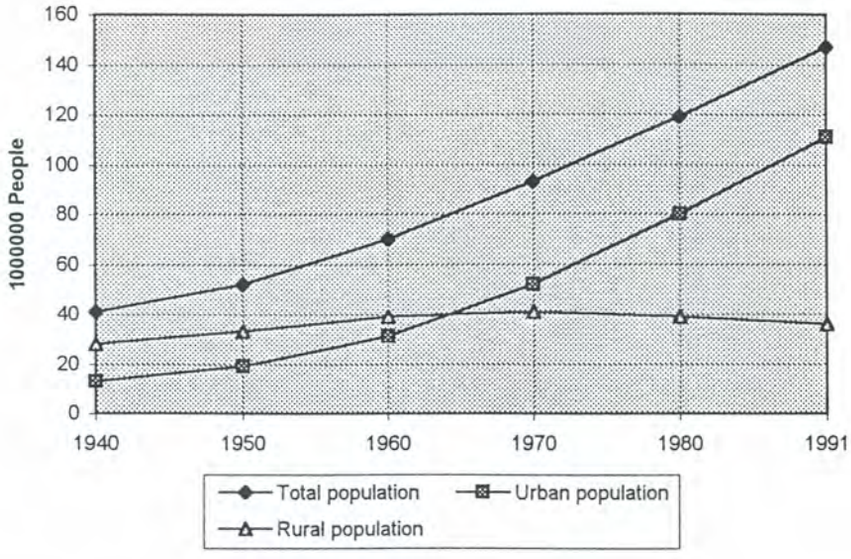


Figure 4 - Brazilian Population Growth
Source: Anuário Estatístico do Brasil 1994

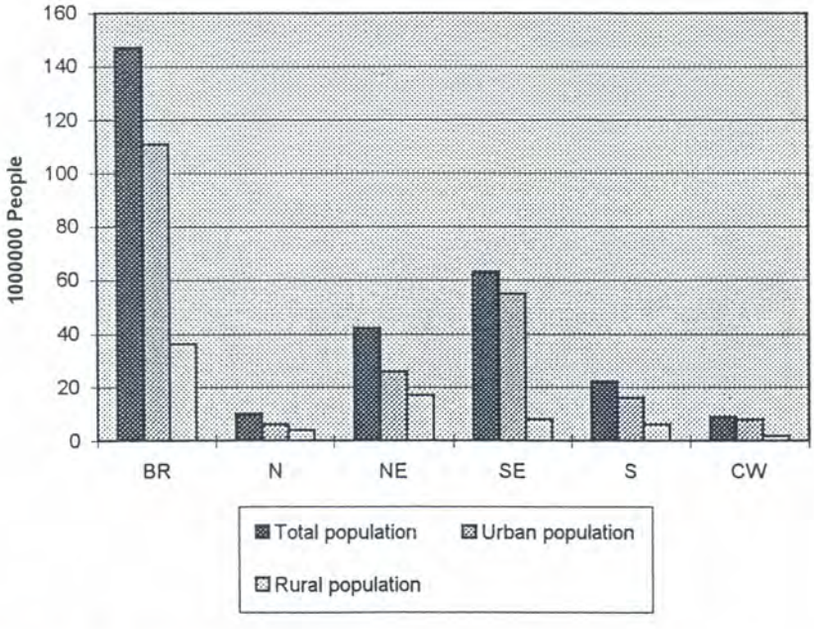


Figure 5 - Brazilian Demographic Distribution (1991)
Source: Anuário Estatístico do Brasil 1994

Table 2 - Farm Area in Brazil

Category	Area (ha)	Area (%)
1 - Crop production	117,565,459	13.49
2 - Animal production	220,926,498	25.36
3 - Animal and crop production	8,806,304	1.01
4 - Horticulture	501,707	0.06
5 - Wood production	8,735,324	1.00
6 - Poultry	1,481,399	0.17
7 - Small animal farm	171,958	0.02
7 - Natural plant extraction	16,604,421	1.90

Source: Censo Agropecuário 1985

Table 3 - Land Distribution in Brazil

Farm size (ha)	Farm establishments		Total area	
	Number	%	ha	%
< 10	3,064,822	52.83	9,986,637	2.67
10 - 100	2,160,340	37.24	69,565,161	18.56
100 - 1000	517,431	8.92	131,432,667	35.06
1000 - 10000	48,286	0.82	109,625,898	29.23
> 10000	2,125	0.04	54,314,565	14.48
not declared	8,805	0.15	-	-
Grand total	5,159,851	100.00	374,924,929	100.00

Source: Censo Agropecuário 1985

Table 4 - Brazilian Agricultural Production - 1992

Product	Production	Cultivated area		Yield
	10^3 t	10^3 ha	%	t/ha
Sugar cane	271,474.9	4,224.6	8.67	64.60
Orange	98,411.5	997.4	2.05	99.54*
Corn	30,506.1	13,888.1	28.49	2.28
Cassava	21,918.6	2,032.1	4.17	12.00
Soybean	19,214.7	9,463.6	19.42	2.04
Rice	10,006.3	4,876.7	10.00	2.13
Coffee	2,588.7	2,514.7	5.16	1.03
Dry beans	2,797.1	5,530.1	11.35	0.54
Wheat	2,795.6	1,973.1	4.05	1.43
Potato	2,432.1	173.7	0.36	14.04
Tomato	2,141.3	52.9	0.11	41.01
Cotton	1,863.1	1,641.3	3.37	1.17
Banana	562.4	525.6	1.08	1.09
Cacao	328.5	745.0	1.53	0.45
Peanut	172.2	100.7	0.21	1.71
Total	467,213.1	48,739.6	100,00	-

(*) 10^3 units/ha

Source: Anuário Estatístico do Brasil 1994

Table 5 - Irrigation in brazilian agricultural

Region	Number of farms using irrigation								Farms which use		Farms not using		Irrigated area
	Flooding		Surface		Sprinkler		Other						
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	(ha)
Brazil	112,334	44.1	54,538	21.4	59,684	23.4	27,056	10.6	253,612	4.37	5,548,197	95.63	1,959,824
N	267	14.2	207	11.0	580	30.9	820	43.7	1,874	0.34	541,839	99.66	43,244
NE	34,426	37.4	33,129	36.0	13,167	14.3	11,198	12.2	91,920	3.28	2,706,319	96.72	366,831
SE	44,080	41.7	16,830	15.9	37,386	35.3	7,409	6.9	105,705	10.63	888,273	89.37	599,564
S	32,483	68.6	2,586	5.5	5,837	12.3	6,390	13.5	47,296	3.95	1,151,246	96.05	886,963
CW	1,078	15.8	1,786	26.2	2,714	39.8	1,239	18.2	6,817	2.55	260,520	97.45	63,220

Source: Censo Agropecuário 1985

MECHANIZATION OF AGRICULTURAL OPERATIONS

Over the last four decades, the use of mechanization has been increasing in Brazilian agriculture. The last Census (1985) showed that practically all farms use some source of external energy in basic agricultural operations. Table 9 shows the use of mechanical source of power.

Table 6 - Number of farms related to power source in Brazilian agriculture

Farm size (ha)	Animal		Mechanical		Human		Total
	No.	%	No.	%	No.	%	No.
< 10	705,127	23.0	438,460	14.3	1,921,23	62.6	3,064,82
10 - 100	848,159	39.2	652,016	30.1	660,165	30.5	2,160,34
100 - 1000	133,349	25.7	200,519	38.7	183,563	35.4	517,431
1000 -	9,133	18.9	28,909	59.8	10,244	21.2	48,286
> 10000	357	16.8	1,547	72.8	221	10.4	2,125
Not	605	6.87	702	7.97	7,498	85.1	8,805
Grand total	1,696.73	29.2	1,322.15	22.7	2,782.92	47.9	5,801.80

Source: Censo Agropecuário 1985

Table 7 - Distribution of the Brazilian 4-wheel tractor fleet

Power range	Up to 10cv		10cv - 20cv		20cv - 50cv		50cv - 100cv`		Above 100cv		Total	
Region	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
N	971	2.71	1,256	2.13	2,361	2.26	5,019	1.28	2,445	3.27	12,052	1.81
NE	4,309	12.01	4,751	8.07	8,161	7.82	18,685	4.77	5,821	7.79	41,727	6.27
SE	12,865	35.86	17,730	30.14	45,977	44.07	135,395	34.58	22,980	30.74	238,947	35.92
S	15,577	43.42	31,312	53.22	35,815	34.33	180,283	46.05	23,334	31.22	286,321	43.04
CW	2,151	6.00	3,780	6.44	12,016	11.52	48,122	12.29	20,164	26.98	86,233	12.96
Brazil	35,873	100.0	58,829	100.0	104,330	100.0	391,504	100.0	74,744	100.0	665,280	100.0
%	5.39		8.84		15.68		58.84		11.23		100.00	

Source: Censo Agropecuário 1985

Table 8 . Agricultural machinery production (Units) - 1980 - 1994.

Year	Tillers	Wheel tractors	Crawler tractors	Combines	Total
1980	6,896	58,812	4,285	6,003	75,996
1981	4,548	39,341	3,133	4,891	51,913
1982	5,364	30,346	1,900	3,434	41,044
1983	3,213	22,663	751	3,323	29,950
1984	2,595	45,842	1,348	5,806	55,591
1985	3,300	43,914	1,762	6,427	55,403
1986	7,128	51,559	2,409	6,747	67,843
1987	4,313	47,758	2,677	6,727	61,475
1988	2,026	39,958	2,596	5,651	50,231
1989	3,007	32,530	2,038	5,020	42,595
1990	2,519	25,102	1,746	2,971	32,338
1991	1,886	16,478	1,068	1,959	21,391
1992	1,790	16,114	989	2,445	21,338
1993	1,403	25,185	1,234	3,445	31,267
1994	1,538	41,094	1,705	5,326	49,663

Source: ANFAVEA. 1995.& Anuário Estatístico 1994

Embrapa

BRAZILIAN AGRICULTURAL RESEARCH ENTERPRISE

CPAC

CERRADOS AGRICULTURAL RESEARCH CENTER

CPAC

The CERRADOS AGRICULTURAL RESEARCH CENTER – CPAC is one of the 39 units which compose the BRASILIAN CORPORATION FOR AGRICULTURAL RESEARCH – EMBRAPA, linked to the MINISTRY OF AGRICULTURE, FOOD SUPPLY AND LAND REFORM– MAARA.

Inaugurated in January of 1975, the CPAC is located at Planaltina, Federal District. Its experimental base has 3500 hectars of land, with 25000m2 of constructed area (library, laboratories, greenhouses, offices, etc). The CPAC have 511 employees in its staff (105 researchers).

MISSION

To generate, promote and transfer knowledge and technologi for the sustainable development of the agrosilvipastural complex of the Cerrado Region.

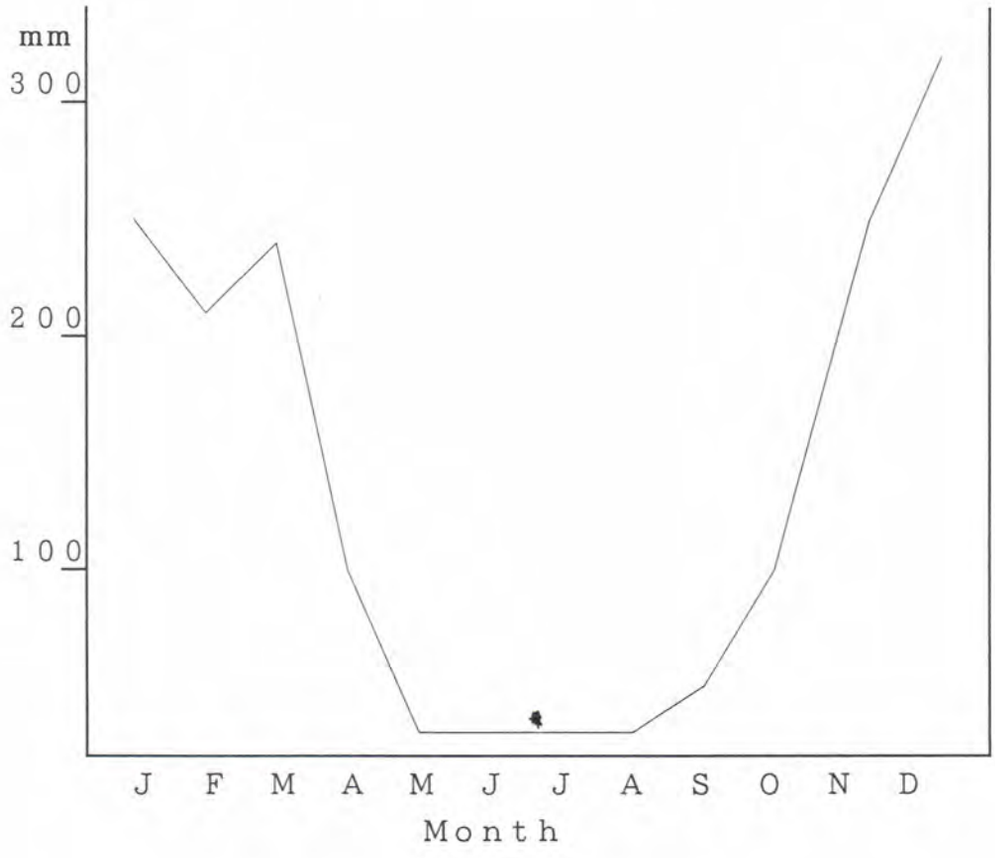
MAIN PROBLEMS FOUND IN CERRADOS REGION

- Insufficient knowlwdge about the region(for agriculture 20 years a go).
- Irregular water supply.
- Soil fertility and management.
- Unsuitable production sistems.

IN THIS MOMENT CPAC HAVE SOLUTIONS

RAIN DISTRIBUTION IN CERRADOS REGION

PPT=1570mm



INTERNATIONAL COOPERATION

1. JICA – JAPAN
   – Plant protection
   – Resources evaluation
   – Soil and water management
   – Agricultural mechanization and equipments

2. CIAT – CALI, COLOMBIA
   – Patures

3. CORNELL UNIV. – USA
   – Soil research

4. ORSTON/CIRAD – FRANCE
   – Production systems
   – Resources evaluation/ management

5. OTHERS (Brazilian Univ., Research Centers, Farms, Comp., etc...)

CPAC RESEARCH PROGRAM

RESOURCES EVALUATION

- Geomorfology and soils
- Hydrology
- Climate and vegetation
- Socio-economy

RESOURCES: USE AND MANAGEMENT

- Soil fertility
- Soiol biology
- Soil-water-plant relationships
- Soilmanagement and conservation
- Agricultural mechanization and equipmments

PRODUCTION SYSTEMS

- Annual crops
- Perennial crops
- Pastures and forages
- Plant protection
- Farm management systems

CPAC

RESEARCH PROGRAM:
195 projects coordinated by CPAC
056 projects coordinated by other intitutions

Staff	Actual	Rented services	Cooperation projects	Trainees	Total
Research	106	—	11	19	138
Administr.	80	—	01	—	81
Support	379	28	10	—	417
Total	565	28	22	19	636

FARM TRACTORS EVOLUTION(ha/tractor) IN BRAZIL AND REGIONS.

Region	Years					
1920	1940	1950	1960	1970	1980	1985
Brazil	5571	2274	463	205	90	80
North	35446	3844	1005	548	277	332
Northeast	23076	11694	2788	1418	373	377
Southeast	4616	1628	285	117	60	57
South	2368	1766	380	171	62	52
Central-West	25963	4376	623	232	102	86

CHAPTER 3

Training in NARC-National Agriculture Research Center-Upland Farm Mechanization Laboratory.

INTRODUCTION

The soil compaction is a big problem in agriculture actual with effects in the soil density, porosity, permeability and the conservation of natural resources. This problem causing not good consequences for the crops and soil erosion.

The compaction of the soil may be caused for the big traffic of the heavy machinery, soils worked in not good conditions or high moisture content, depth of the work not adequate and constant.

The compaction reduces pore space and increases shear strength of soil. Impeded water infiltration can cause increasing erosion. The wheel traffic is one of the major factors causing this problem in this case(Ngunjiri and Siemens, 1995).

Compaction caused by tractor tires reduce water infiltration and cause increase runoff and decrease availability of water plants(Way et al., 1995).

The effect of repeated tractor passes was studied by Oni and Adeoti (1995), and after 15 passes of the tractor the soil cone penetrometer pressure increase 1000 kPa. Similar results were also reported by Wood et al.,(1993).

There are differents equipments to break the compaction soil. Subsoilers are the more commons and recommended. News models this equipment there are and studied today. Nagasaki et al.,(1996), using a vibrosubsoiler showed advantages this equipment about can be decreasi the draft and power. Similar studies were developed by Sakai et al.,(1993), Gao et al.,(1993), and Araya(1994).

These equipment need be availables for the optimum use and good results in soil properties. Today the electrical instrumentation is the best method for this and can be big precision and fast.

The objective of this report is about the training in available tillage implements and use the adequate instrumentation. The equipment studied aws a vibrosubsoiler working in different operational conditions.

MATERIALS AND METHODS

Materials

The training about this work was developed in the NARC-National Agriculture Research Center, Upland Farm Mechanization Laboratory. The materials utilized are shown below and in fig. 1, 2 and 3.

- Vibrosubsoiler Kawabe.
- Tractor Kubota model m6950.
- Strain amplifier Kyowa model DPM-310A, 6 channels.
- Three point dynamometer using 2 octogonal ring transducer.
- Draft in the tractor.
- Strain gauges in the inferior points of the hydraulic system of the tractor.
- Torciometer for the PTO, Kyowa cap. 100kgm.
- Magnetic sensor for the PTO RPM and Digital Engine Tachometer, Ono Sokki model CT-552.
- Data recorder TEAC Digital Recorder model DR-M2a, cap. 8 channels.
- Microcomputer and softwers for datas analysis.

Methods

In the first part of the training:

- Installation of the equipment.
- Installation of the subsoiler.
- Calibration of the equipment and sensors.
- Available of the calibrations after recorder and transference for computer.

In the second part:

- Tests and data collect in the field. The tests were conduced in two soil conditions, soft and compacted soil. Also in two RPM of the tractor engine , 1500 and 2000RPM causing different speeds and vibration, and two depth of the work.

- Available and analysis of the data with computer and appropriate software.

Available

- Traction Forces.
- PTO, RPM and torque.
- Speed of the tractor and subsoiler.
- Depth in soil worked.
- Width of work.

Obs.: Not are includes soil available and characteristic, because the short time for this specific training with the vibrosubsoiler and instrumentation was not permit.

In my opinion and in futures studies, will be necessary include soil characteristics and effects as soil type(texture, etc.), moisture content, penetration resistance, soil profile, bulk density, etc. A correct experimental delineation and statistics studies to be need.

RESULTS AND DISCUSSION

In the first part are shows the calibration data, volts x m , in laboratory figure 4(with respective equation) and in the field figure 5. The channel are defined as:

CH.1 - dynamometer, octagonal ring transducer(left).
CH.2 - dynamometer, octagonal ring transducer(right).
CH.3 - second point in hydraulic the tractor.
CH.4 - draft.
CH.5 - torciometer PTO.
CH.6 - RPM PTO.

In annex 1 are shown others calibrations necessary and developed for other researchers in the NARC.

The objective of this calibration are to found adequate equivalence volts to units of measurement in each channel, kN, kgm and RPM.

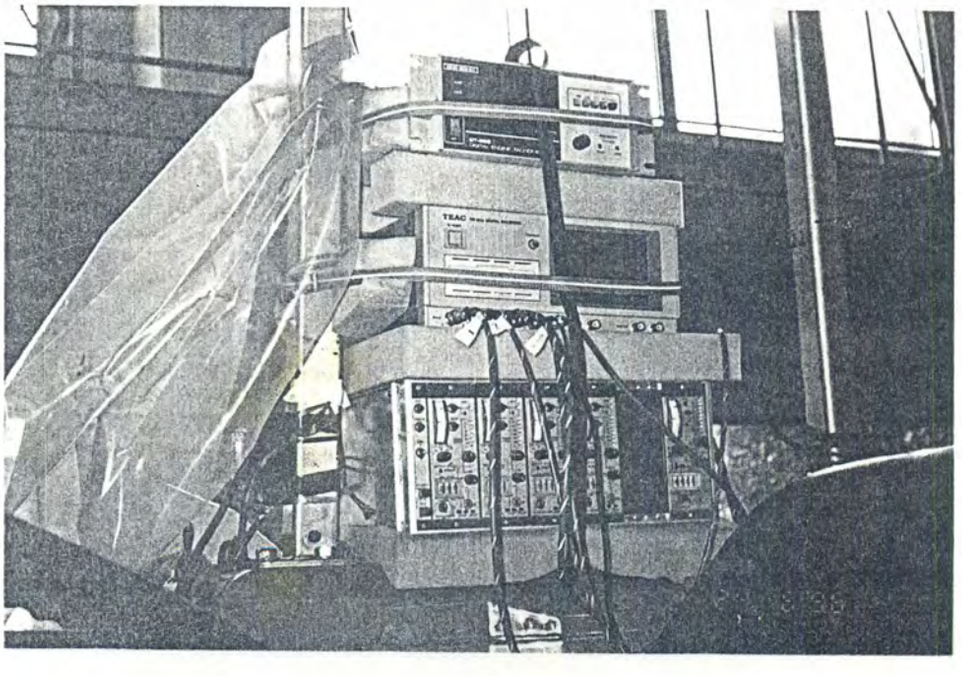
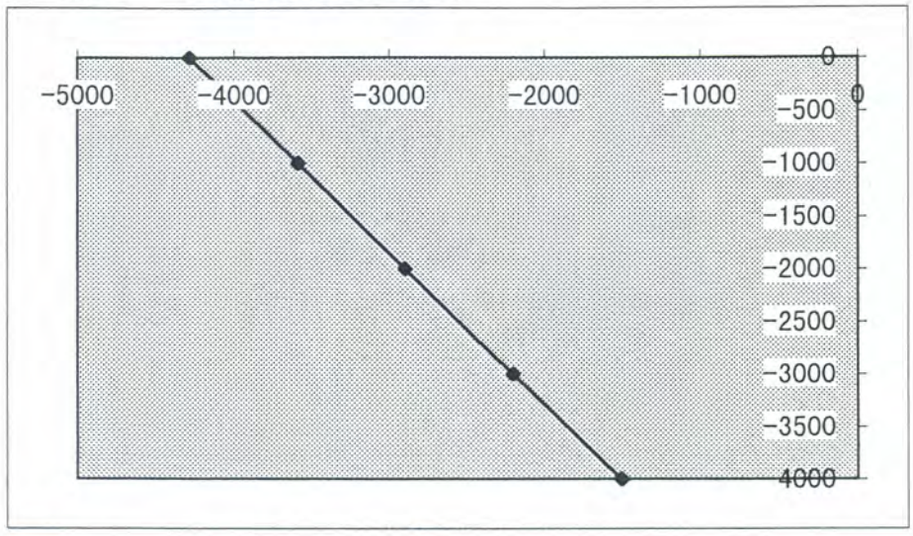
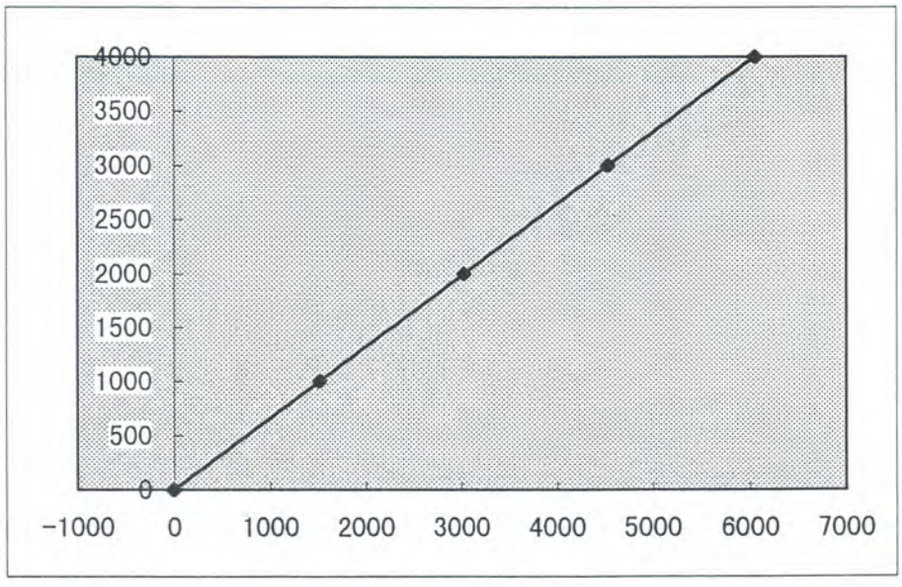

TEAC

Figure 4. Calibration data and respective equation.

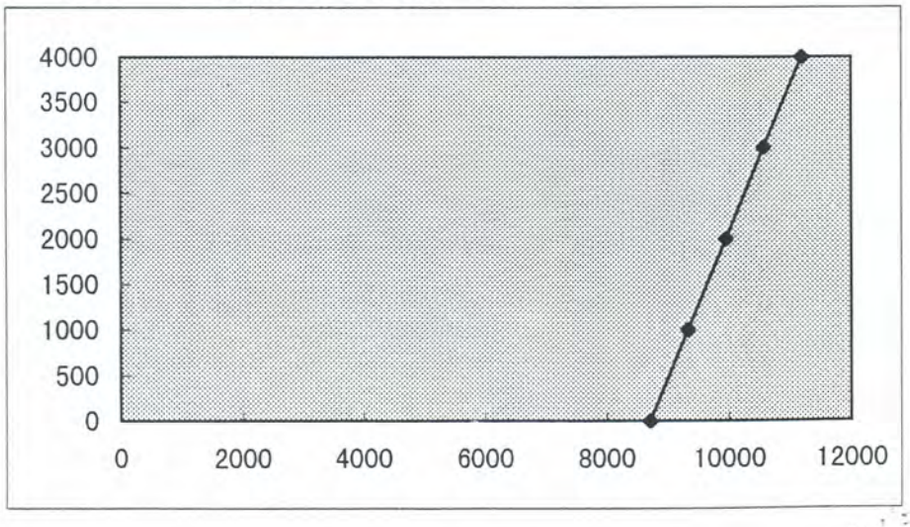
Ch.1 F=K(0,69418v-4285,24)



Ch.2 F=K(1,51119v-1,18)



Ch.3 F=K(0,61755v-8716,3)



Ch.5 F=K(2,70706+10,18)

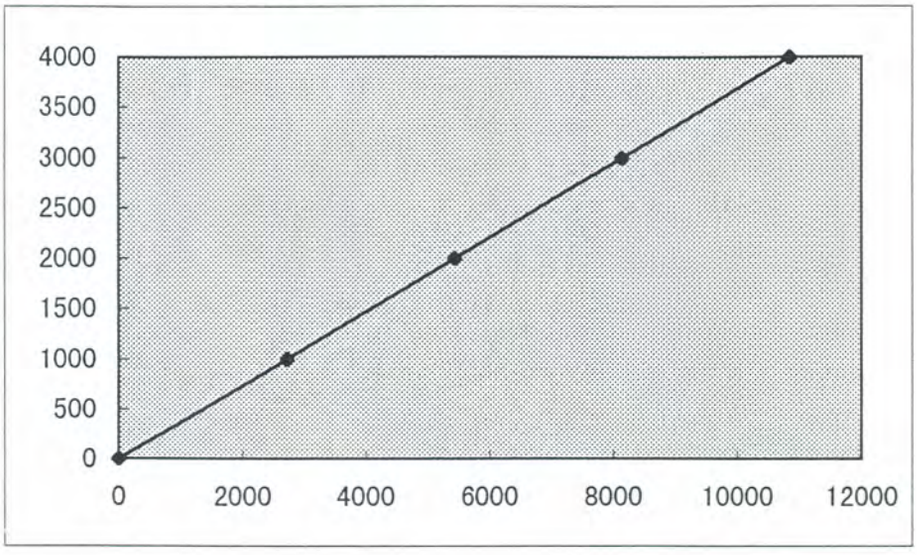
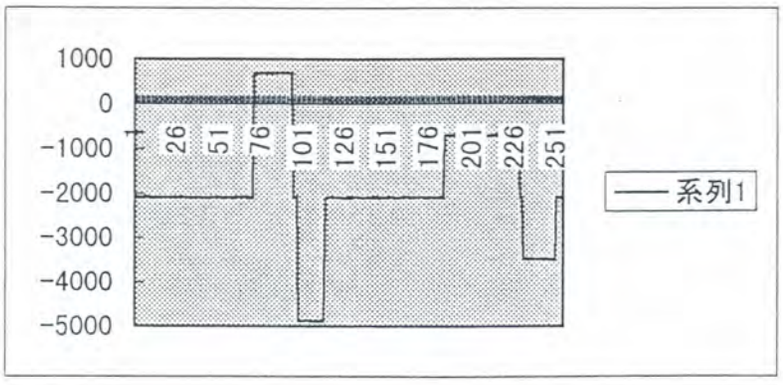
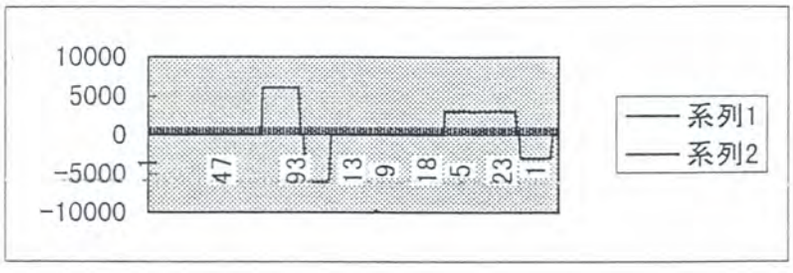


Figure 5. Calibration data in the field.

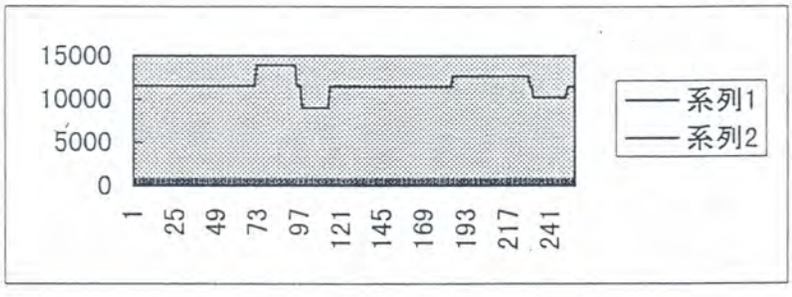
CH.1



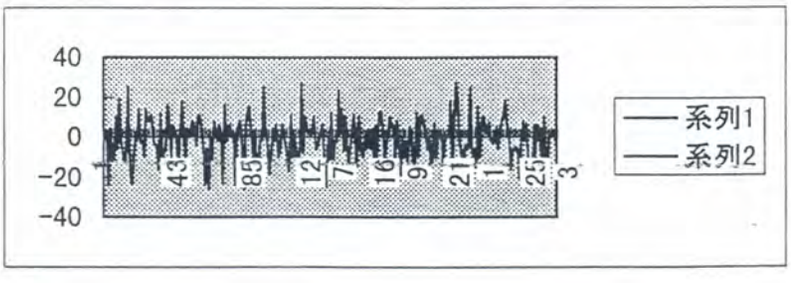
CH.2



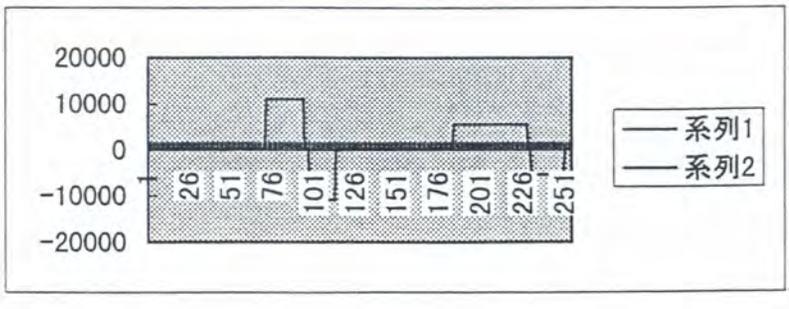
CH.3



CH.4



CH.5



The results obtained in the field are shown in table 1 and are in volts and will be must change for adequate equivalence unit(kN, kgm and RPM) in the sequence of this type work in Brazil, because we have similar equipment objective of this training. In annex 2 are shown one example about the data collected and charts. Not are possible the statistics analyses because we don't have a adequate experimental delineation and the main objective of this training was in instrumentation for available tillage soil equipment.

Table 1. Results of the tests in the field.

Data: 28-06-96 in soft soil with vibration

	Ch.1	Ch.2	Ch.3	Ch.4	Ch5	Ch.6
Test01	Averages(in volts)					
with vibra	-2281,5	1155	7648	76	25	-1,5

Speed=0.52m/s(1.88km/h)
Depth=30cm
RPM Tractor Engine=2000

Test02	Averages(in volts)					
with vibra	-381.094	9712.927	10166.43	73.72917	-40.8229	192.5521

Speed=0.53m/s(1.91km/h)
Depth=30cm
RPM Tractor Engine=2000

Test03	Averages(in volts)					
with vibra	-566.352	7920.871	10462.11	25.93069	-44.2772	187.2475

Speed=0.52m/s(1.88km/h)
Depth=20cm
RPM Tractor Engine=2000

Test04	Averages(in volts)					
with vibra	-1273.98	4684.832	10582.97	23.40458	-36.2748	181.9771

Speed=0.96m/s(3.5km/h)
Depth=20cm
RPM Tractor Engine=2000

Test005	Averages(in volts)					
with vibra	5343.45	26471.69	12121.8	-490.698	10750.62	3.418006

Speed=0.39m/s(1.4km/h)
Depth=20cm
RPM Tractor Engine=1500

Data: 01-07-96 in compacted soil

	Ch.1	Ch.2	Ch.3	Ch.4	Ch5	Ch.6
Testh000	Averages(in volts)					
with vibra	7431	27614.26	10697.02	48.32673	-9.14851	185.7426

Speed=0.46m/s(1.67km/h)
Depth=30cm
RPM Tractor Engine=2000

Testh001	Averages(in volts)					
with vibra	-793.209	21312.48	9268.493	23.37313	2.393035	191.4726

Speed=0.49m/s(1.77km/h)
Depth=23cm
RPM Tractor Engine=2000

Testh003	Averages(in volts)					
with vibra	117.4987	19203.24	9318.615	-207.461	5.762803	142.469

Speed=0.39m/s(1.42km/h)

Depth=19cm
RPM Tractor Engine=1500

Testh004	Averages(in volts)					
No vibratic	6247.916	26604.95	12720.49	-162.717	10753.29	2.741036

Speed=0.37m/s(1.34km/h)
Depth=26cm
RPM Tractor Engine=1500

Testh005	Averages(in volts)					
No vibratic	5256.631	26379.69	12085.38	-480.372	10750.6	3.392749

Speed=o.36m/s(1.29km/h)
Depth=31cm
RPM Tractor Engine=1500

Testh006	Averages(in volts)					
No vibratic	4152.138	27448.3	10751.55	-593.349	67.96552	3.375479

Speed=0.49m/s(1.76km/h)
Depth=31cm
RPM Tractor Engine=2000

Data: 02-07-96 in soft soil

	Ch.1	Ch.2	Ch.3	Ch.4	Ch5	Ch.6
Cald000						
0 point	-93.3846	3857.901	9025.901	-3.45055	12.67003	4.604396

Testd000	Averages(in volts)					
With vibrat	6972.621	21344.32	9386.473	25.16016	-1.53125	3.984375

Speed=0.51m/s(1.82km/h)
Depth=33cm
RPM Tractor Engine=2000

Testd001	Averages(in volts)					
With vibrat	3579.974	18881.61	9202.641	25.8658	-3.4026	4.069264

Speed=0.36m/s(1.31km/h)
Depth=34cm
RPM Tractor Engine=1500

Testd002	Averages(in volts)					
With vibrat	7002.068	23235.49	9750.48	31.97509	-6.29893	3.391459

Speed=0,50m/s(1.80km/h)
Depth=35cm
RPM Tractor Engine=2000

Testd003	Averages(in volts)					
With vibrat	9599.563	26489.54	9817.069	60.78544	-6.7318	2.597701

Speed=0.35m/s(1.26km/h)
Depth=38cm
RPM Tractor Engine=1500

Data: 02-07-96 in compacted soil

	Ch.1	Ch.2	Ch.3	Ch.4	Ch5	Ch.6
Testd005(4)	Averages(in volts)					

With vibrat 4694.91 24243.35 9221.865 24.79279 3.198198 2.558559
Speed=0.43m/s(1.55km/h)
Depth=31cm
RPM Tractor Engine=2000

Testd006(5) Averages(in volts)
With vibrat 15574.64 26731.43 10548.59 70.9602 -15.3632 3.41791
Speed=0.31m/s(1.13km/h)
Depth=33cm
RPM Tractor Engine=1500

Testd007(6) Averages(in volts)
No vibratic 14036.33 27791.2 11579.25 63.24917 -7.6113 3.501661
Speed=0.36m/s(1.30km/h)
Depth=30cm
RPM Tractor Engine=1500

Testd008(7) Averages(in volts)
No vibratic 10973.15 27204.23 9794.309 25.08306 -8.53561 3.687708

Testd008 Averages(in volts)
12212.3 27737.42 10828.93 46.82609 -789372 3.874396

ANNEX 1

検査成績表 トルクメータ
CALIBRATION SHEET

型式 Model	TP-100KMSA53	容量 Capacity	100kg-m	製造番号 Serial No.	EC0109
検査年月日 Inspected date	1981.12.23	温度 Temp.	18 ℃	湿度 Humid.	52 %

1. 出力電圧感度 Sensitivity: 764 (1528) μV/V (×10⁻⁶)
2. 非直線性 Non linearity: 0.09 %F.S.
3. ヒステリシス Hysteresis: 0.20 %F.S.
4. 校正係数 Calibration constant: 0.13089 kg-m/1μV/V (0.065445 kg-m/1.0×10⁻⁶)
5. 零点の温度影響 Thermal zero shift: 0.05 %F.S./℃
6. 出力の温度影響 Thermal effect on sensitivity: 0.05 %/℃
7. 入出力抵抗 Input & output resistance: 入力 Input 348.0 Ω; 出力 Output 348.4 Ω

8, 過負荷.
・200kg-m 時の出力電圧感度. 3052×10⁻⁶

株式会社 共和電業
KYOWA ELECTRONIC INSTRUMENTS CO., LTD.
TOKYO, JAPAN

検査者 Inspector 山下
責任者 Supervisor 宮崎

エネルギー・フローチャート.

エンジン出力) = (前車軸出力) + (後車軸出力) + (PTO軸出力) + (油圧出力) + (けん引出力) + (伝達ロス)
O.K. O.K. O.K. O.K. O.K.

◎データ処理方法.

① エンジン出力

$$E_{power} = \frac{2\pi \times E_{rpm} \times E_T}{75 \times 60}$$

② 前車軸出力

$$W_{F.power} = \frac{2\pi \times W_{F.rpm} \times W_{F.T}}{75 \times 60}$$

③ 後車軸出力

$$W_{R.power} = \frac{2\pi \times W_{R.rpm} \times W_{R.T}}{75 \times 60}$$

④ PTO軸出力

$$P_{TO.power} = \frac{2\pi \times (P.rpm\ \text{rpm}) \times (P.T\ \text{torque})}{75 \times 60}$$

⑤ スリップ率

$$S = \frac{l_0 - l}{l_0} \times 100\ (\%)$$

l_0: 無負荷走行の車輪1回転あたりの進行距離 (m)
l: 負荷けん引時の 〃 (m)

《注》 ホイール車による走行距離の check.
後車輪1回転あたり

⑥ けん引出力

$$\frac{D_R \times V_{DP}}{75}\ (PS)$$

draft. coefficient
draft. output

⑦ 油圧モータ (?) $L_p = \frac{P \times Q}{7500}$

P: 吐出し圧力 (kg/cm²)
Q: 吐出量

Input データ整理, 摘出

○ 比抵抗 = ブラウタけん引抵抗 / 耕深 × 耕幅 (kg/cm²)

◎ 自己相関
◎ 相互相関
◎ 諸特性値の out put (一覧表)
作図および相関係数

1000rpm = 1v

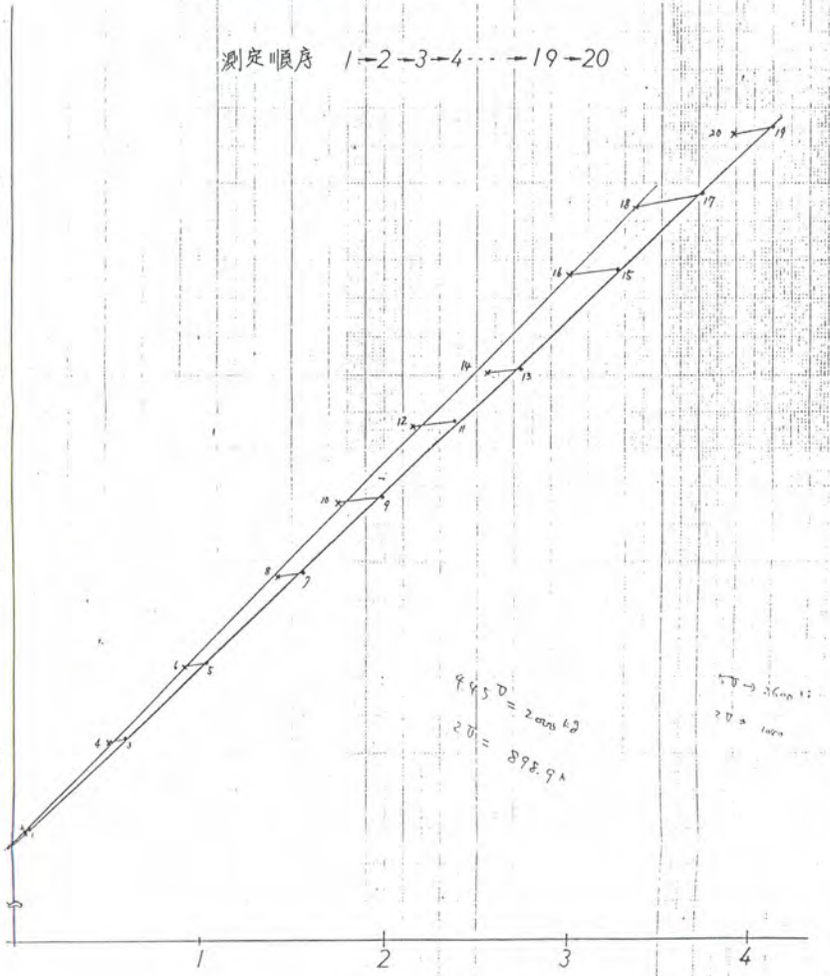
S56年10月8日

No 1-2

牽引負荷検出装置のヒステリシス

(負荷変動が小さい場合)

測定順序 1→2→3→4・・・→19→20



ANNEX 2

TEST03

1	-2170	-1582	10409	35	8	189
2	-605	4421	10073	23	85	191
3	-3725	-1576	10796	15	-6	190
4	-2430	591	9938	33	-14	191
5	45	3724	10151	20	-73	192
6	-3259	-4834	10970	6	-442	186
7	-843	4200	10178	28	4	186
8	366	8362	10023	16	82	179
9	-4095	819	11509	16	-1	184
10	-1608	2907	9363	23	2	184
11	2678	7446	9872	34	-19	193
12	-354	348	11503	10	-146	190
13	-521	1192	9921	37	-4	189
14	96	11911	10630	8	14	183
15	-3174	3275	11337	29	2	186
16	-1092	2061	9825	29	-20	191
17	497	10827	10760	35	-15	188
18	-1748	-226	11519	17	-235	186
19	-1908	1499	10220	19	10	190
20	685	7622	10094	11	14	187
21	-1554	-2595	10829	16	5	186
22	-2145	8855	10020	26	-4	191
23	1447	10065	10928	37	-5	188
24	-2528	849	11015	48	-119	194
25	-2698	8759	10000	15	3	190
26	-323	10612	10608	23	73	186
27	-4784	4638	11034	26	4	191
28	-820	6201	9721	23	-4	191
29	1051	8880	10637	31	-37	187
30	-2528	4784	10864	35	-10	181
31	-623	1075	9719	10	29	188
32	1393	6146	10971	36	7	186
33	-2518	-2646	10703	33	-7	189
34	-982	7756	9228	15	2	184
35	-31	7958	10603	25	-208	183
36	-1846	2012	11267	52	-28	194
37	-1170	6516	9836	46	14	186
38	-1161	7037	10613	52	33	186
39	-3654	484	10313	52	-7	184
40	-828	9651	9945	29	3	184
41	-563	6861	10905	39	-288	191
42	-3494	3579	11015	30	-9	184
43	-214	5943	10085	6	31	186
44	-922	4746	10492	136	72	186
45	-4142	237	10250	47	-25	188
46	922	5990	9342	23	-14	190
47	601	5638	10210	140	-221	191
48	-2220	1244	10122	20	-17	184
49	641	8046	9693	123	-1	184
50	-2016	8769	10547	47	27	191
51	-4290	2737	9997	25	-21	185
52	-1134	12957	9338	140	-8	190
53	251	8735	10861	20	-62	188
54	-1375	3617	10354	110	-25	190
55	271	9439	9541	10	49	188
56	353	9512	10770	15	6	186

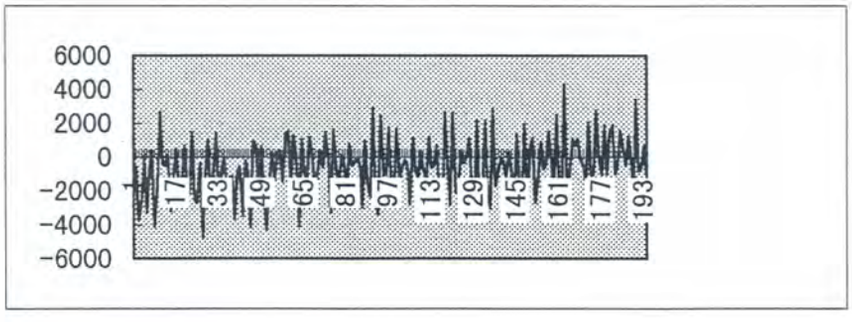
57	-1453	5500	10523	134	-20	186
58	1404	9450	9509	28	-33	190
59	1506	6631	10327	27	-76	179
60	-1866	7879	10773	31	-16	190
61	1275	9653	9911	47	75	196
62	178	8235	10856	8	2	186
63	-4067	4513	10178	28	-18	186
64	1037	13604	10021	10	-18	186
65	-791	12150	11321	25	-300	186
66	-1523	1571	10475	37	3	183
67	1155	10273	9816	20	4	188
68	406	5747	10828	11	2	186
69	-2090	866	10130	9	-19	177
70	-791	16855	9885	35	-23	191
71	368	7159	10903	25	-297	191
72	-594	4053	10757	32	0	191
73	1442	8379	9486	19	-1	190
74	-27	6486	10887	4	-4	186
75	-3251	1648	10329	33	-13	186
76	1640	10042	9601	39	-32	184
77	-634	10067	11093	41	-288	193
78	-1649	629	10216	30	14	186
79	62	11766	10105	37	26	184
80	-502	6972	11050	30	-6	187
81	-2279	719	9817	20	-14	186
82	793	13111	9468	8	-10	179
83	-502	7255	10788	38	-267	195
84	-292	2668	10533	23	7	184
85	-160	14235	9891	26	10	186
86	-384	7304	11186	31	2	184
87	-2962	231	10215	31	-12	191
88	951	13167	9907	14	-5	183
89	-1441	8065	10870	30	-62	192
90	-2319	6867	10497	7	-20	187
91	2919	9414	9817	11	171	190
92	-2368	11045	11141	23	-4	186
93	-3378	1544	9818	45	-10	186
94	2391	12789	10405	40	2	185
95	-1086	8596	10874	24	-368	192
96	-981	2330	10575	35	11	186
97	1758	11295	10191	39	8	190
98	-1844	7232	10864	20	31	181
99	-2435	2720	9765	27	-18	188
100	1658	13878	10480	23	-18	182
101	-1196	5429	11243	56	-379	191
102	-619	5767	10275	30	8	192
103	-188	15909	9991	35	14	186
104	-461	6746	11225	18	0	186
105	-2765	4299	10205	14	-12	191
106	1155	15120	10326	36	-27	189
107	-778	6478	10995	37	-242	188
108	-1226	5599	10088	15	16	186
109	364	14057	10000	11	95	181
110	-717	2015	11009	23	2	186
111	-1238	976	10345	13	-18	186
112	1194	13929	10224	29	-10	185

113	-621	3759	10770	28	-99	184
114	-456	4062	10324	31	15	187
115	720	12053	10541	31	32	186
116	-2090	6826	11616	29	16	189
117	-3378	4262	9937	5	-36	182
118	2613	11842	10208	46	-15	191
119	-362	3743	11461	16	-293	191
120	-2808	9714	10218	38	-4	191
121	2606	9274	10019	18	69	187
122	-2062	6137	11283	46	-3	190
123	-1787	5266	10215	23	-20	190
124	362	18129	11013	5	-9	181
125	-339	2573	11172	18	-389	185
126	-25	973	10768	29	0	189
127	1087	11852	10337	27	71	186
128	-1485	4891	11104	14	2	179
129	-3416	7979	10318	14	-31	187
130	2169	12822	9971	20	-12	184
131	-2838	10269	11526	37	-393	193
132	-2784	9753	10340	16	2	187
133	2136	8645	10105	28	48	186
134	-2159	4868	11422	40	-7	184
135	-3041	7548	9847	23	-56	194
136	2856	11738	10145	18	-23	189
137	-1688	8345	11567	26	-300	188
138	-728	2809	10235	23	4	188
139	-64	14583	10524	24	82	186
140	-257	1619	11092	29	2	182
141	-1206	4078	9975	18	-25	189
142	243	19481	9832	14	-8	186
143	-671	4235	10975	23	-318	191
144	-2427	7598	10543	34	-10	194
145	1380	11367	10092	27	60	186
146	-1723	4467	11101	14	-3	186
147	-2526	4700	9228	35	-27	191
148	1930	13376	9675	36	-19	190
149	-2768	12131	11307	14	-141	186
150	557	7359	9984	43	4	190
151	1125	16061	10235	8	24	179
152	-2677	6508	11256	18	-7	188
153	-1520	3595	9909	39	-10	184
154	879	16693	10490	37	-12	187
155	-702	5848	11374	24	-293	191
156	-357	5985	10336	31	8	190
157	1487	11177	10132	18	136	185
158	248	870	10672	25	-16	190
159	-2033	6723	9854	21	-12	192
160	2473	12108	10131	33	-19	186
161	-2301	6225	10934	24	-404	186
162	-2041	9163	10089	18	-1	188
163	4309	7064	9809	42	26	184
164	-1780	7271	11128	14	8	183
165	-626	2643	9698	32	-83	192
166	1062	14133	10126	39	-49	191
167	658	3457	11242	6	-209	186
168	1092	8326	10257	30	13	188

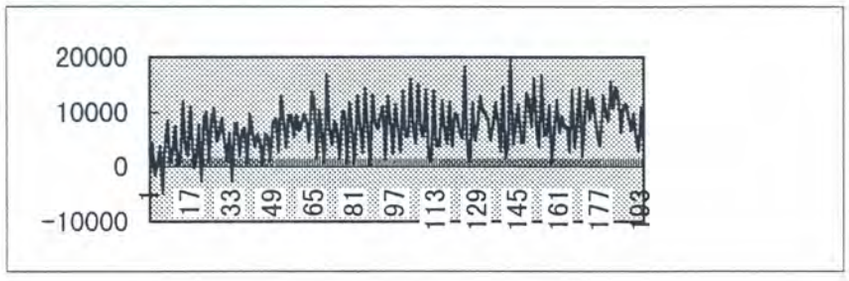
169	−73	14328	9954	16	11	182
170	−524	1859	10917	27	−6	186
171	−1459	8944	10358	33	−14	186
172	2032	14014	10009	48	−37	191
173	−1056	8717	10052	42	−381	186
174	−986	12600	9939	27	−8	189
175	2758	9428	9735	31	47	190
176	−191	5487	10704	41	−15	193
177	−1022	3862	9840	39	−26	186
178	1901	12926	9736	4	−20	188
179	−993	9902	10440	28	−113	187
180	1355	8262	9721	23	19	186
181	1893	15556	10140	27	27	191
182	−999	10671	9852	24	−6	187
183	−432	14467	10150	4	−10	186
184	1538	12742	9815	36	−24	186
185	690	6325	10347	32	−268	188
186	−506	11034	10645	9	0	187
187	1207	11413	9961	14	34	186
188	24	9165	10323	24	−8	184
189	−2096	6634	10294	12	−8	185
190	3377	9614	9638	33	−39	190
191	−824	5065	11021	40	−277	188
192	−516	2794	10650	−4	15	183
193	754	10780	9795	41	29	191
194	−1164	4273	11129	14	3	182

averages	−593.119	−6759886	10397.43	29.18041	−38.567	187.2835
Test03		AVERAGES	A70 to 170			
	−566.352	7920.871	10462.11	25.93069	−44.2772	187.2475
	−566.352	7920.871	10462.11	25.93069	−44.2772	187.2475

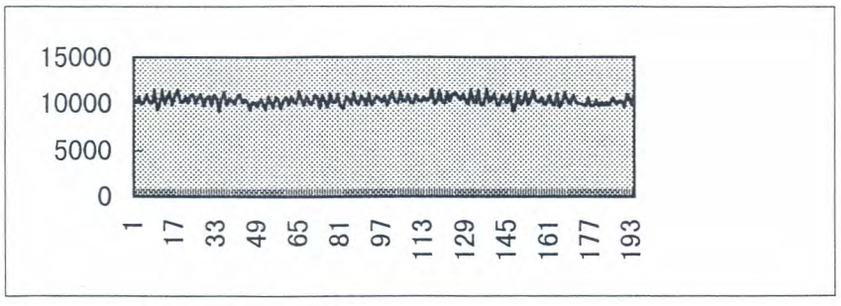
CH.1



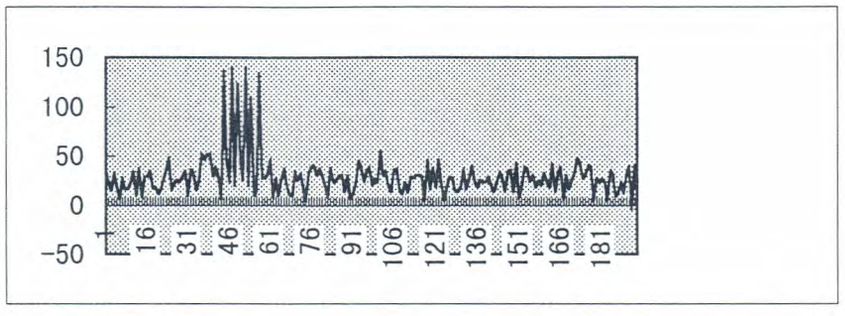
CH.2



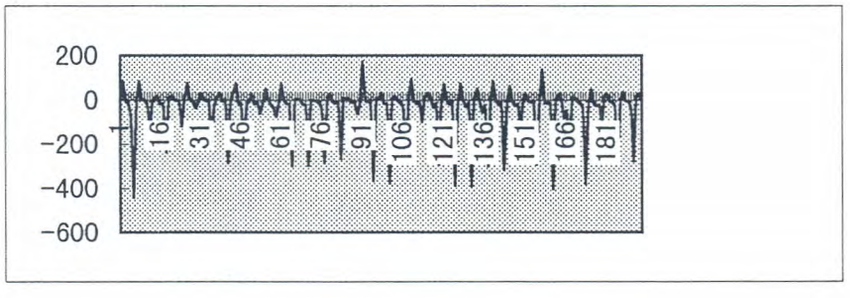
CH.3



CH.4



CH.5



CH.6