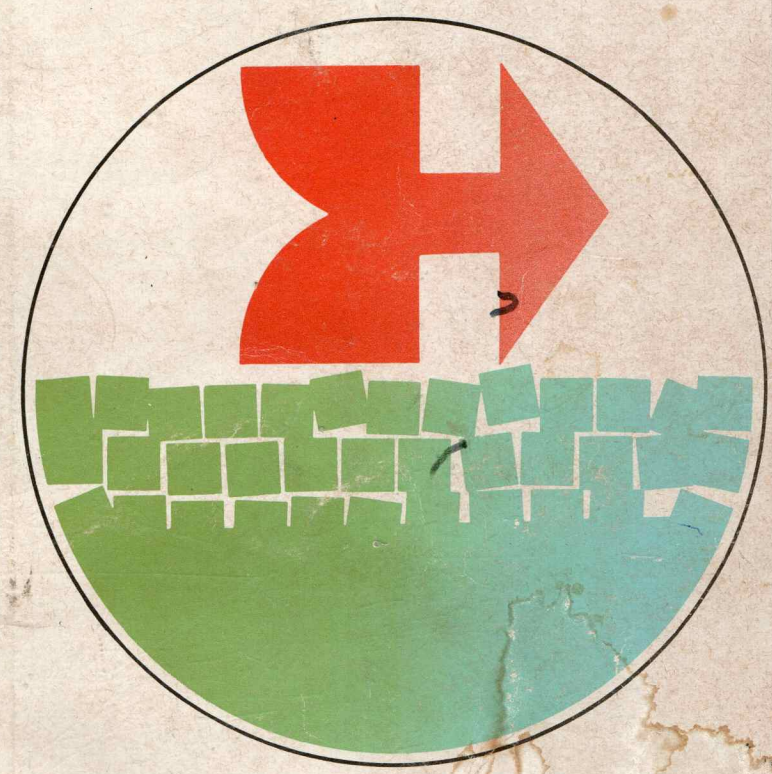
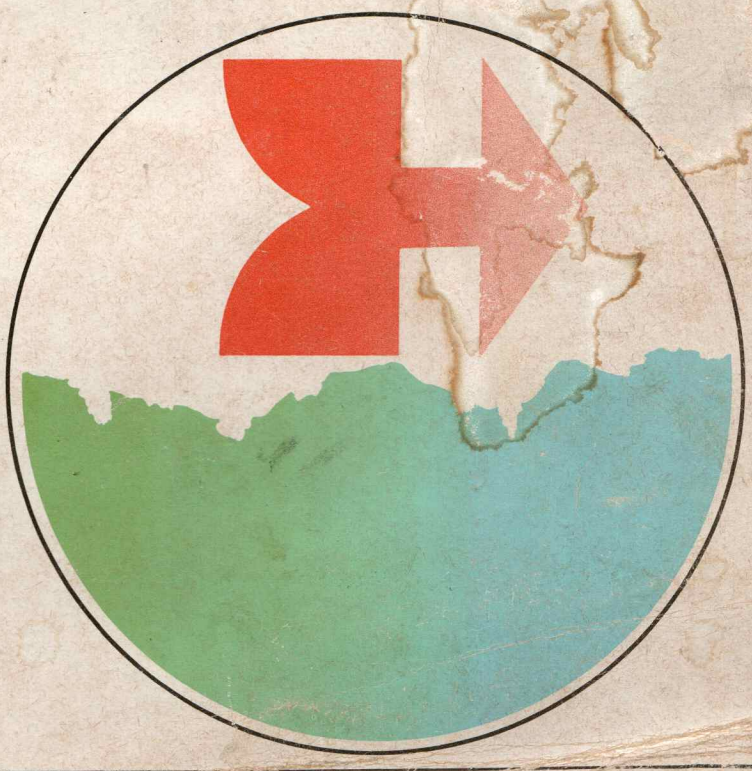
SAME

"SAME" four wheel drive system



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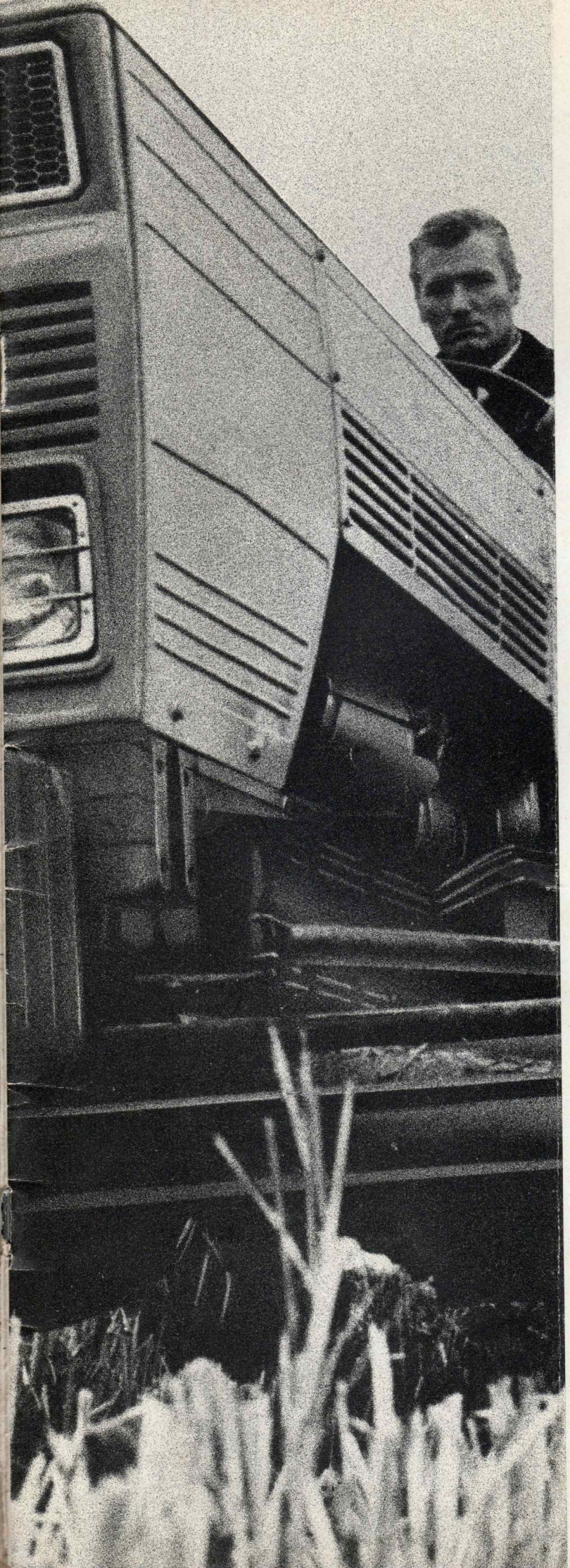
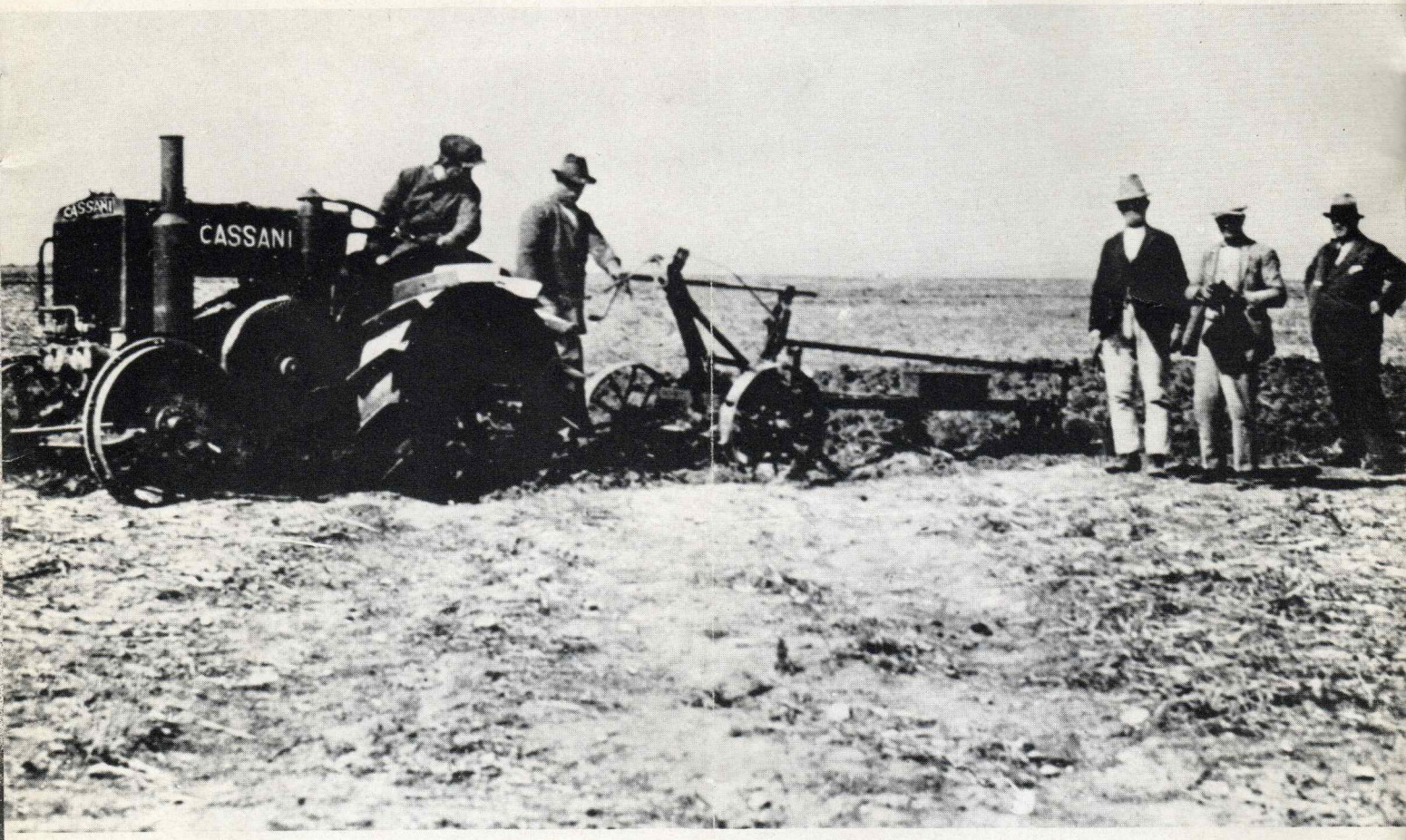


contents

On the track of a constant avanguard tradition:

YESTERDAY

— The world's first Diesel engine agricultural tractor, the Cassani 40 HP (1927)



TODAY

"SAME"
4 wheel drive
means that the
tractor will
go everywhere
always

The technical development of agricultural tractors, on fhich agricultural tractors, on which marked by three fundamental stages:

the fundamental stages in the development of agricultural tractors

— A « Same » Leone 70 four wheel drive tractor at work during the beetroot harvest.

1

abolition of the chassis and uniting of the engine block and transmission housing into a single body.

2

substitution of « spiked » iron wheels by tyred wheels (1930).

3

introduction of hydraulic systems and the three point hitch for carried equipment (1937).
Emphasis should also be given to another fundamental stage in agricultural mechanization, even though strictly speaking outside the scope of the present discussion, and that is to say the first application of Diesel engines to agricultural tractors, made by Francesco Cassani, founder of the « SAME » Company, with the construction of his « Cassani 40 HP » in 1927 (1).

(1) « Among those who first put forward truly new and avant-garde concepts in the construction of agricultural tractors, the names of Francesco and Giovanni Cassani, of Treviglio, stand out. In 1927, while still very young, they were the first in the world to apply the Diesel engine to the agricunltural tractor, which application then spread, uncontested, throughout the field of agricultural motorization. The agricultural tractor designed by the Cassani brothers, constructed in the Castelmaggiore (Bologna) workshops, was driven by a Diesel engine with pre-chamber injection, two horizontal side-by-side cylinders, 27-30 HP at 500 r.p.m., with compressed air starting. The first United States tractor featuring the Diesel engine was a Caterpillar appearing in 1931; after the Cassani brothers, in Italy it was the Breda Company that was responsible for applying the Diesel engine to tractors ».

extract from « The Italian Pioneers of Agricultural Mechanization » by Nerlo Nerli in « Agricoltura e Civiltà delle Macchine » published by the Ente Autonomo per la Fiera di Verona, 1967.

the conventional tractor

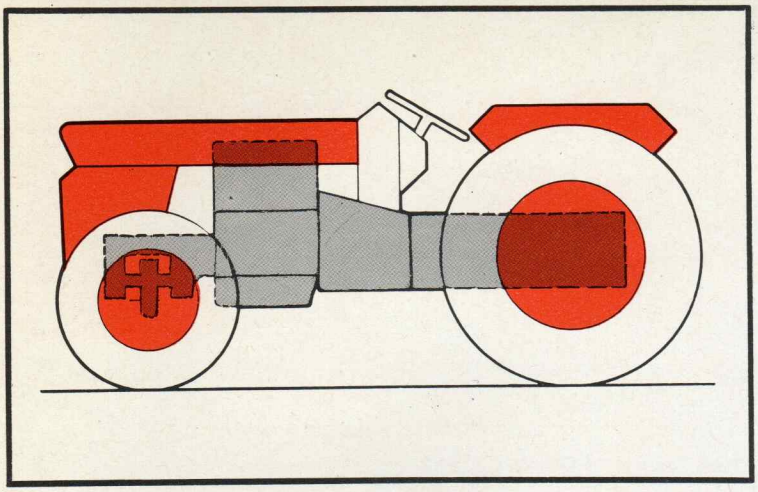


Fig. 1 - *Conventional tractor*

From these innovations is derived the modern conventional tractor, which can be described as follows:

vehicle with girder shaped single piece body, supported by four rubber tyred wheels, front leading and rear drive wheels. It may or may not be equipped at the rear with hydraulic lifter with three point hitch.

Fig. 1 gives a schematic representation of a conventional tractor.
To perform its towing function as efficiently as possible in the particular agricultural environment, the ideal tractor should possess the following characteristics:

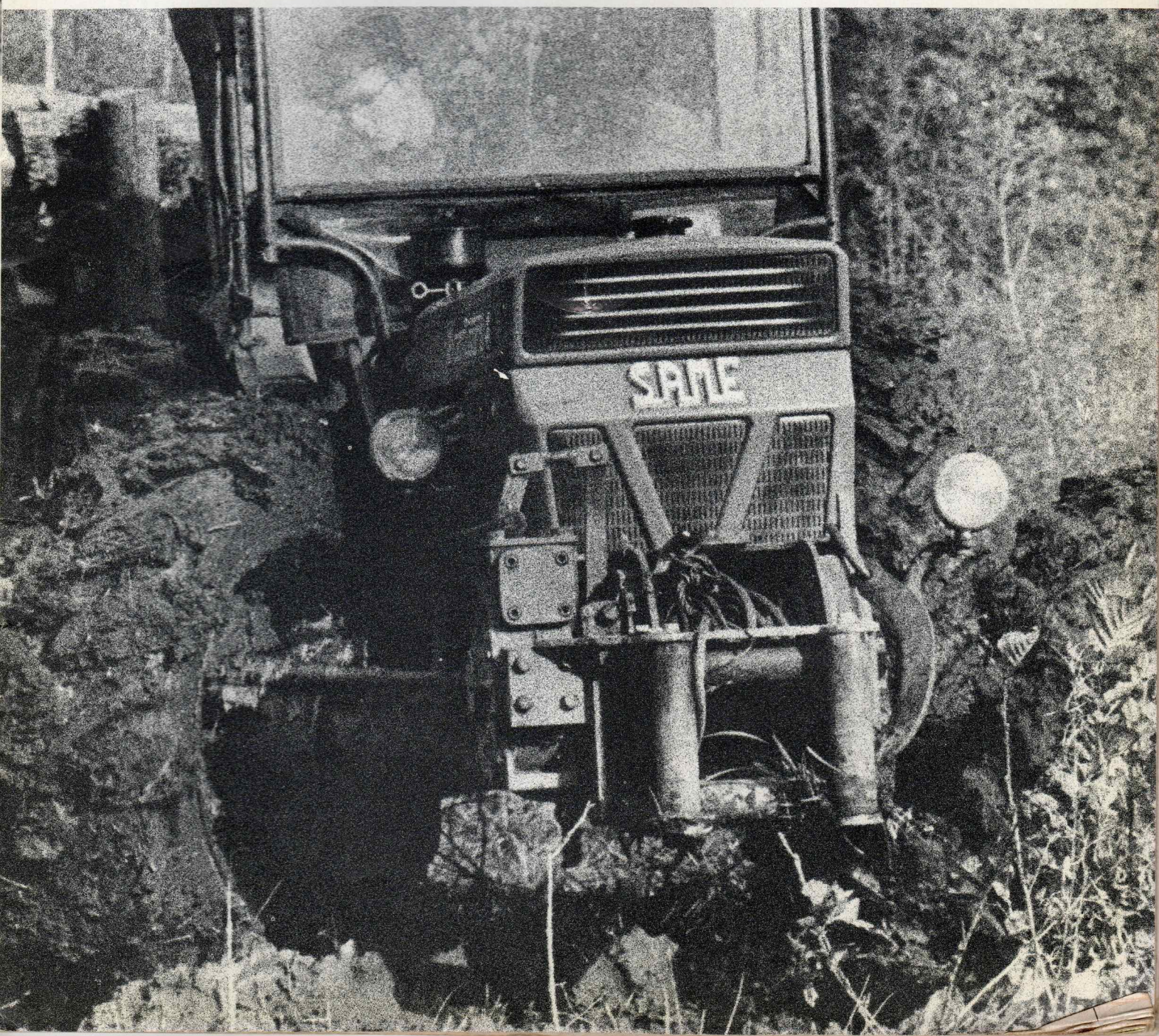
the characteristics of the ideal agricultural tractor

low weight	so as not to compress the yielding soil of the fields, to perform crop work, to require limited energy for its forward movement
limited dimensions	to be able to work either on large or small plots, to keep the width of the interspaces to a minimum, to be able to manoeuvre country roads without difficulty and to work between rows of plants
great manoeuvrability	to keep driver's fatigue to minimum and to allow work to be performed in the most difficult locations
a high degree of comfort for the driver	to allow long working hours without excessive fatigue
stability	to provide the driver with physical safety even in the trickiest working conditions
maximum towing capacity	to achieve the main aim of the machine
wide speed range	to carry out the widest variety of agricultural work, from work calling for very slow speed (less than 1 km/h (0.62 nph) to road transport

distribution of tractor weight between front and rear wheels

An agricultural tractor should have maximum towing capacity, which is determined by adhesion and thus by the weight of the machine coming to bear on the drive wheels. This is called adhesive weight.
The said towing capacity comes into conflict with the lightness-in-weight to which manufacturers tend, in part for economic but mainly for technical reasons; and because of this tendency the total weight of the machine has to be very carefully distributed between the front leading wheels and the rear drive wheels.

A « SAME » CENTAURO FWD tractor carriyng out forestry work in the Soissons zone of France.



For, if the front wheels are too light and thus have only slight adhesion, they are not able to provide the traction necessary to effect steering, especially on gradients.
If, on the other hand, the rear drive wheels are too light, the consequent lack of adhesion causes them to slip even when te tractive effort or traction involved is not of a high order.
The modern trend is to reduce the total weight of the tractor to minimum in relation to engine HP (generally 40 kg of weight per 1 HP). Optimum distribution is thus sought after, and practice teaches that the static distribution should be 1/3 on the front wheels and 2/3 on the rear weels (Fig. 2).

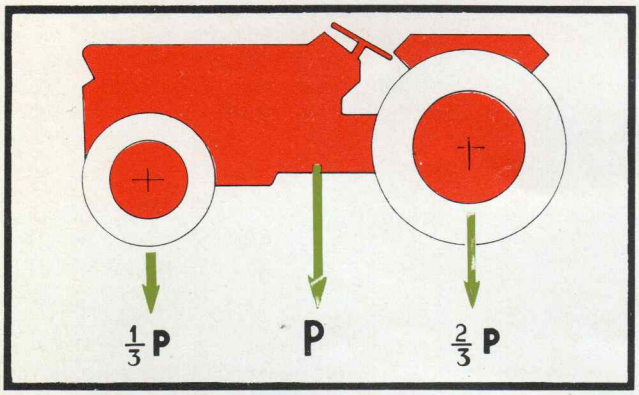


Fig. 2 - *Distribution of weight in a conventional tractor.*

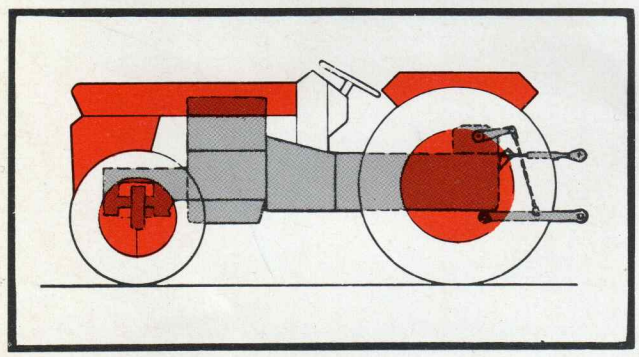


Fig. 3 - *Conventional tractor with three-point hitch.*

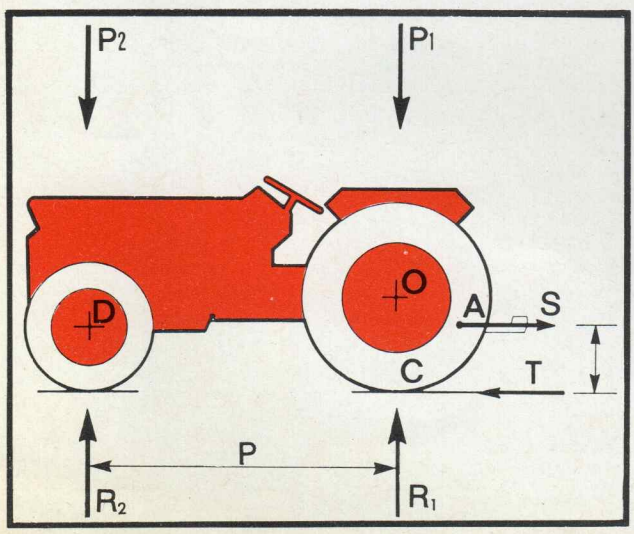


Fig. 5 - *Distribution of weight, and stability.*

Fig. 4 - *Effect of the three-point hitch on the stability of a « SAME » FWD tractor.*

static weight-distribution

This distribution is determined by the weight coming to bear on the front and rear wheels with the tractor motionless and without implements. It is established at the planning stage with account taken of the fact that, during service, because of the effect of tractive effort and the height-wise position of the drawbar, there are continuous weight-transfers from the front wheels onto the rear wheels. These weight-transfers, variable as tractive effort is variable, can reach values so high as to eliminate completely the weight coming to bear on the front wheels with consequent annulment of driving capacity and danger of pitching causing the probable overturning of the machine.

stability

Stability is a fundamental characteristic, though there was no need for special attention to it with the first enormous tractors on account of their large wheel base, the considerable static weight bearing on the front wheels and their relatively limited HP.
But the importance of stability is seen in all its significance with the advent of single-body tractors, since as well as weight-reduction there was with these a reduction of wheel base and increase in engine power.

the three-point hitch

The greater stabilization of tractors, notwithstanding maximum weight reduction (even magnesium alloy transmission housings were used!) has been decisively contributed to by the three-point hitch. The greater the tractive effort, the more energetically **does the upper link force the front wheels downwards** (Figs. 3 & 4). During service, however, this stability shows some shortcomings, which can be summarized as follows:
lack of front wheel adhesion with the implement raised, with driving difficulties over uneven ground;
tendency to pitch when the implement is about to be raised;
extreme dangerousness of the upper link when, alone, it is deliberately or unconsciously used for towing.
Of course, by this we do not mean to underrate the importance of the three-point hitch, which has marked a fundamental stage in the development of agricultural mechanization.

the stability equation

(see fig. 5)
The stability problem can in any case be solved either by loading the front axle or by lengthening the wheel base (also called axle base) so that the product of the weight coming to bear on the front wheels (P_2) multiplied by the length of the wheel base (p) proves superior to the maximum tractive effort (S) multiplied by the height (h) of the drawbar

$$P_2 \times p > S \times h$$

This equation, which is highly simplified but nevertheless valid as reference point for the rapid evaluation of the stability of a tractor, is the result of a series of simplified hypotheses which can be summarized as follows:
1 tractor with only the two rear wheels as drive wheels; **2** tractor given uniform motion on horizontal flat surface; **3** lines of action of the reactions of the soil R_1 and R_2, vertical, passing through the centres of the rear axis and of the front axis, respectively O and D; **4** line of action of the tractive effort T (soil reaction) tangential to the wheels at C and horizontal; **5** line of action of the tractive effort S horizontal and parallel to the forward-moving direction of the tractor; **6** resistance to rolling = 0; **7** the minor forces acting on the tractor left out account.
Starting out from these hypotheses it is possible to study the conditions of stability and the effect of the weight-transfer on stability, and to represent, as in Fig. 5, on a vertical plane containing the longitudinal axis of a tractor, the forces acting on this.
The total weight distributed on the rear axle and the front axle can be represented by P_1 and P_2 respectively (when the tractive effort is equal to zero).
The soil reactions can be represented by three components; R_1, R_2 and T. Wheel base will be indicated by p and height off the graund of the traction hook by h. Considering the tractor as a free body, the algebraic sums of the horizontal forces (parallel to the displacement), of the vertical forces (perpendicular to the displacement), and of the moments with respect to an axis, should prove to be equal to zero.

$$T - S = 0 \quad (1)$$

$$R_1 + R_2 - P_1 - P_2 = 0 \quad (2)$$

The algebraic sum of the moments with respect to C, intersection of the soil reaction R_1 and T, is:

$$P_2 p - Sh - R_2 p = 0 \quad (3)$$

From the three equations given above it is an extremely simple matter to calculate the value of the soil reactions against tractor weight and tractive effort. In fact:

$$R_2 = P_2 - S\frac{h}{p} \quad (4)$$

and since

$$R_1 = P_1 + P_2 - R_2$$

there is obtained

$$R_1 = P_1 + S\frac{h}{p} \quad (5)$$

Analysis of these equalities shows that:

a
the longitudinal stability of a tractor is largely determined by R_2; in fact, when the tractive effort S is so great that the term $S\frac{h}{p}$ is equal to P_2, then R_2 becomes equal to zero. From this moment on, every increase in tractive effort will involve the lifting off the ground of the wheels, thus jeopardizing the tractor's stability.

b
tractive capacity is affected by R_1 which increases with increase of the tractive effort S. The term $S\frac{h}{p}$ which intervenes to vary the value of the two soil reactions R_1 and R_2, by so-to-say decreasing the weight of the front axle to increase that to the rear axle in function of the tractive effort S (see equations 4 and 5) is currently named « weight transfer ».

c
it is possible to retard the pitching of the tractor by lengthening wheel base; in fact, in the equation 4, by making $R_2 = 0$, there is obtained:

$$S = P_2\frac{p}{h}$$

It can be deduced from this equality that S will be greater according as the wheel base p is greater and as the height h of the towing hook is lower. However, an over-long wheel base adversely affects manoeuvrability and complicates the construction of the tractor, while a low height of the towing hook means that the height off the ground is insufficient.

adhesion

Similar reasoning can be applied to adhesion: the product of the weight coming to bear on the rear wheels multiplied by the coefficient of adhesion should prove higher than the maximum effort allowed by the engine and by the transmission. This effort, in fact, is higher according as the engine is more powerful and as the transmission ratio of movement from engine to wheels is higher.
As a result of these requirements and with the construction of ever lighter, more powerful and more compact machines, it has of course proved necessary to reach a technical compromise; it is on the basis of this compromise that the previously mentioned weight distribution has been arrived at.

how to obtain greater adhesion and thus greater towing effort

By producing both crawler and total ahdesion wheeled tractors, tractor technique has from the earliest times followed two paths for the creation of machines with improved adhesion

crawler tractors

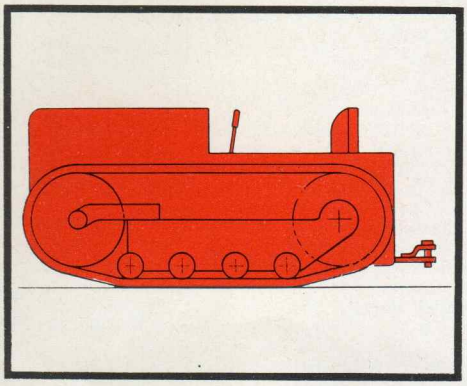


Fig. 6 - *Crawler tractor.*

The barycentre of the machine is shifted somewhat forward, so as to have uniform weight distribution on the crawler elements resting on the ground. In practice, the weight of the tractor in statically distributed to the extent of two-thirds on the front chain-stretcher wheel and to the extent of one-third on the rear drive wheel. The small dimensions possible for the chain-stretcher and drive wheels even with high powers, make it possible to lower the centre of gravity considerably, with increase of transversal stability. The track is an anticulated organ whose movement is impeded by a multiplicity of friction: of the links with one another — of the links on the toothed drive wheels and on the chain stretcher wheels — on the support rollers. While friction remains percentually limited at low machine translation speeds and allows high towing efficiency (80% and more), at speeds of more than 12-13 km/h it becomes very high indeed. Generally speaking, at about 15 km/h the towing capacity of a crawler tractor tends to cancel itself out and thus its tractive efficiency tends to zero.

The following, therefore, are the advantages of the crawler tractor: ☐ longitudinal and transversal stability ☐ adhesion and thus high towing capacity ☐ high tractive efficiency at low speeds ☐ low pressure of tracks on the ground.

The disadvantages are: ☐ high purchase price ☐ high maintenance and repair costs ☐ low efficiency at high speeds ☐ impossibility of carrying out culture work in view of the size of the tracks and the low height off the ground ☐ impossibility of circulation on public roads without the use of special shoes, which are of long, tedious and costly application.

tractors with total adhesion

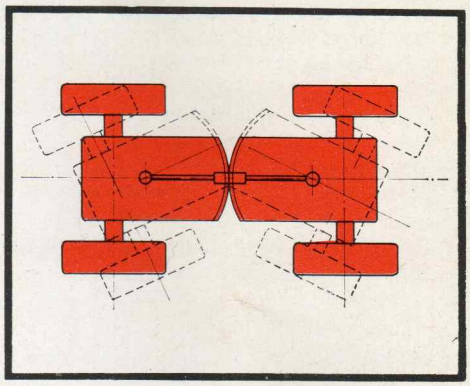


Fig. 7 - *Tractor with integral adhesion.*

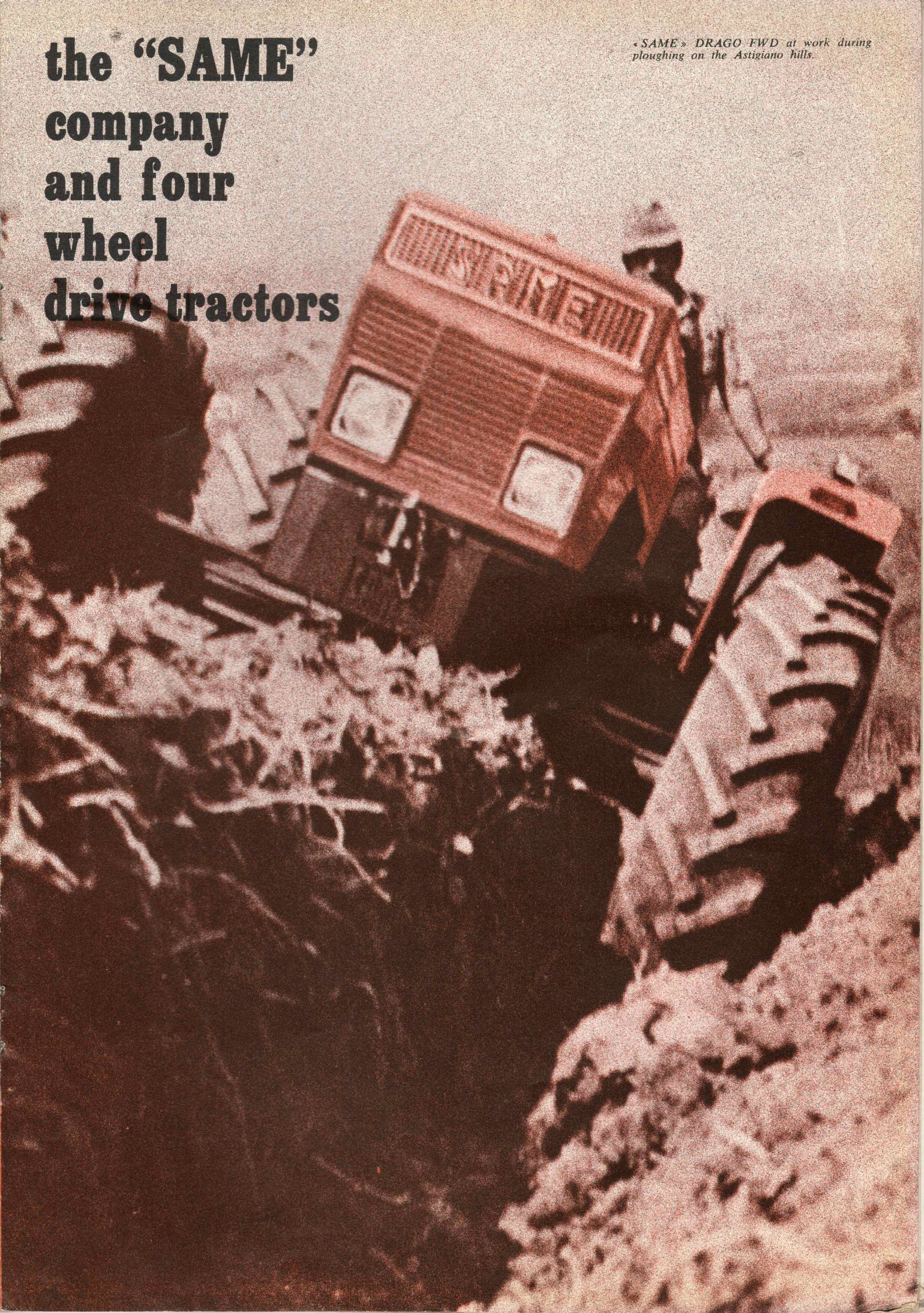
The term integral adhesion tractors is meant to denote those machines of structure different from conventional tractors and with all four wheels drive wheels and all of the same diameter. The best-known example is the « Pavesi Tolotti » tractor, produced in 1914. These vehicles, as said above, are characterized by the identical diameter of the four wheels, which during service have, in order to achieve equal adhesion, to have the same weight brought to bear on them. The barycentre is consequently taken forward in such a way that, with the tractor motionless, two-thirds of the weight bears on the front wheels and one-third on the rear wheels.

In this way there are obtained machines with wheels having total adhesion, where the weight distribution is no longer of decisive importance for the equilibrium between stability, steerability and towing capacity. The wheels in these machines are non-steering, and various solutions are adopted for driving them.

The advantages of these machines are: ☐ great longitudinal stability ☐ high towing capacity ☐ high tractive efficiency at all speeds.

The disadvantages are: ☐ High purchase price ☐ mechanical complexity and consequent heavy repair costs.

the "SAME" company and four wheel drive tractors



« SAME » DRAGO FWD at work during ploughing on the Astigiano hills.

The advent of crawler and total adhesion wheeled tractors has solved the problems of stability and of towing capacity, but has aggravated the economic problem on account of the high purchase prices, considerable repair costs and, in the case of crawler tractors, of reduction of annual utilization.
Fig. 8 is instrucitve in this connection, and gives percentage breakdown of the annual employment of a tractor in farms ranging from 15 to 100 hectares in size. Transport work takes from 37% to 51% of the total annual employment, sowing and culture work from 16% to 18%. These last-mentioned kinds of work cannot be done with crawler tractors, and so the unit running cost of these tractors becomes high in part because of their lower annual utilization.

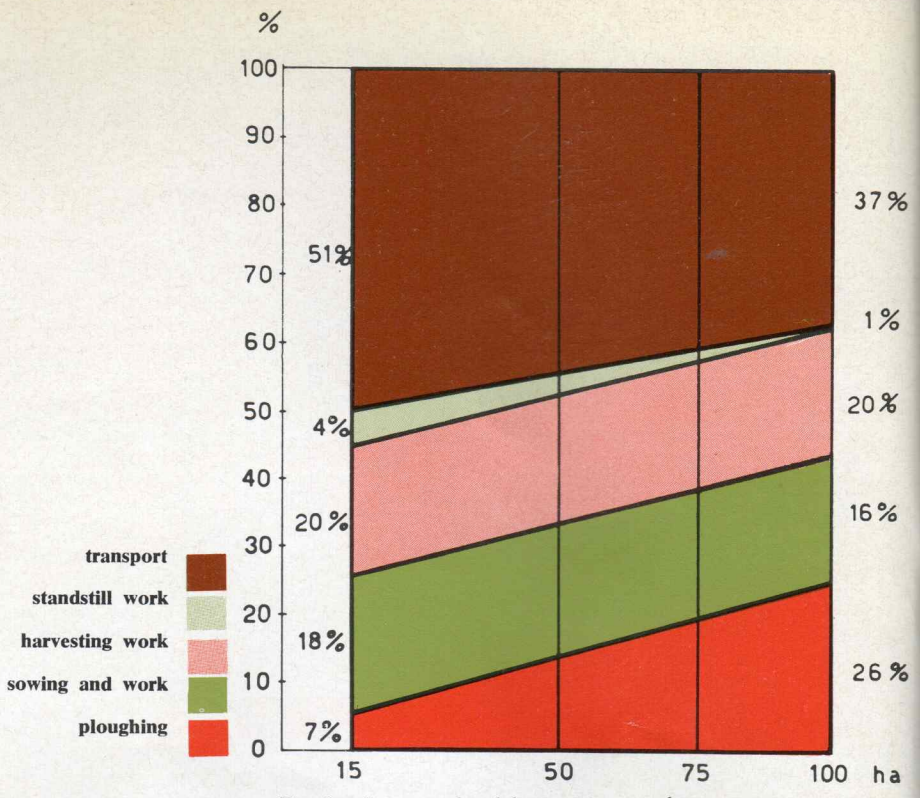


Fig. 8 - *Percent. breakdown of annual use of a tractor.*

A fleet of « SAME » ARIETE FWD tractors in use for the vast ploughing works on virgin soil on the Tessenei plains, Africa.

Having discarded the « crawler » solution on account of its high cost and incomplete utilization, the « SAME » Company turned its attention to the 4-wheel drive solution starting from the conventional 2-wheel drive tractor, which it had always manufactured robust, economical and dependable. From this excellent starting-point the Company set to work to make the front leading wheels drive wheels, without altering the overall design of the tractor.

It is easy to describe this change in words, and possibly even easier to imagine it, but in practice Ing. Cassani and his team of technicians worked long years on planning, experimenting all the way for the solution of constructional and functional problems — which had to be overcome in that the aim was not to convert the Company's own tractors or those of others but to make possible mass production on a strictly rational basis. The following page illustrates the characteristics of the « SAME » 4-wheel drive system as originally designed and realized and in its basic developments arising not from a wish for novelty but from a policy of constant technical and constructional improvement. That this policy has been appreciated is witnessed to by the fact that 50% of the « SAME » Company total production is in 4-wheel drive tractors.

the advantages of "SAME" FWD tractors

The practical results of « SAME » FWD tractors were from the time of their first appearance highly reassuring, since they demonstrated to the fullest extent the qualities of maximum adhesion and great stability that had been expected of them, though at the same time allowing the same manoeuvrability as with conventional tractors.

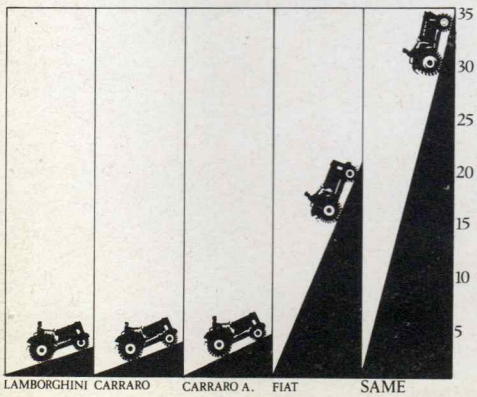
The « SAME » FWD solution further provided very considerable economic advantages, confirmed by the growing spread in use of these machines.

Engine HP being equal, the production costs — and thus the sales price — prove much lower as compared with all other types of total traction tractors, or crawler tractors.

Additionally, equipment previously purchased for towing or for the three point hitch of conventional tractors can be used without any modification. The steering is more gentle than with other total traction machines, and « SAME » FWD tractors are thus very easily manoeuvred.

The application of the front drive axle increases longitudinal stability, since because of its greater weight the 1/3 + 2/3 static weight distribution become 2/5 + 3/5, thus guaranteeing total absence of pitching, even in the worst environmental conditions (slopes and rough ground) and towing conditions.

With « SAME » FWD tractors the transmission of movement to the front drive wheels can be disengaged, which proves very useful when the towing and environmental conditions are not difficult.



Overall number of double traction tractors in Italy

(official U.M.A. data as at 31-12-1971)

SAME 33.392	O.M. (FF.SS.) 373	NUFFIELD 41	BOCCHINI 7
FIAT 20.144	POLENTES 297	AMOG 38	V.T.B. 7
CARRARO A. 4.238	M.A.N. 275	MASSEY-FERGUSON 33	VENIERI 5
CARRARO 3.886	FALCO 252	ZETOR 30	MERK-PULLAX 4
LAMBORGHINI 3.590	UNIMOG 236	RENAULT 27	PESCHIERA 3
GOLDONI 3.266	ROSSI 221	CANTATORE 21	RAIMONDI 3
LANDINI 2.927	HOLDER 174	DEL MONTE 20	EICHER 3
O.M. 2.154	CAST 128	ADRIATICA 18	SAMAT 2
MERONI 1.895	BELARUS 95	MOTOMECCANICA 15	CATERPILLAR 2
FERRARI 1.794	STEYR 92	DEUTZ 13	SULZER 2
P G S 1.679	I M T 68	TOSELLI 12	JOHN DEERE 2
PASQUALI 1.572	CALZOLARI 67	BUOSI 12	BUSATTO 1
VALPADANA 1.436	MARTINELLI 57	ERON 11	FENDT 1
BERTOLINI 1.320	FORD 48	F.C. 10	COUNTES 1
SLANZI 554	ISOTTA FRASCHINI 42	BARALDI 8	
NIBBI B. & FIGLIO 479	O.C.M.A. 41	HANOMAG 8	**TOTAL 87.152**

The front driving axle of the « SAME » FWD tractor consists of a sturdy housing for the differential nitre wheel gearing, the differential and the two drive-axles terminating in two homokinetic joints, bolted to the wheel hubs. These hubs are rotatable on the pins of the support forks which are operated by means of bars and tie rods by the steering mechanism (Fig. 10). The pinion of the mitre wheel gearing is driven by the toothed wheels of either the gearbox or of the final transmission.

the earliest system

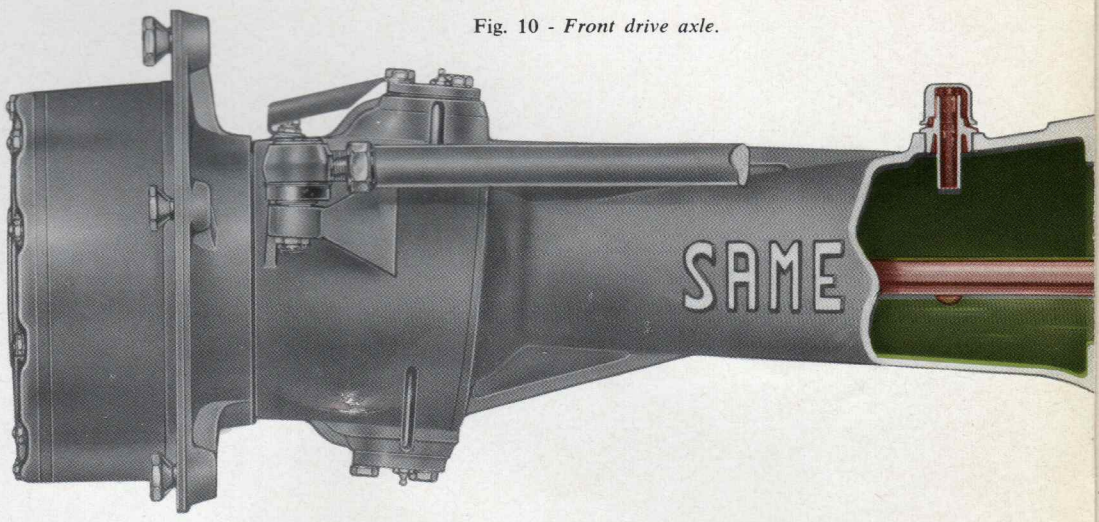
The movement transmitted to the front leading wheels A, which also become drive wheels, is derived from a mitre wheel gearing applied to the cylindrical toothed wheel of the final reduction gear by means of the bevel drive pinion B. The shaft of this reduction gear may be made one with cardan shaft C. by means of the lock D.

The cardan shaft C, terminating in the universal joints E and F, is in its forward part stably connected to the shaft of the bevel drive pinion G meshed with the crown wheel of the front differential H, the drive axles of which, terminating in a constant-velocity universal joint, are linked to the front drive wheels.

Fig. 9 - *Articulated shaft version.*

how the fully original "SAME" 4 wheel drive system works

Fig. 10 - *Front drive axle.*



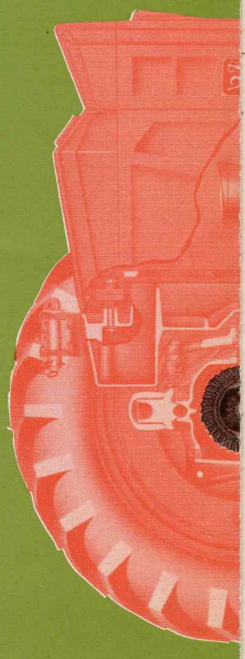
the original "SAME" system 4 wheel drive

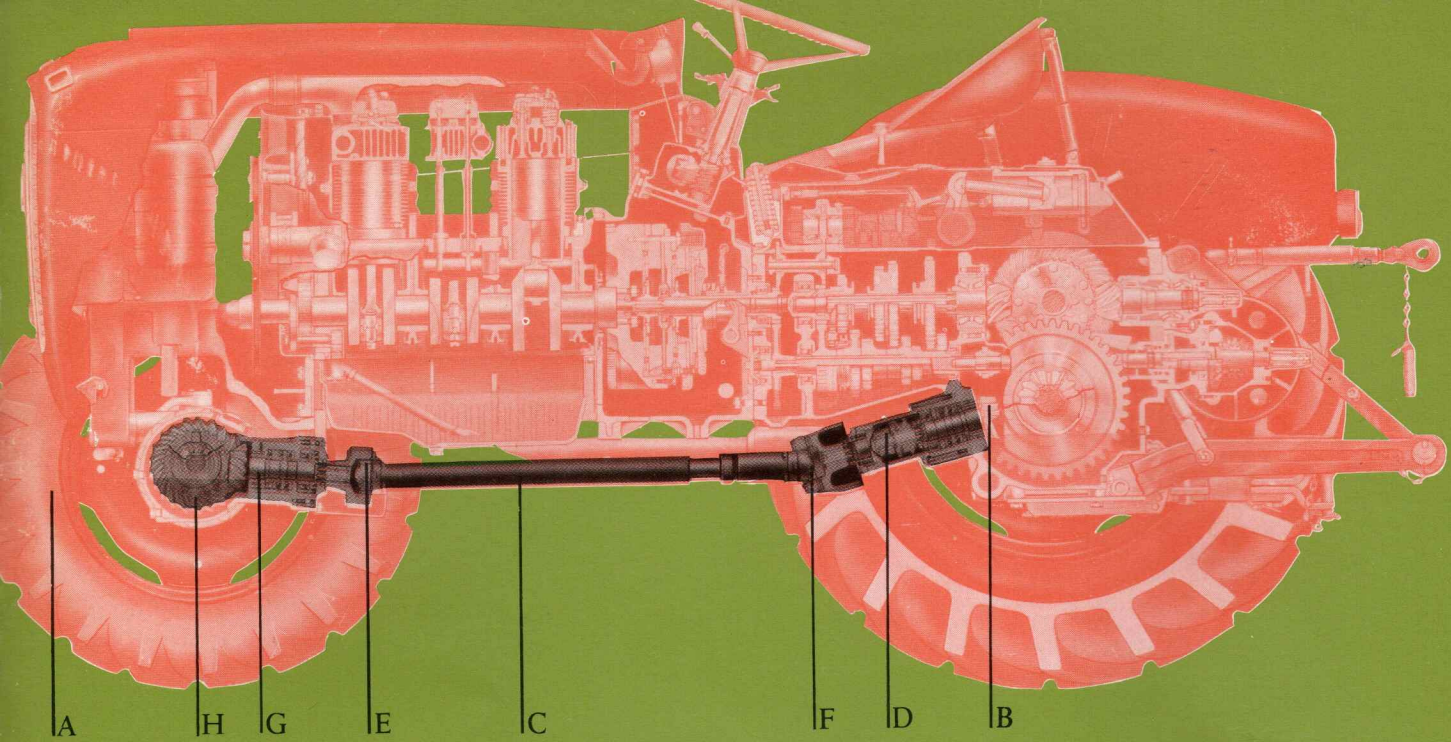
Fig. 11 - *Rigid shaft version.*

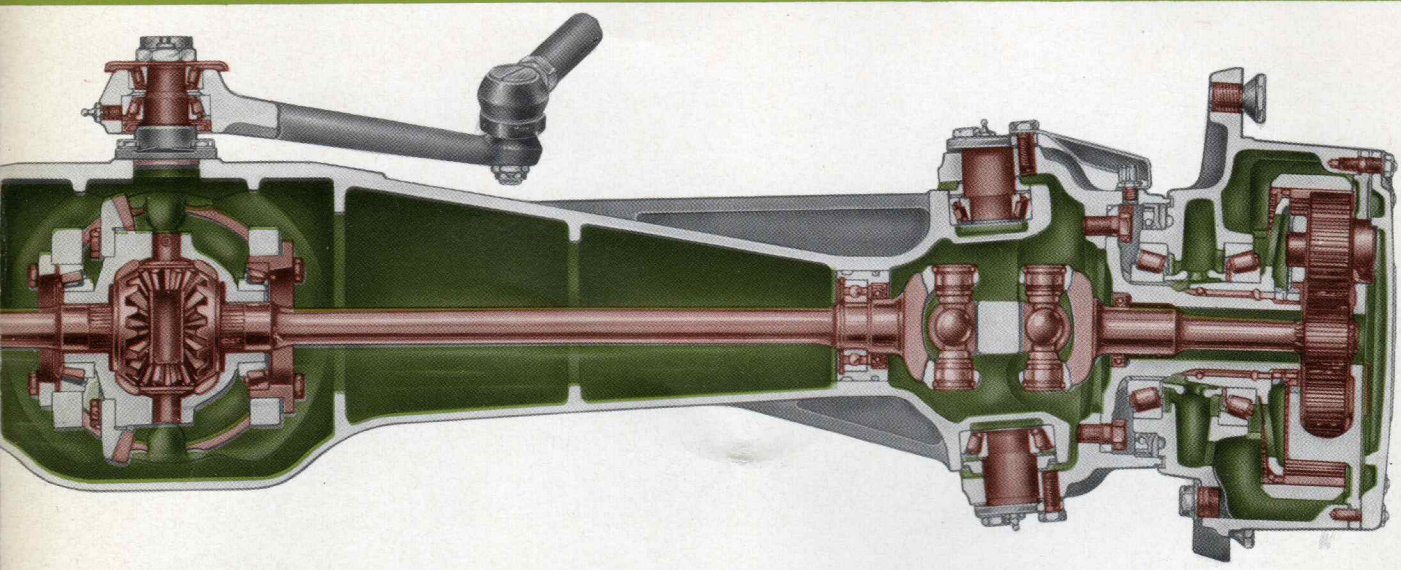
The movement transmitted to the front leading wheels A, which also become drive wheels, is derived from a gear of the reverse reduction gear of the gearbox by means of the toothed wheel B. This toothed wheel can be made one with the cardan shaft C by means of the lock D.

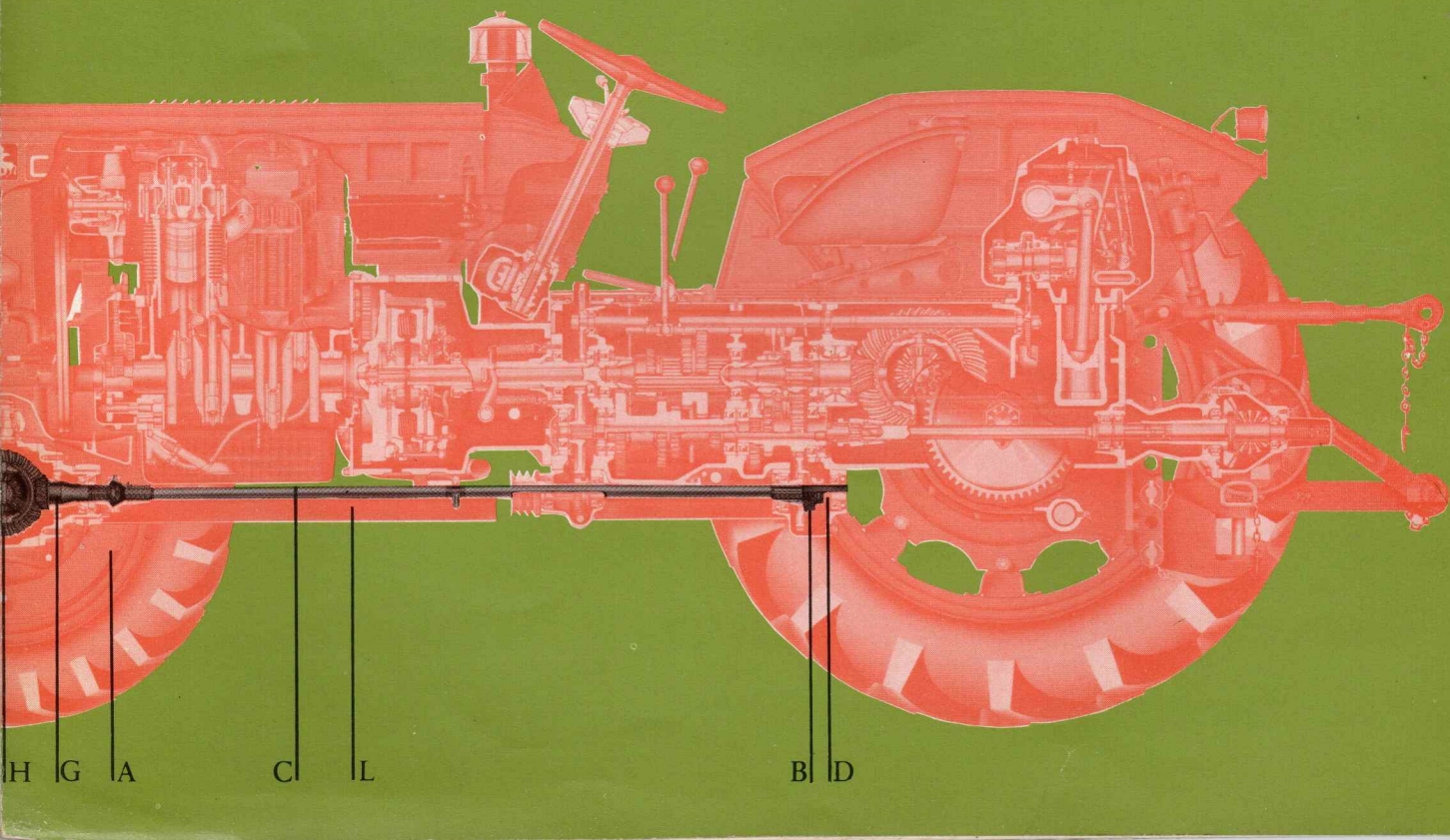
The transmission shaft C, undivided, without universal joints is stably linked up in its forward part with the shaft of the bevel drive pinion G meshed with the crown wheel of the front differential H, the drive axles of which terminate in a constant velocity universal joint and in the plane pinion of the planetary reduction gears which give movement to the front wheels.

The transmission shaft C is very close to the body of the tractor and is therefore without difficulty protected by the casing L.




A
H
G
E
C
F
D
B




H
G
A
C
L
B
D

the technical and scientific results achieved by "SAME" 4 wheel drive tractors in Italy

Eminent Italian lecturers in agricultural engineering have made technical and scientific examination of « SAME » FWD machines.

In 1956, **Prof. Ing. Di Paola of the University of Bari** carried out some dynamometric tests on a « SAME » DA 25 FWD tractor with and without engagement of the front traction, and in the second case obtained data fully comparable with those given by a 2 wheel drive tractor. The results are summarized in the Tables that follow:

Table A - Results of dynamometric tests
(Meadow with fresh surface grass)

Drive wheels	gear	max. value of average tractive effort kg.	corresponding slip %
2	I	910	22
2	II	890	25
2	III	629	8
4	I	1.359	18
4	II	972	9
4	III	637	5

Table B - Work tests
(Ground dry on surface, wet in depth; with previous forage cultivation, recently cropped)

Drive wheels	max. working depth cms.	hourly work capacity in hectares ha/h	hourly work capacity in m^3/h	fuel consumption hourly kg/h	fuel consumption per hectare kg/h	fuel consumption per 100 m^3 kg/1000 m^3
2	38	0,1175	446	4,24	36,1	9,5
4	35	0,1527	535	3,99	26,1	7,5

Prof. Di Paola reached the following conclusions:

« To sum up, the advantages of double traction as against single traction can be stated as follows: the capacity of four drive wheels to provide superior tractive effort or traction as compared with two drive wheels is appreciable for the first speed ratio, that is to say for lower forward speeds; with two drive wheels the hourly work capacity in hectares and in m^3 is appreciably lower, and fuel consumption per hectare and per 1000 m^3 is appreciably higher as compared with that of four drive wheels, and this without any considerable variation of hourly consuption ».

Later, **Prof. Nerlo Nerli, lecturer in agricultural engineering at the University of Pisa,** more exactly in 1957, carried out some tests on a « SAME » DA 30 FWD tractor with respect to a « SAME » DA 30 TWD tractor. The results of these tests were truly remarkable, and the author's conclusions were as follows:

Track tests

« To sum up, the track tests once again confirm that the four drive wheels allow improvement in performance and in efficiency at the hook of the tractor, especially at the lower gear speeds, and thus appreciably attenuate the difference in behaviour at the different gear speeds; this means that the machine can with advantage be used for a greater number of agricultural operations which, even at the lower speeds, can be carried out with a still relatively high hook efficiency.

Field tests

The data reported in the table show that the advantage of four drive wheels as against two is increased in field work as compared with what occurs on the hard track: since the adhesion conditions in field work are considerably worse, the difference in slip plays a more important part vis-a-vis the useable power available at the hook. It is in fact found that the increase in useable power, when change is made from two to four drive wheels, was 17% in second gear on the track while in the field it proved to be 28.6% and even with respect to speed, which on the track did not give appreciable power increase because of the high degree of adhesion resulting from the forces in play, in the field the power increased by 15.3%.
The advantange of four drive wheels with regard to efficiency at the hook is reflected also in the lower fuel consumption found per cubic metre of turned ground; the fuel consumption, moreover, can in any case be defined as excellent for the two wheel drive tractor as well ».

Prof. Franco Dallari, when making a test with a special type of plough, used, among other machines, a « SAME » DA 30 FWD tractor employed for traction with 2 and 4 drive wheels operative. Prof Dallari has the following comments to make on the technical results obtained:

« Also worthy of note are the results obtained using the identical « SAME » DA 30 FWD tractor that was used in the fourth test, on the same plot of land in the same conditions, but with the bringing into play of the two front wheels for drive purposes. The data relate to findings regarding the work carried out with the four wheel drive tractor and plough, in out-of-furrow position, compared to work in the same out-of-furrow conditions done by the tractor with only the two rear drive wheels operative.
The work depth proved higher by 11% and the work section by 10% (in this latter test there was more efficient adjustment of the position of the plough).
Fuel consumption was lower by 17% when referred to the hectare, and by 41% when referred to the volume of turned ground.
Power outputs were lower by 1% and by 13% referred to the hectare and to the volume of turned ground; also lower was the ratio between nominal power and dm² of section worked, and the number of centimetres of depth (by 10% and 22%).
The use of the front traction in this experiment was clearly beneficial ».

In 1965, in his work « Efficient and safe mechanical means for the development of agricultural transport in gradient areas » Prof. Dallari made the following comments on the tests carried out by Prof. Giovanni Vitali of the University of Florence:

« There was also proven the usefulness in such circumstances (tests on the SAMECAR agricultural double traction vehicle on the road with trailer) of the four drive wheels for the tractive vehicle in the aforesaid conditions, and particularly in the case of gradients of more than 20%.
In comparative experiments with the same means, with the four drive wheels engaged and with only two engaged, over the same run, the average speed with the four drive wheels proved to be 8.42 km/h, while with the two drive wheels it proved for a variety of reasons to be 5.15 km^{32}h, that is to say a decrease of 39%.
It should further be stated that, if in determined sections of the run the front traction had not been engade even for a very short period, it would not have been possible to move forward at the very steep points. Furthermore, and again in the comparative tests, the fuel consumption with the four drive wheels proved to be 4.2 g/qkm as compared with 6.5 g/qkm with two drive wheels, in the same load and run conditions ».

results of traction tests performed on TWD and FWD "SAME" tractors

at the « Experimental Institute of Agricultural Mechanization » University of Milan

This important experimental research on 4-wheel drive tractors was brought to a close by Prof. G. Pellizzi and Prof. G. Colzani of the « Experimental Institute of Agricultural Mechanization » University of Milan, who in 1967 carried out a series of tests (dynamometric - slip - consuption) on two « SAME » LEONE 70 tractors, one 2-wheel drive (with and without ballast) and one 4-wheel drive (with and without engagement of front traction) on different tracks (cement track - turf - dry wheat stubble - wet wheat stubble).

The tests provided a mass of data (approximately 5,000 findings) which, after processing and editing in the form of tables, diagrams and graphs, properly commented, are the basis of the excellent publication « Results of traction tests on 2-wheel and 4-wheel drive " SAME " LEONE tractors ».

In endorsement of what has thus far been stated, we now quote from the more important sections of the concluding chapter:

« The results in themselves are sufficiently eloquent as regards the substantial advantage of using 4-wheel drive as compared with 2-wheel drive tractors ».

To support the conclusions drawn by the above mentioned famous University teachers, here below we are giving characteristic diagrams in which the slipping data concern the crawling effort per Kg. of weight of the tractors split up according to the total weights of the tractors:

LEONE 4WD tractor without ballast Kg. 2670.

LEONE 2WD tractor without ballast Kg. 2520.

LEONE 2WD tractor with ballast Kg. 2920.

Every diagram concerns one of the following kinds of surface:

concrete
turf
wheat stubble
seed bed
wet wheat stubble

We also point out how the number of the prerogatives of the 4WD tractor become more and more evident as the rolling track becomes more and more yielding.

The tests in effect gave the following findings: on the various terrains the coefficient of adhesion, with slip rate of 15%, goes from a maximum of 0.6 (turf) to a minimum of 0.3 (wet stubble).

During work, with worsening of the adhesion conditions of the terrain and resultant deeper sinking of the drive-wheels there is a tendency for less and less tractor-weight to come to bear on the drive-wheels; indeed this takes place sometimes to such an extent that the drive-axle is lightened as a result of the fact that the towing hook tends to be raised through its coupling to the implement or machine being pulled: this of course means that the TWD tractors are less and less able to make tractive efforts.

Other conditions being equal, the 4-wheel drive tractors will provide tractive effort 1.2 to 1.3 times greater than that of the 2-wheel drive tractors on firm land such as turf and wheat stubble, and as much as 2.2 to 2 times greater on high-moisture land with low adhesion possibilities.

Moreover, as the result of lower slip — gear and engine rpm being equal — these tractive efforts are achieved at high speeds with FWD tractors than with TWD tractors.

On agrarian land the power — in point of tractive effort or traction potential — is always greatly under-employed; for the limit is set by the adhesion between wheels and terrain, to that power exploitation decreases for the low gears, with TWD tractors, to a minimum of 10-15%; hence the very low values of the average tractor power employed, as found by various Authors.

On the whole, the maximum exploitation of TWD tractors is achieved at higher speeds than in the case of FWD tractors, with the result that, in the gear-speeds used for ordinary work, TWD tractors provide operating performance — which in the case in point can be expressed globally with the efficiency index values — **capable of falling to half that attainable with FWD tractors.**

In the specific instance, the optimal utilization of power by the TWD tractor is obtained only for ground speeds greater than 12-13 km/h (7.5-8 mph), which in terms of tractive effort or traction are speeds of little interest as far as farming is concerned. With the FWD tractor, on the other hand, a high utilization of tractor power is obtained even at speeds of 8-10 km/h (5-6.2 mph).

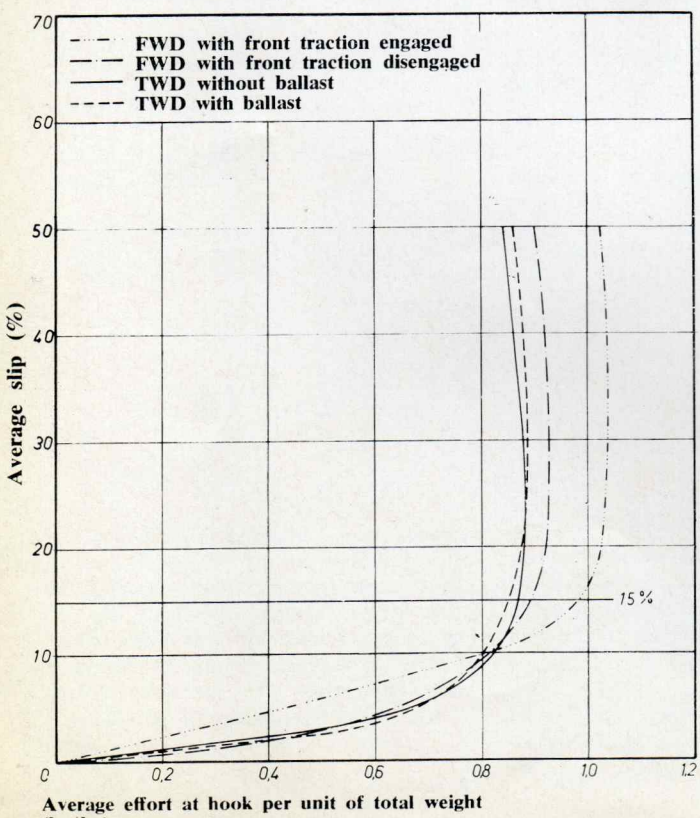
This last speed has also shown itself to be

Continued on page 21

Fig. 12

Test on cement concrete

Slip curves - average effort at hook per unit of total weight of the tractor.



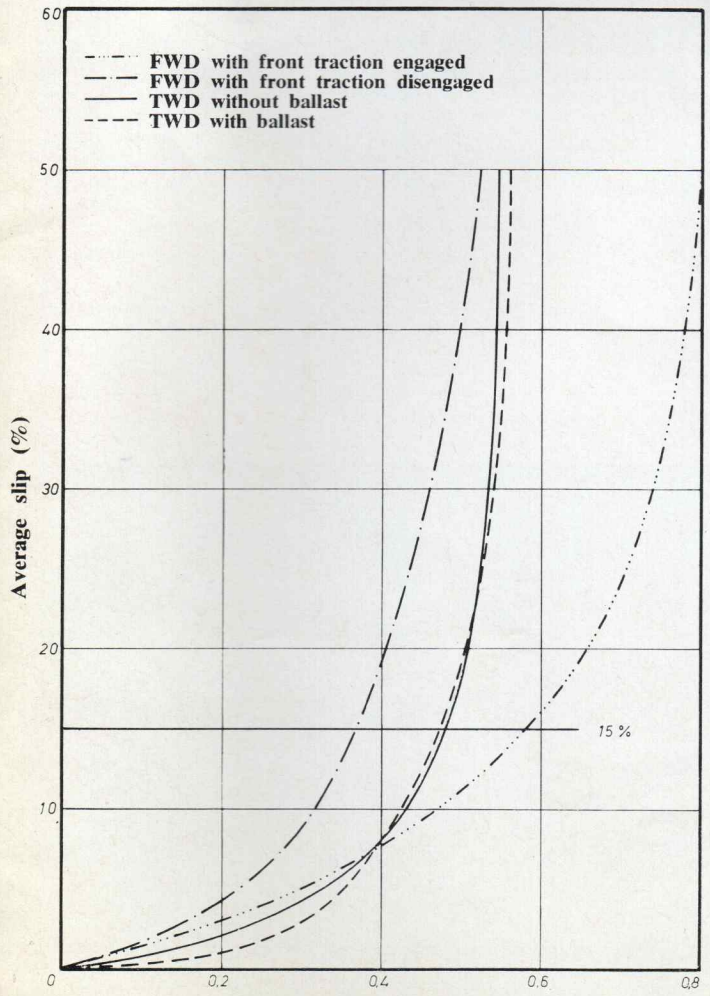
Tests on wheat stubble

Tests on turf

Fig. 13

Tests on turf

Slip curves - average effort at hook per unit of total weight of the tractor.

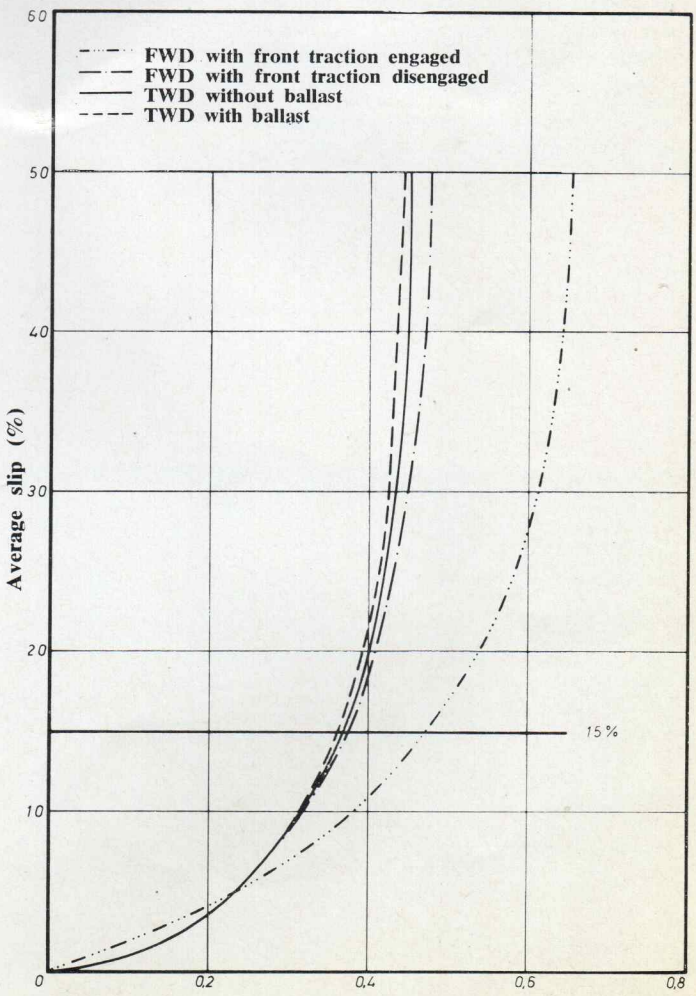


Average effort at hook per unit of total weight (kg/kg)

Fig. 14

Tests on wheat stubble

Slip curves - average effort at hook per unit of total weight of the tractor.



Average effort at hook per unit of total weight (kg/kg)

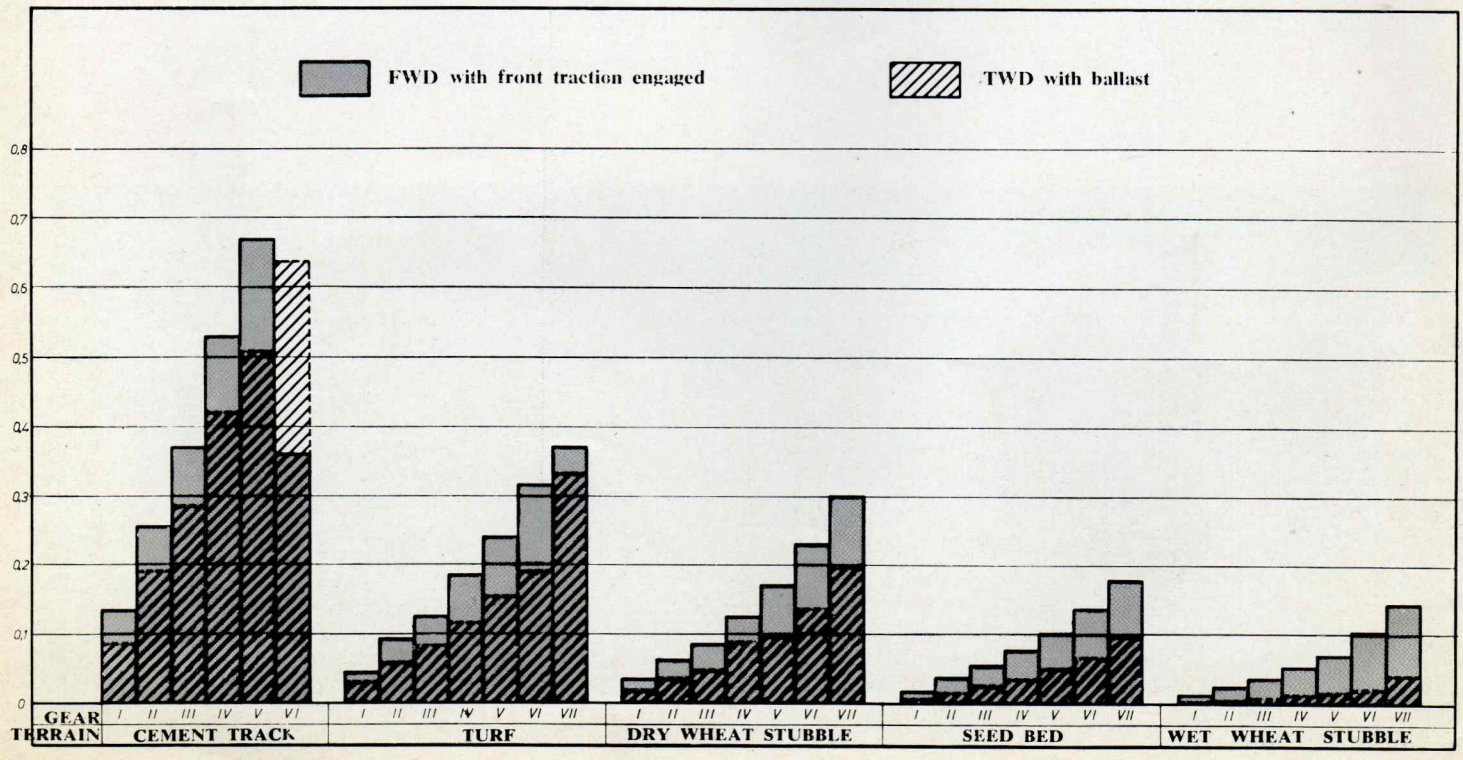
SUMMARY

In Spring-Summer 1967, the Experimental Institute of Agricultural Mechanization of Milan carried out traction tests on various types of soil with two SAME Leone 70 tractors, one of which had 2 wheel drive (TWD) and the other of which had 4 wheel drive (FWD).

The TWD tractor, furthermore, was experimented with both in the normal version and in the weighted version, while the FWD tractor was tested with front traction engaged and disengaged. The tests were made on the following soils: artificial track in concrete, grassy turf, dry wheat stubble; seed-bed; flooded wheat stubble. The findings concerned: forward speeds; tractive efforts at the various speeds and at the different slippages; the slippages themselves and the fuel consumption. From the results obtained the correlating curves were arrived at: slippages and relative total efforts at hook, per unit of weight of the tractors; the hook powers and relative efforts; the total hook powers per unit of weight of the tractors and the forward speeds. It proved in this way possible to give empirical expression of the behaviour of the four version tested on the different soils and, in particular, on farm lands, and their performances, by means of an overall index of efficiency as product of the index of utilization of weight (ratio between average hook power and total weight of tractor) and the index of utilization of power (ratio between average hook power and maximum power available by the engine). It proved, among other things, that, with 15% slippage, the TWD tractor — which on concrete track shows tractive capacity of the order of 75% of that of the FWD tractor with front traction engaged — gives gradually decreasing performances with the worsening of the soil conditions, down to the point, on the seed-bed, of expressing hook efforts of the order of 50% of those given by the FWD version and, on flooded stubble, down the point of expressing values equal to little more than 40%.

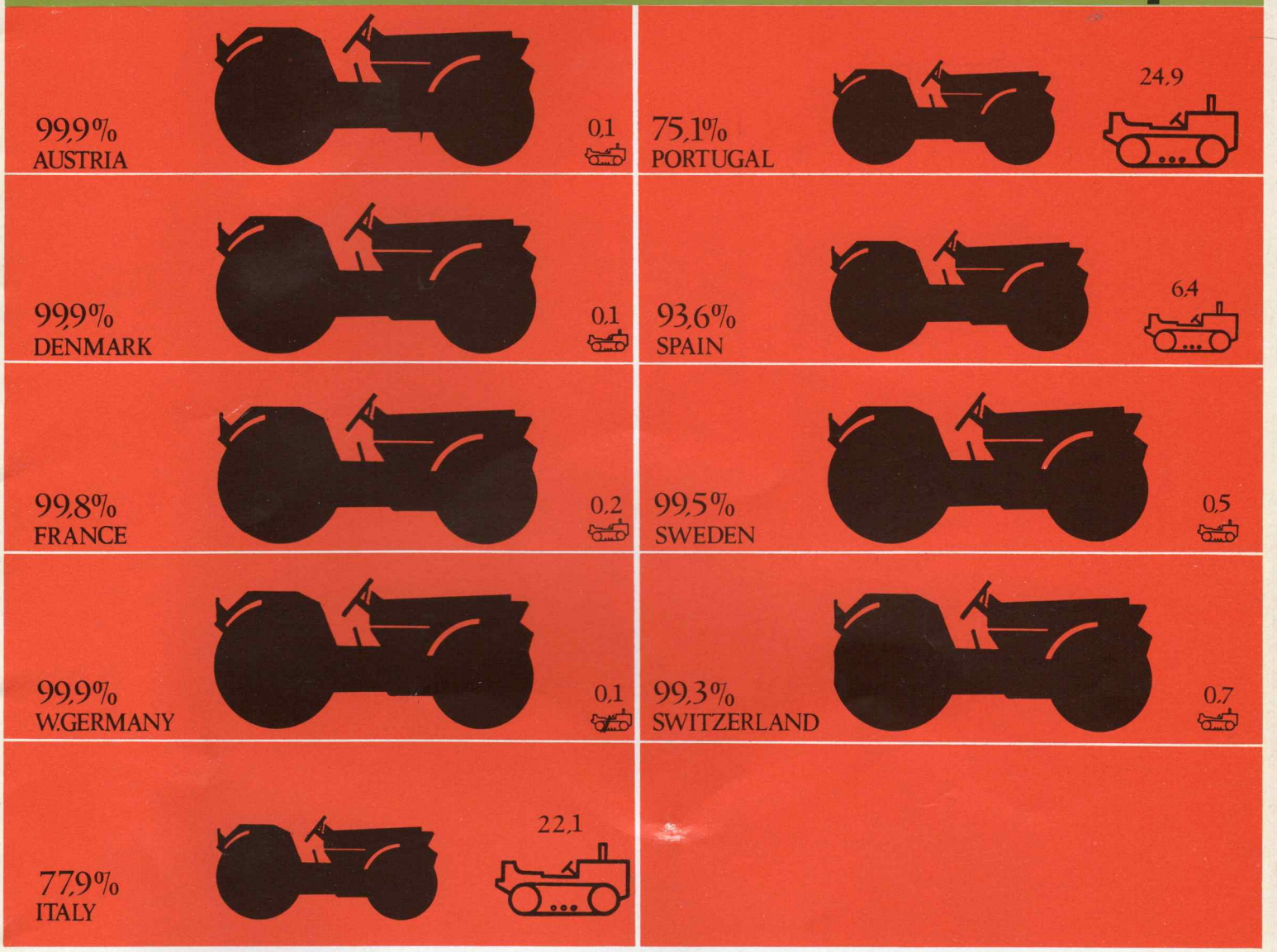
Therefore, the 4 wheel drive tractor — conditions being equal and regarding the capacity to exert tractive efforts — provides performances that are better than those of the 2 wheel drive tractor according as the adhesion conditions are worse.

Fig. 17 - **Histograms of the index of efficiency of the FWD tractors with front traction enaged and TWD tractors without ballast at 15% slip in the various gears and on the different test terrains.**



How the maximum adhesion on fields is achieved in Europe: progress in agricultural mechanization is accompanied by an ever-increasing use of 4 wheel drive tractors.

breakdown of wheeled and crawler tractors in Europe



4 wheel drive tractors as compared with crawler tractors

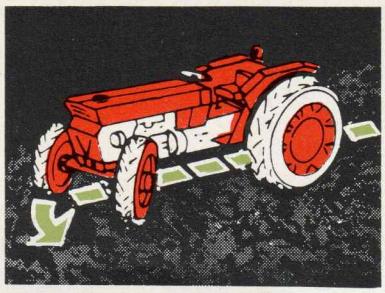
Experimental research has not confined itself merely to comparison between 2 and 4 wheel drive tractors but includes also comparison between 4 wheel drive wehicles and crawler vehicles.
In fact, the British National Institute of Agricultural Engineering has carried out interesting comparative tests between 4 mheel drive tractors and crawler tractors for various types of agricultural work. The results were clearly set out by Prof. L. E. Osborne in a documented report, which reached the following conclusion:
In recent years the continuous increase in maintenance costs for crawler tractors and the difficulties involved in the movement of these tractors and their implements on public roads have led many crewler owners to consider replacing them with wheeled tractors. The results so far obtained show that the 4 wheel drive tractor offers advantages equal to those of a crawler tractor of the same power in the widest variety of ground conditions.

As regards the Italian agricultural environment, the doubt has been put forward that the crawler tractors may be selected almost exclusively for very deep ploughing operations thus too costly in relation to the limited and debated increase of the consequent agricultural production.
In this connection, Prof. Giovanni Candura of the University of Naples has made a careful and thoroughgoing study, which was the subject of the conference « Wheeled and crawler tractors », held at the Accademia dei Georgofili in Florence.
The late Prof. Candura reached the following conclusions:
« To sum up, the test results so far obtained on wheeled and crawler tractors of equal sales price show: the uselessness of carrying out deep work on loose ground; the validity of the opinion as to the advisability of working the earth at a depth of 35 cms in order to obtain the advantages of deep working in clayey soils also; the possibility of eliminating slip in wheeled tractors by using rotary extensions, the advisability of effecting agricultural transport with the conjoined use of wheeled tractor and trailet, added to the previously mentioned considerations, lead to a good deal of doubt as to the correctness of the choice made by Italian farmers: new crawler tractors registered at U.M.A. in 1964 numbered 11,203 over a total of 42,580, i.e. 26.3%; this is a percentage higher than that of the total number (23.3%), while in Germany it can be said that crawler tractors are not used at all in agriculture.
Howver different Italian and German agricultural conditions may be, there is no good explanation for the enormous difference in the use of crawler tractors. The Italian farmer should therefore be advised to make a very careful choice of the type tractor to be used on his farm, particularly in the light of the ever-increasing development of agricultural transport ».

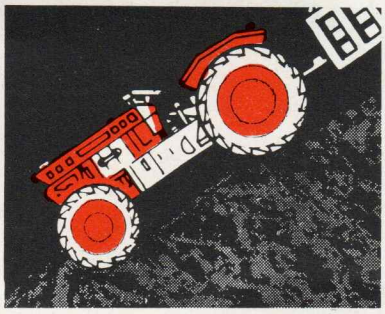
The « SAME » Centauro FWD first place in the first E.N.P.I. (National Body for the Prevention of Accidents) competition for safety on hills and in the mountains

Further arguments in favour of è wheel drive tractors are provided by the results of public competitions, such as the one held at Grottaferrata in April, 1966 under the auspices of the National Body for the Prevention of Accidents (E.N.P.I.) After exhaustive and careful tests, a « SAME » Centauro FWD tractor won first place - competing also with crawler tractors - thanks to its very great stability.

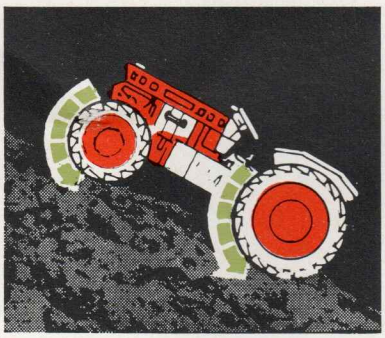
This stability was due not only to the low centre of gravity, to the studied wheel base measurement, to the well-sized bodywork - but above all to the front traction which, in dynamic phase, allowed safer manoeuvre on rough and sloping ground.



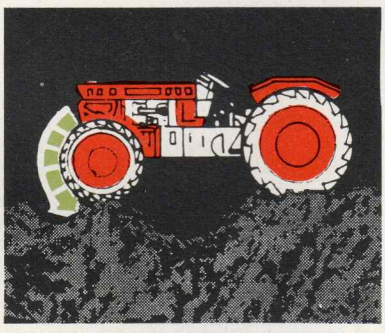
With the front drive wheels the vehicle constantly follows the trajectory given by the driving direction, particularly over muddy terrain or gradients, thus preventing any kind of side slipping.



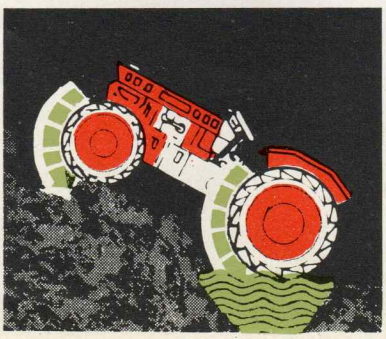
In descent the four drive wheels if connected mechanically, both with one another and with the engine always provide a sure braking effect because, and the considerable axle distances guarantee a high degree of adhesion, even on ground of uneven consistency.



The front traction converts the weight on the wheels into as much adhesion; this allows steep slopes to be overcome and the towing of large implements over icy, snow-bound or muddy ground.



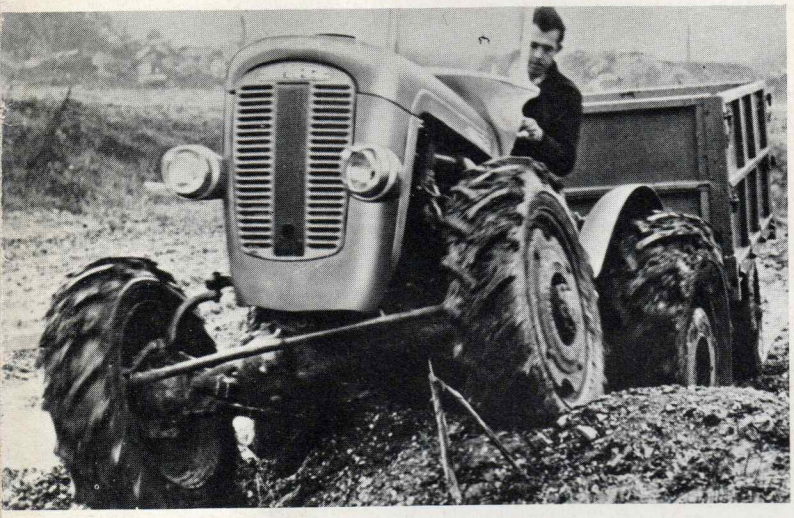
Any obstacle coming in the way of the forward movement of the vehicle is first met by the front axle, which in itself has sufficient torque to overcome it, and thus performs the function of a crawler tractor.



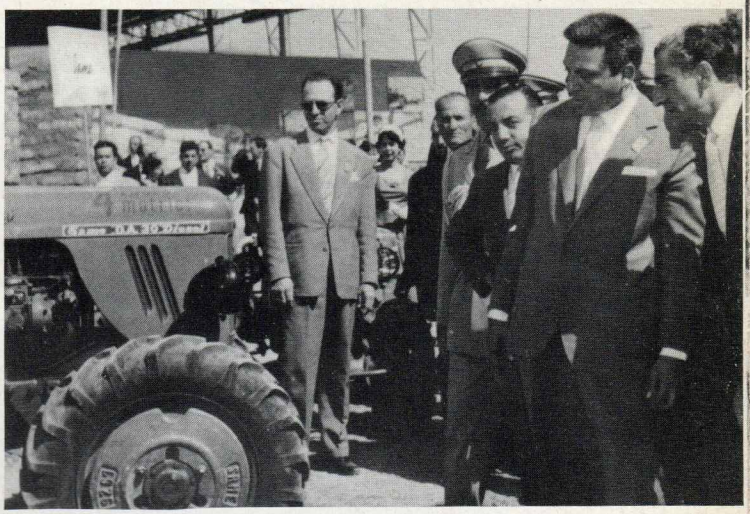
In the 4 wheel drive tractors the distance between the axles, both engines, allows traction to be developed at the same time over different ground zones, so that if one axle is bogged down in the mud the other is very likely to bear one on firm ground.

the advantages of SAME FWD tractors

« SAME » FWD tractors represent an ideal solution, both of pratical and technical nature, of the difficulties entailed in the classic solution of the conventional two wheel drive tractor. Although the « SAME » FWD tractor maintains the by now universally accepted architecture of the conventional tractor, it fully exploits the total weight of the machine in the interets of towing capacity. This leads to positive technical results which are analysed in the following pages.



England



Iran

Yugoslavia

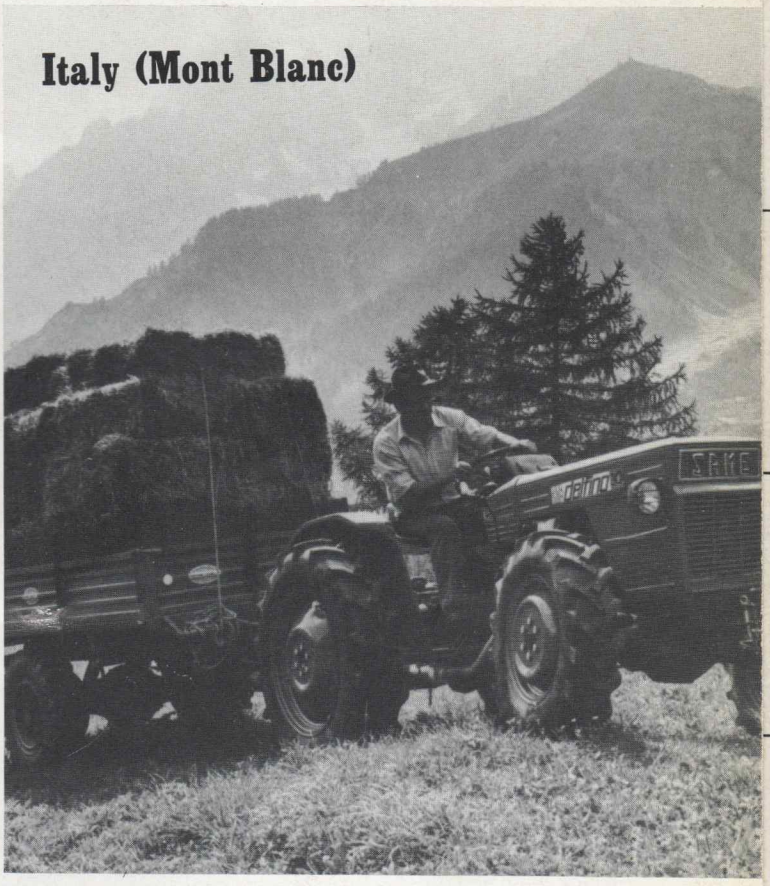
France

Germany

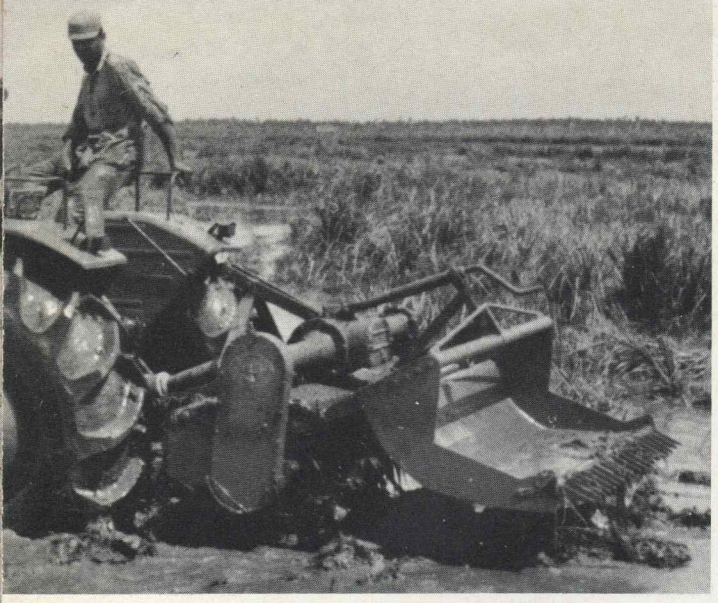
Switzerland

Cuba

Italy (Mont Blanc)



Spain



« SAME » FWD tractors integrally exploit the total weight of the machine in the interests of towing capacity. In practice their superiority in the field has been demonstrated, with a 30% increase in tractive effort, which is as much as 80% on the least favourable terrains.
This advantage makes it possible to use larger implements without having to employ high speeds for full exploitation of engine power.

This is an advantage deriving directly from the greater tractive effort of « SAME » FWD tractors. If slippage, with effort being equal, is much lower in 4 wheel drive tractors, the mechanical efficiency is greater because energy losses are smaller.

With the front wheels acting both as leading and drive wheels there is no pushing forward of earth and mud as occurs if the wheels are leading wheels only, especially if there exist lateral forces with non-centered implements. With the 4 drive wheels steering is thus always prompt and efficient, on a good road surface, on ice and in mud ond where there are cross-falls. The larger dimensions of the front wheels mean less compression of the soil.

In two wheel drive tractors the weight distribution is such as to cause the maximum tractive effort to coincide with the commencement of heeling over.
With the « SAME » four heel drive tractors the possibilities of greater loading of the front axle, supposing that the towing, capacity remains unaltered, rules out heeling over and thus brings stability to maximum.

In crosswise operations on gradients the active effect of the front drive wheels bears a more precise and surer steer, and avoids deviatons due to forces of gravity. In operations on gradients, the greater adhesive weight facilitates the steepest slopes.

With front-mounted implements, the lesser adhesion of the rear wheels in offset by the increase of that of the front drive wheels; the thrust value is thus left unchanged.
With rear-mounted implements, the transfer of the weight from the front to rear wheels does not modify towing capacity, while the considerable static weight coming to bear on the front wheels forestalls pitching.

The distribution of the maximum efforts between front and rear wheels leads to longer life for machines engaged in very heavy work.

In long and steep deescents, especially when a trailer vehicle is being towed, the braking action of the engine should be used; with four drive wheels, this action is particularly effective.

30% increase
sometimes reaching 80%
in efficiency at towing hook

greater mechanical efficiency
and thus even as much as 50%
fuel saving as a result
of lower energy losses

easy and efficient steering
on yelding ground or between
crop rows
decreased compression of the soil

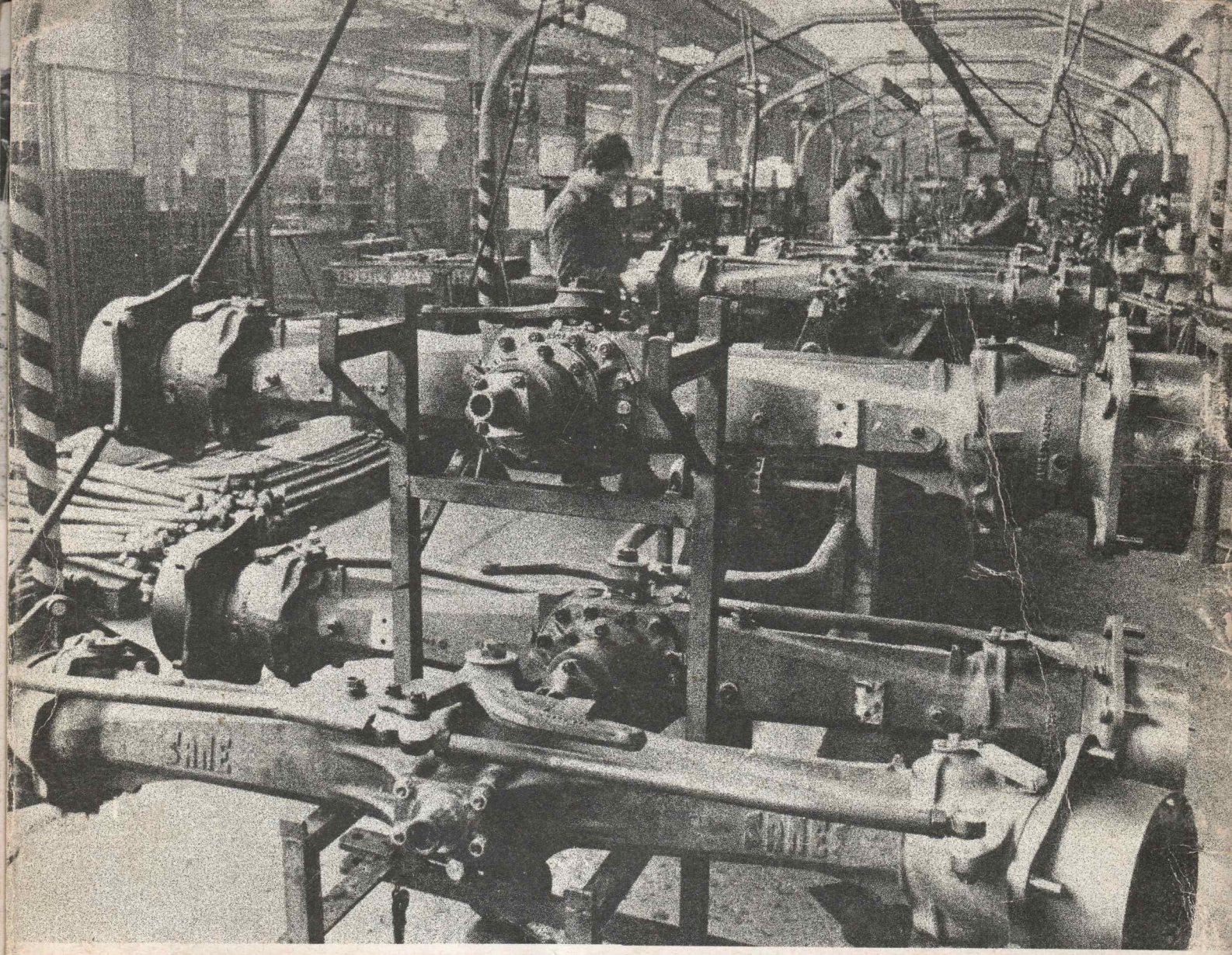
maximum stability
and safety

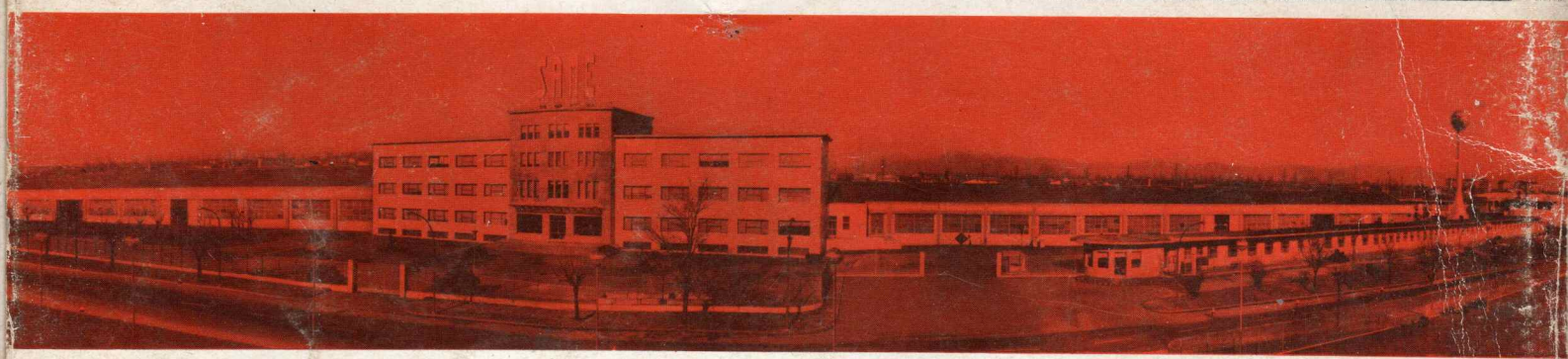
the doubled adhesion
means double safety

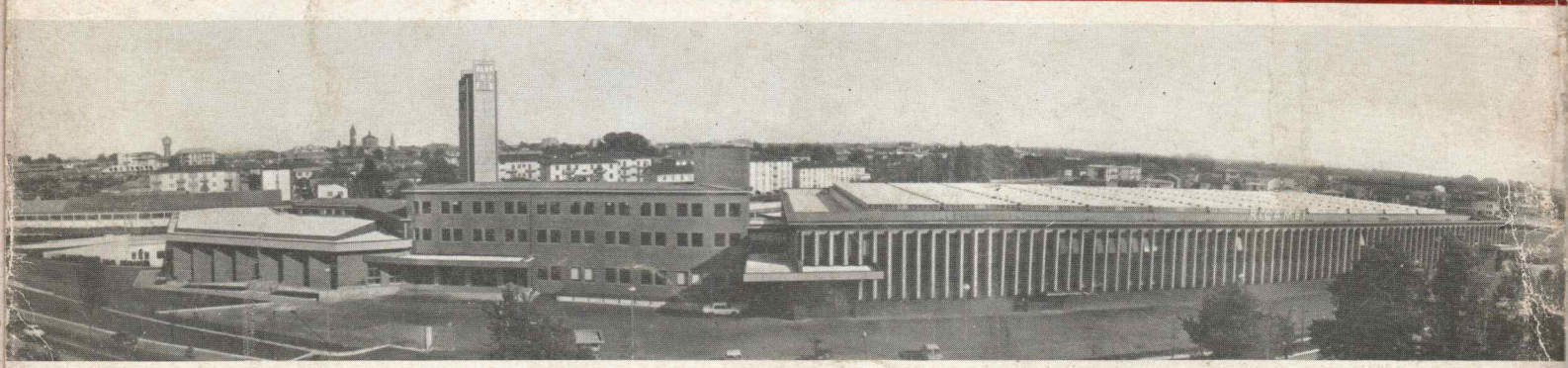
full use
of all implements

longer life as a
result of the subdivision
of effort between
front and rear wheels

four drive wheels
have a better
braking action than two







SAME

SAME S.p.a.
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Telex: 32472 Sametrac

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