The jeep as a source of power and transportation on farms and ranches in Texas / H.D. Smith.

Smith, H. P. (Harris Pearson), 1891-

College Station, Tex. : Texas Agricultural Experiment Station, 1946.

https://hdl.handle.net/2027/txa.tarb086630

TEXAS AGRICULTURAL EXPERIMENT STATION

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College Station, Texas

BULLETIN 679 APRIL 1946

THE JEEP AS A SOURCE OF POWER AND TRANSPORTATION ON FARMS AND RANCHES IN TEXAS

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Division of Agricultural Engineering

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D58-646-6M-L180

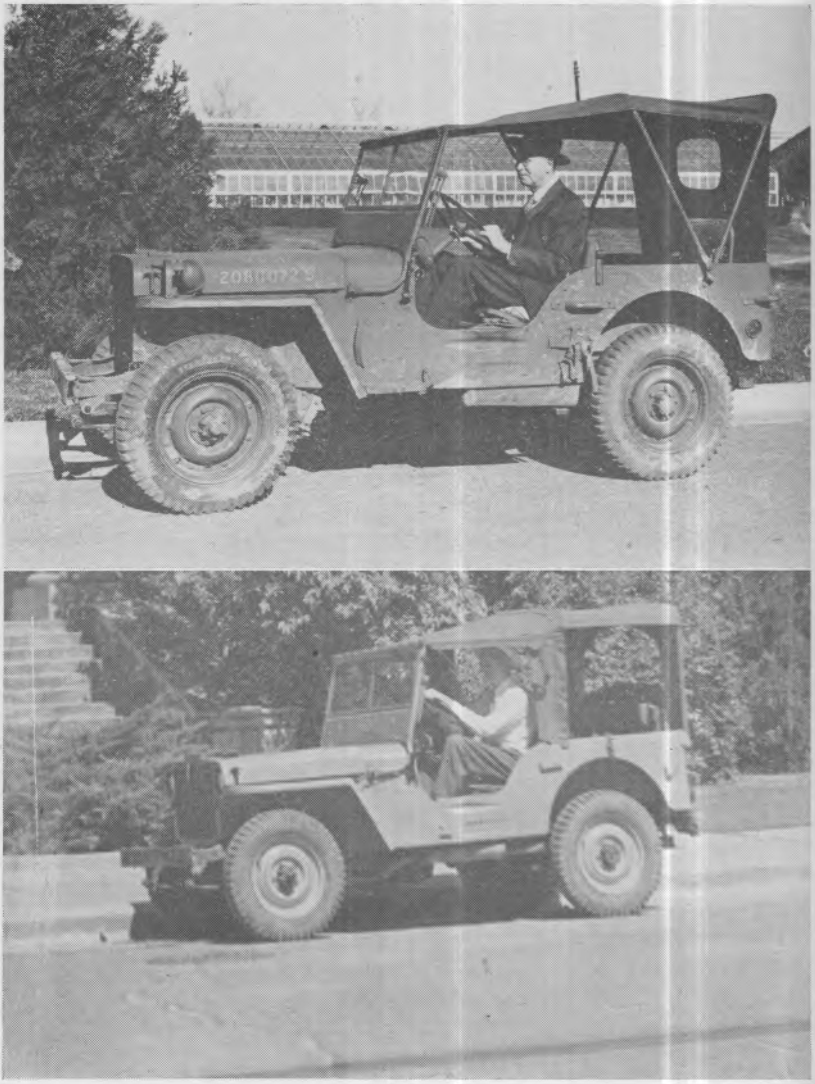

Fig. 1. Top—The military jeep at the time of delivery to the Texas Agricultural Experiment Station, December 4, 1944. Bottom—The Universal jeep used in tests by the Texas Agricultural Experiment Station, which was delivered April 5, 1945.

Hundreds of ideas have been suggested as to the possible use of the jeep as a peacetime vehicle in all phases of agriculture. Many of these suggestions are practical, while others are not. The manufacturer, prospective buyers, and others realize that there is a wide range of adaptability to agricultural uses, and that there are certain limitations to the jeep's overall use as a source of power and transportation in relation to agriculture. Consequently, a military jeep and a peacetime Universal jeep were tested during 1945 to determine their adaptability as a source of power and transportation on the farms and ranches in Texas. This bulletin reports the results of these tests.

Both models of jeeps were capable of pulling loads, exerting drawbar pulls of 900 to 1200 pounds under many different field and road conditions. The peacetime jeep, because of gear ratio reductions, could pull heavier loads than the military jeep.

The peacetime Universal jeep, when equipped with spring seat cushions, side curtains and doors, governor, drawbar, power take-off and pulley, is more comfortable and more adaptable to general farming and ranching operations than the military jeep which is not equipped with these accessories.

The jeep is adaptable for pulling light-draft broadcast tools such as harrows, land rollers, rotary hoes, grain drills, hay rakes and other similar implements.

The jeep is not adaptable as a source of power for pulling row-crop implements such as planters and cultivators.

For general field work the jeep does not compare favorably with the tractor as a source of power with respect to maneuverability, fuel consumption and the handling of implements.

As a truck, the jeep provides an excellent source of power for pulling trailers and for hauling produce from farm to market and supplies to the farm, and for odd jobs about the farm, but it does not compare favorably in capacity to the pick-up truck for hauling.

As an automobile, the comforts of the jeep do not compare favorably with those of an automobile.

The jeep, however, is an excellent vehicle for general utility use about the farm and ranch.

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There have been hundreds of ideas suggested as to the possible use of the jeep as a peacetime vehicle in all phases of agriculture. Many of these suggestions are practical, while others are not. The manufacturer, prospective buyers, and others realize that there is a wide range of adaptability to agricultural uses, and there are certain limitations to its overall use as a source of power and transportation in relation to agriculture. The best way to determine the usefulness of the vehicle is to test it under actual operational conditions.

For this reason, the War Food Administration arranged with the Army for the release of a few military jeeps for experimental purposes, one of which was assigned to the Texas Agricultural Experiment Station. This military jeep was overhauled and put in good condition by the Willys-Overland Motors, Inc., and was delivered by them to the Texas Station on December 4, 1944 (Fig. 1—top).

As the military jeep was designed to meet military requirements, and it was known that certain changes would make it more suitable for agricultural operations, the Willys-Overland Motors, Inc., developed the "Universal jeep" styled and equipped with accessories that would aid in making the vehicle more adaptable and serviceable for the farm and ranch (Fig. 1—bottom). One of these new Universal jeeps was delivered to the Texas Agricultural Experiment Station on April 5, 1945.

Therefore, both jeeps were tested as to their adaptability as a source of power and transportation during 1945. This bulletin reports the results of these tests.

Comparative Specifications of the Universal and Military Jeeps

The following specifications were taken from data furnished by the Willys-Overland Motors, Inc.:

General: The chassis for both the military and Universal jeeps is a four-wheel unit of the four-wheel drive type with an 80-inch wheel base and front wheel steering. The track or tread is 48¼ inches from center to center of the tires.

	Universal	Military
Turning radius	Right 18 ft.	Right 18 ft.
Turning radius	Left 18 ft.	Left 18 ft.
Overall length (to rear of body)	122¾ in.	132¼ in.

Overall width	59 in.	62 in.
Overall height—top up	69 in.	69¾ in.
Overall height—top down	52⅝ in.	51¼ in.
Track or tread	48¼ in.	48¼ in.
Road clearance at axles	8⅝ in.	8⅝ in.
Road clearance at vehicle center	9⅜ in.	10–3/32 in.

Performance: The maximum weights, loads and speeds are as follows:

	Universal	Military
Maximum gross vehicle weight	3420 lbs.	3250 lbs.
Maximum pay load	800 lbs.	800 lbs.
Maximum recommended road speed	60 MPH	60 MPH
Maximum trailer weight (highway use)	5500 lbs.	3500 lbs.
Maximum recommended drawbar pull	1200 lbs.	900 lbs.

Frame: Same for both jeeps except for minor details and reinforcements of rear end for Universal jeep. The drawbar on the Universal jeep is extra.

Cross Members: Same for both jeeps.

Shock Absorbers: Same for both jeeps except for mounting and extended length of rear units.

Springs: Same for both jeeps.

Front Axle—Spicer Model—25: Same for both jeeps except gear ratio and steering bell crank.

Rear Axle—Spicer Model—23-2: Same for both jeeps except for gear ratio.

Hypoid Differential: Universal, 5.38 to 1 ratio; Military, 4.88 to 1 ratio.

Propeller Shaft: Same for both jeeps.

Clutch: Capacity of clutch on Universal jeep is 34 percent greater than clutch on military jeep.

Transmission—Warner Model—T-90A: Approximately ⅛ in. wider gear tooth contacts and different gear ratio as follows:

Ratio	Universal	Military
1st	2.798 to 1	2.665 to 1
2nd	1.551 to 1	1.564 to 1
3rd	1.000 to 1	1.000 to 1
Reverse	3.780 to 1	3.554 to 1

Transfer Case: Universal jeep same as military jeep except gear ratio is 1.97. The case has separate control handles, located in the center of driver's compartment, one lever for shifting of low range gear, and one lever for shifting the declutching mechanism for the front wheel drive and is designed so as to prevent low range gearing being utilized when front axle drive is disengaged.

Hand Brake: Universal jeep same as latest model military jeep.

Service Brakes: Both jeeps are equipped with internal expanding hydraulic brakes operating on all four wheels.

Engine: Same for both jeeps, except Universal jeep has different carburetor throttle. Specifications of the engine for Universal jeep are as follows:

Type—gasoline—"L" head
Number of cylinders—4
Bore—3⅛ in.
Stroke—4⅜ in.
Displacement—134.2 cu. in.
Compression ratio—6.48 to 1
Horsepower: SAE rating—15.6
Actual—60 at 4000 R.P.M.

Other Features: Minor changes between the military jeep and the Universal jeep have been made in muffler arrangement, radiator shrouding, steering bell crank, electrical equipment to meet civilian requirements, and instruments, such as, speedometer and gasoline and oil gauges. Lighting equipment has been changed to meet legal requirements of state laws. The Universal jeep is equipped with drop center wheels carrying 6.00x16 four-ply tires.

Optional Accessories and Equipment: A variable speed governor can be obtained having 9 positions of control. A power take-off shaft, and pulley drive are available for operating extra equipment. The shaft turns at 536 R.P.M. in a clockwise direction when viewed from the rear, and delivers to the implement approximately 25 H.P. at a road speed of approximately 4.2 MPH, or 17 H.P. at 2.9 MPH. The 8 in. pulley drive is attached to the power take-off shaft and will furnish 30 H.P. at a belt speed of 3100 feet per minute. Extra weights are provided to maintain good traction of front wheels when pulling heavy loads. These weights can be used on either the Universal or military models.

Table 1. Maximum Road Speeds

Transmission in	Transfer case in			
	High range		Low range	
	Universal	Military	Universal	Military
High	60	65	24	33
Intermediate	38	41	16	21
Low	21	24	9	12
Reverse	16	18	6	9

Capacities of Various Units: The capacities of the fuel tank, engine

crank case, radiator and various other units for the Universal and military jeeps are as follows:

	Universal	Military
Fuel tank (gallons)	10.50	15.00
Engine crank case refill (quarts)	4.00	4.00
Cooling system (quarts)	11.00	11.00
Transmission (pints)	1.50	1.50
Transfer case (pints)	3.00	3.00
Front axle differential (pints)	2.50	2.50
Rear axle differential (pints)	2.50	2.50
Front axle steering knuckle bearings (pounds)	.50	.50
Oil bath air cleaner (pints)	1.25	1.25
Brake system brake fluid (pints)	.75	.75

Suggested Uses for the Jeep on Farms and Ranches

Many uses for the jeep have been suggested such as follows:

1. Manure spreading
2. Plowing
3. Harrowing with disk, spring and spike tooth harrows
4. Land rolling
5. Seeding—drill and broadcast
6. Cultivating—rotary hoe
7. Plant thinning—cotton and beets
8. Spraying
9. Harvesting—binders, grain and row, combines
10. Transfer of implements, barn to field and field to field
11. Pulling trailers
12. Wire stretching
13. Inspection and repair of fences
14. Feed hauling
15. Water hauling
16. Milk delivery (bulk)
17. Pumping
18. Operating of small portable saw mill
19. Grinding
20. Operation of thresher
21. Operation of corn cutter
22. Filling silos
23. Pulling stone boat or sled
24. Fire fighting—community or forestry
25. Inspection of livestock on range
26. Removal of sick or dead livestock
27. Logging
28. Transporting of labor
29. Brush clearing
30. General utility vehicle

Gear Ratios

The military jeep was designed to give adequate speeds and maneuverability for military purposes with no thought of the vehicle later being used as a source of power for the farm. Consequently, the gear ratios are such that slow rates of travel necessary to operate some farm tools cannot be obtained without throttling down the engine. When this is done, engine horse power is reduced to a point that the tool cannot always be operated efficiently.

In developing the Universal jeep different gear ratios were used to give more power at slower rates of travel. In the transmission, wider gears, improved lubrication and larger bearings were included in the improvements. The transmission has three forward gear ratios with 1 to 1 in high, 1.55 to 1 in intermediate, and 2.8 to 1 in low gear. The gear reduction was increased somewhat to arrive at a lower road speed for the same engine speed.

For the same reason, the transfer case ratio reduction was increased almost 25 percent and is 2.43 to 1.

The last units in the power transmission are the axles. Similar to the increase in reduction in the transmission and transfer case, the axle ratio was changed from 4.88 to 5.38.

The road speeds obtained with these ratio and maximum engine speeds are shown in Table 1.

Power Take-off and Vehicle Speeds

To satisfactorily operate many machines, the operator should know the speed of the power take-off shaft or the belt pulley as well as the vehicle ground speed. A great variety of speeds are made available by the manual governor control, the gear ratios in the transmission and transfer case and by interchanging the gears in the power take-off housing.

Tables 2 and 3 indicate the speeds for each of the nine positions of the manual governor control. Note that the shaft speeds are all computed with the vehicle in four wheel drive, and that of the belt pulley in the transmission drive only. Reference to these tables will be of material assistance in the operation of much equipment especially the farm combine or grain separator.

Table 2. Power Take-off Shaft Speeds (R.P.M.) and Vehicle Ground Speeds (M.P.H.) Power Take-off Gear Ratios

Governor Control Positions	Transfer In	20–24 RATIO						24–20 RATIO						Engine Speed
		Transmission Gear In						Transmission Gear In						
		Low		Inter.		High		Low		Inter.		High		
		Take-off Shaft R.P.M.	Vehicle Speed M.P.H.	Take-off Shaft R.P.M.	Vehicle Speed M.P.H.	Take-off Shaft R.P.M.	Vehicle Speed M.P.H.	Take-off Shaft R.P.M.	Vehicle Speed M.P.H.	Take-off Shaft R.P.M.	Vehicle Speed M.P.H.	Take-off Shaft R.P.M.	Vehicle Speed M.P.H.	
1	Low	298	2.22	537	4.01	833	6.22	428	2.22	773	4.01	1200	6.22	1000
	High	298	5.40	537	9.75	833	15.13	428	5.40	773	9.75	1200	15.13	
2	Low	357	2.67	644	4.81	1000	7.47	514	2.67	928	4.81	1440	7.47	1200
	High	357	6.48	644	11.71	1000	18.15	514	6.48	928	11.71	1440	18.15	
3	Low	417	3.11	752	5.62	1166	8.72	600	3.11	1083	5.62	1680	8.72	1400
	High	417	7.56	752	13.66	1166	21.17	600	7.56	1083	13.66	1680	21.17	
4	Low	476	3.56	859	6.42	1333	9.96	685	3.56	1237	6.42	1920	9.96	1600
	High	476	8.65	859	15.61	1333	24.20	685	8.65	1237	15.61	1920	24.20	
5	Low	536	4.00	967	7.22	1500	12.08	771	4.00	1392	7.22	2160	12.08	1800
	High	536	9.73	967	17.56	1500	27.22	771	9.73	1392	17.56	2160	27.22	
6	Low	595	4.44	1074	8.02	1666	12.45	857	4.44	1547	8.02	2400	12.45	2000
	High	595	10.81	1074	19.51	1666	30.25	857	10.81	1547	19.51	2400	30.25	
7	Low	655	4.89	1182	8.83	1833	13.70	942	4.89	1702	8.83	2640	13.70	2200
	High	655	11.89	1182	21.46	1833	33.27	942	11.89	1702	21.46	2640	33.27	
8	Low	714	5.34	1289	9.63	2000	14.94	1028	5.34	1856	9.63	2880	14.94	2400
	High	714	12.97	1289	23.41	2000	36.31	1028	12.97	1856	23.41	2880	36.31	
9	Low	774	5.78	1396	10.43	2166	16.19	1114	5.78	2011	10.43	3120	16.19	2600
	High	774	14.05	1396	25.36	2166	39.33	1114	14.05	2011	25.36	3120	39.33	

Table 3. Pulley Speeds (R. P. M.)—8-in. Pulley. Power Take-off Gear Ratios

Governor Control Positions	20—24 Transmission Gear in			24—20 Transmission Gear in			Engine Speeds
	Low	Inter.	High	Low	Inter.	High	
1	255	460	714	367	663	1028	1000
2	306	552	857	440	795	1234	1200
3	357	645	1000	514	928	1440	1400
4	408	737	1143	587	1061	1645	1600
5	459	829	1285	660	1193	1851	1800
6	510	921	1428	734	1326	2057	2000
7	561	1013	1571	807	1458	2262	2200
8	612	1105	1714	881	1591	2468	2400
9	663	1197	1857	954	1723	2674	2600

Governor

From the discussion under gear ratios, power take-off and vehicle speeds it is seen that the governor plays an important role, as indicated in Tables 2, 3 and 4. The governor has nine positions of control. By setting the governor and the throttle most any desired engine speed may be obtained. Generally the governor is used only for field and belt work, where uniform performance is needed, but if desired it can also be used for limiting the speed on the highway.

The military jeep was not equipped with a governor and all controls were manipulated manually. This requires close attention on the part of the operator.

Table 4. Effect of Governor on Speed of Universal Jeep in Low Transmission and Transfer Cases

Governor control position	Engine speed (R. P. M.)	Vehicle speed (M. P. H.)
1	1000	2.2
2	1200	2.6
3	1400	3.1
4	1600	3.3
5	1800	4.0
6	2000	4.4
7	2200	4.8
8	2400	5.2
9	2600	5.7

Clearance

Road clearance at the axles is 8⅝ inches for both the military and Universal jeeps. At the center of the vehicle the road clearance for the military jeep is 10-3/32 inches and 9⅜ inches for the Universal jeep.

For the average farm and ranch operations these clearances appear to

be adequate. In all the operations performed with each of these vehicles no trouble was encountered from lack of clearance.

Hitch

When the military jeep was delivered it was equipped with standard military bumpers and trailer hitch. This type of hitch could not be used with typical farm pin and ball trailer hitches. The vehicle was not equipped with a drawbar so that farm tools, such as plows, harrows and the like, could be attached. Therefore, the regular rear bumpers, bracket for auxiliary gas tank, and military trailer hitch were removed and a drawbar 28 inches in length and 15 inches from the ground was placed on the jeep as shown in Fig. 2. A trailer hitch for use of a pin or ball such as used on the average farm was substituted for the military type hitch. This hitch was 22 inches above the ground as shown in Fig. 2.

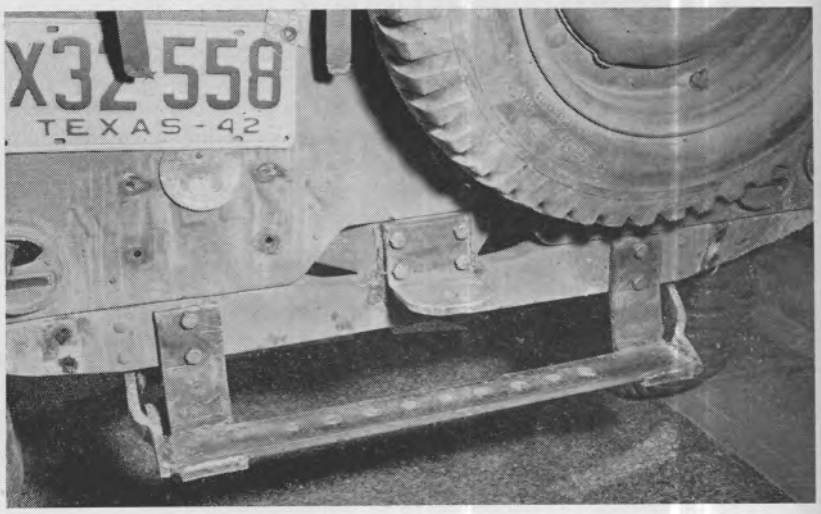

Fig. 2. Drawbar and trailer hitches mounted on military jeep. Either a ball or pin can be used with the trailer hitch.

Later it was found that for some tools the drawbar should extend the full width of the vehicle.

Smith and Trenary[1] found that when heavy loads were hooked to the regular trailer hitch, 22 inches in height, the weight on the front wheels was decreased as the load was increased.

The lower drawbar hitch and weight on the front bumper of the Universal jeep enables the front wheels to have good traction. The weights and low drawbar can be used on the military jeep.

1L. J. Smith and O. J. Trenary, The Jeep as a Farm Truck-Tractor for the Post War Period, Washington Agricultural Experiment Station, Bulletin 455, May 1944.

A two-row tractor type stalk cutter was hitched to the military jeep as far to one end of the drawbar as possible so that the jeep could be made to straddle one row of stalks and at the same time shift the stalk cutter to the side far enough so that two rows of stalks could be cut. With the 28-inch drawbar the jeep could not be driven centered over the row but had to be driven to one side (Fig. 3—left). When pulling a four-row stalk cutter the jeep had to be driven with the wheels on each side running on a row of stalks or stubble (Fig. 3—right).

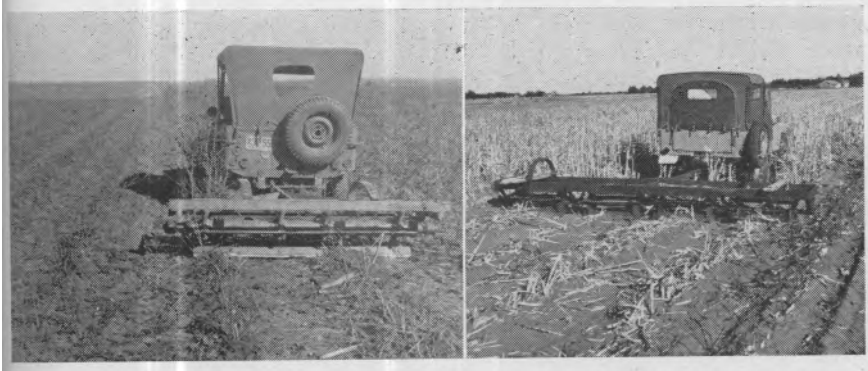

Fig. 3. Left—Military jeep pulling a two-row tractor type stalk cutter cutting cotton stalks. The cutter is hitched to the left end of the drawbar and the left wheels of the jeep are almost running on the row of stalks. Right—The Universal jeep pulling a four-row homemade stalk cutter cutting sorghum stubble. The cutter is hitched to the center of the drawbar of the jeep, thus making it necessary to drive with the wheels running directly on the two center rows.

A longer drawbar would also be useful in towing implements over the highway as the jeep then could be hitched so that it would not extend out into the highway more than the implement.

Heavy loads hitched to the extreme side would cause excessive side draft.

Field Maneuverability

The usefulness of any source of power for the operation of field implements depends to a large extent on its maneuverability. The turning radius of both jeep models with no load on pavement or firm ground is 18 feet. If the ground is soft, such as plowed ground, the turning radius is affected and the radius is increased. The effect will be less if the vehicle is in four-wheel drive.

Even the minimum turning radius of 18 feet or a circle 36 feet in diameter creates a handicap when handling row-crop machinery. A wide headland is required to permit the trailing implement to clear the end of the row, then swing around and become lined up with the rows for the next trip across the field. Under ordinary cropping conditions the headlands at the ends of the rows are not wide enough for such turning and, as a consequence, several feet of crop row may be damaged at each end.

The auto steering does not permit quick enough turns for maneuvering machines such as binders to maintain square corners in the harvesting operation.

When plowing an irregular shaped field and using a jeep for power, it is necessary at each corner to continue straight ahead until the plow reaches the corner, then steer the jeep sharply to the left for several feet, then swing back to the right, pass the corner, then continue steering to the right to bring the plow in line with the furrow. Such a maneuver would require making a complete circle of several feet over the plowed ground which would be well packed after a few turns over it. Therefore, when plowing and using a jeep for power it would be best to plow by lands and do the turning at the ends across the headland.

On the other hand, when a jeep is used to pull a disk harrow, spike tooth or spring tooth harrow where overlapping or even turning is not required, the jeep can maneuver the turns satisfactorily.

Cooling System of Jeep

The capacity of the cooling system of the jeep is 11 quarts, or 1 quart less than 3 gallons. Under ordinary road driving, light loads and summer weather conditions of Texas the engine will operate at approximately 175 to 180 degrees F. However, it was found that when the atmospheric temperature rose to 90 to 95 degrees F. or higher, and loads above 600 pounds drawbar pull were used, the temperature of the engine ranged higher than 180 degrees F. If capacity loads were pulled the engine overheated. The military jeep is equipped with a four-blade fan and the radiator is not shrouded and, as a consequence, the engine of this jeep had a tendency to run hotter than the Universal jeep which is equipped with a six-blade fan and the radiator is shrouded. Trash collecting on the screen in front of the radiator will reduce air flow through the radiator and affect the cooling of the engine.

When doing stationary belt work, such as operating a feed mill or silage cutter, the temperature of the engine can be held down 6 to 8 degrees by raising the hood.

Fuel Consumption

From December 4, 1944, to December 31, 1945, the military jeep was driven a total of 6,257 miles for all operations performed in the field, on ranches, as a general utility vehicle about the farm and over the highway.

From April 7 to December 31, 1945, the Universal jeep was driven a total of 11,707 miles for all operations.

As the Universal jeep was more comfortable than the military jeep it was used as a general utility vehicle more than the military jeep.

Records were kept of the fuel consumption of both the Universal and military jeeps involving a total of over 4,000 miles over paved roads with no load.

At speeds of 20 to 30 miles per hour both jeeps averaged 20 miles per gallon of fuel, (Table 5). As the speed was increased the fuel consumption

Table 5. Fuel Consumption Over Highway—No Load

Kind of surface	Number of trips	Wheel drive	Engine temperature	Average miles per hour	Total miles traveled	Total fuel used (gallons)	Average miles per gallon
Universal Jeep							
Pavement	4	2	175	20–30	228	11.35	20.1
Pavement	8	2	170	30–40	732	38.25	19.1
Pavement	11	2	170	40–50	2696	151.50	17.8
Dirt (dry)	3	2	175	30–40	222	14.50	15.3
Mud	2	2	175	20–30	138	10.80	12.4
Military Jeep							
Pavement	1	2	170	20	20	1.00	20.0
Pavement	3	2	175	30–40	250	14.10	17.7
Pavement	1	2	175	40–50	453	27.00	16.8
Mud	1	2	175	15–35	36	2.50	14.4

increased. At high speeds of 40 to 50 miles per hour the Universal jeep averaged 17.8 miles per gallon of fuel while the military jeep averaged 16.8 miles per gallon. At normal speeds of 30 to 40 miles per hour the average per gallon was 19.1 miles for the Universal jeep and 17.7 miles for the military jeep.

On dry dirt roads the Universal jeep averaged 15.3 miles per gallon of fuel at speeds of 30 to 40 miles per hour.

When driving over very muddy roads only 12.4 miles was obtained for each gallon of fuel consumed by the Universal jeep and 14.4 miles per gallon by the military jeep. The military jeep consumed slightly more fuel at the various speeds on pavement but less fuel in mud. The trip in mud with the military jeep was partly over roads that had stretches of firm roadbed. This, of course, would not require as much fuel.

Table 6 shows the average fuel consumption in miles per gallon when the jeeps were used to pull trailer loads ranging from 1,250 to 9,727 pounds over paved roads. With the recommended trailer load of approximately 4,000 pounds at speeds of 35 to 40 miles per hour, the Universal jeep traveled an average of 14.5 miles per gallon of fuel. Increasing the load correspondingly increased the fuel consumption.

Table 7 shows the average fuel used for various field operations. Where a 7-foot rotary hoe was operated with the Universal jeep, the fuel used was only .13 of a gallon per acre as compared to .45 of a gallon per acre where a 6-foot tandem disk harrow was operated. Where a one-row cotton chopper was pulled at a relatively slow speed .93 of a gallon per acre was used. Table 7 also shows the fuel consumption of the military jeep for similar field operations.

Hardy[2] states that "the fuel economy of the jeep as a tractor is low

[2]E. A. Hardy, Test of the Jeep as a Farm Tractor, mimeograph report, University of Saskatchewan, 1945.

Table 6. Fuel Consumption Over Highway With Load

Kind of surface	Number of trips	Wheel drive	Engine temperature	Average miles per hour	Total load pulled (pounds)	Miles traveled per trip	Total fuel used (gallons)	Average miles per gallon
Universal Jeep								
Pavement	1	2	180	30–35	3820	296	24.0	12.3*
Pavement	1	2	180–190	35–40	4625	305	21.0	14.5
Pavement	4	2	175–185	25–30	6000	22†	1.4	7.9
Pavement	1	2	185–195	22	9727	11	1.5	7.3
Pavement	1	2	175	30–45	1500	373	22.0	17.0
Pavement and field	4	2	185	25–30	6000	7	.9	7.8
Military Jeep								
Pavement	1	2	170–180	20–35	1250	300	21.0	14.3
Pavement	1	2	180–190	20–35	1500	297	21.0	14.1
Pavement	1	2	175	20–35	1500	74	5.0	14.8
Pavement	1	2	190	20	5000	11	1.5	14.7
Pavement	1	4	190	15–20	9000	11	1.6	13.8

*Driving into headwind of 30-35 miles per hour.
†One-half of round trip of 22 miles made pulling empty trailer weighing 1500 lbs. at 30 to 35 miles per hour.

Table 7. Fuel Consumption in Field Work

Kind of work	Type and size of tool	Acres covered per hr.	No. of hours operated	Miles traveled	Rate of travel (M.P.H.)	Type of soil	Drawbar pull	Axle drive	Engine temperature	Fuel used (gallons)	Gals. per acre
Universal Jeep											
Disking	6′ tandem harrow	3.3	1.50	6.6	2½–3	sandy loam	1150	4	185	2.25	.45
Disking	6′ tandem harrow	2.5	6.00	25.7	2½–3	sandy loam	1150	4	190–200	6.60	.44
Rotary hoeing	two-row	7.5	.67	6.5	10	sandy loam	425	4	180	.63	.13
Harrowing	two-section	2.5	2.00	6.0	3	sandy loam	350	4	170	.75	.15
Chopping cotton	one-row	1.2	3.00	10.0	3–4	sandy loam		4	170	3.25	.93
Seeding	18-hole grain drill	3.3	5.00	16.0	3–4	sandy loam	625	4	170	6.25	.38
Plowing	two 14-in. bottoms		.10		2½	sandy loam	1400	4	180		
Baling hay	Pick-up	4.0	1.00	3.6	3	clay		4	180	1.00	.25
Military Jeep											
Land rolling	8-foot	2.7	.75	3.5	3–5	clay		4	175		
Stalk cutting	2-row	3.3	3.00	13.0	3–5	clay		4	170–180		
Disking	single	3.3	.60	2.5	3–4	clay	425	4	170		
Harrowing	spike two-section	2.0	1.00	4.0	3–4	sandy loam	425	4	170	.55	.28
Harrowing	weighted spike two-section	2.0	1.20	3.5	3–4	sandy loam	625	4	180–200	.59	.30
Seeding	grain drill	4.0	.25	1.0	3–4	clay	400	4	175	.26	.26

Table 8. Fuel Consumption in Belt Work for Universal Jeep

Kind of work	Hours operated	Engine temperature	Pulley speed (R. P. M.)	Fuel used (gallons)	Fuel used per hour (gallons)
Extracting cotton	4.00	165	700	2.25	.56
Filling silo	2.50	180–190	1300	2.25	.90
Feed grinding	1.25	180–190	1600	4.00	3.20

compared to the small tractors. The average economy for the light small tractor is 2.29 cents per horsepower hour and that for the jeep is 4.2 cents per horsepower hour, or 1.75 times that of the average small tractor."

Table 8 shows the fuel consumption of the Universal jeep when used in belt work such as operating a silage cutter and feed grinder. These data show that the fuel consumed varies with the RPM of the pulley and, of course, the RPM of the engine.

Octane Rating of gasoline used: In all tests with the jeeps regular gasoline was used. The specifications obtained from the manufacturer were CFRSTM 70 octane.

The Jeep as a Tractor

The Universal and military jeeps were both used as a tractor to perform field operations such as, disking, harrowing, seeding, rotary hoeing, chopping cotton, baling hay and pulling of loaded trailers.

Disking: The Universal jeep was used to pull a 7-foot 28-disk, tractor tandem disk harrow in disking approximately 20 acres of sandy loam soil. The field had been flat broken and disk harrowed previously, but a light rain had occurred since the last disking. Therefore, the soil was rather loose and fairly dry. Under these conditions the gangs could only be slightly angled to prevent overloading the jeep. The ground was quite rough, which caused the vehicle to pitch; this in turn affected the functioning of the governor; this caused the engine to surge as in the case of a tractor operating over rough ground where the load is not uniform. The drawbar pull was 1,150 pounds (Table 7) even with the gangs slightly angled. Therefore, the jeep was overloaded by 250 pounds. On the day the temperature was 79 degrees and the temperature of the jeep engine ranged at times up to 190 degrees. On the day the temperature reached 90 degrees a strong breeze was blowing, yet the engine temperature at times went above 200 degrees. After the ignition was cut off the engine would continue to fire for a few seconds. The governor was at maximum speed, or the 9th notch, and the throttle almost to maximum. Therefore, the engine was operating at a high speed.

When operating over soft ground at maximum loads it was evident that there was considerable wheel slippage. A test was made to determine

Fig. 4. The military jeep pulling a slightly angled tandem disk harrow.

the influence of high and low air pressure in distance traveled. With 32 pounds air pressure in the tires 16 trips were made, or 3.75 miles was traveled, in the field in 40 minutes. With 20 pounds pressure 18 trips were made, or 4.25 miles traveled, in 35 minutes. The setting of the governor throttle and disk harrow were the same for both tests. This is in line with factory recommendations that for field work the air pressure of the tires be reduced to 18 to 20 pounds.

The military jeep could pull a slightly angled 5-foot tractor tandem disk harrow (Fig. 4) only a short while before the engine became over-

Fig. 5. The military (top) and Universal (bottom) jeeps pulling a two-section spike tooth harrow.

heated. It could, however, pull a single two-gang disk harrow under normal conditions.

With either jeep pulling disk harrows the operating performance did not compare favorably with that of a tractor.

Harrowing: (Spike and spring tooth). Fig. 5 shows both the Universal and military jeeps pulling a two-section spike tooth harrow. The average drawbar pull of a two-section spike tooth harrow over freshly plowed soil was 325 to 350 pounds. If the harrow were weighted with some 200 pounds the pull ranged around 625 pounds. The Universal jeep could pull a two-section harrow satisfactorily, but the military jeep's engine overheated when pulling a weighted harrow.

When using a spring tooth harrow only two sections could be pulled by either jeep.

Fig. 6. The Universal jeep hitched to a plow equipped with two 14-inch general purpose plow bottoms. The drawbar pull was 1400 pounds which was an overload for the jeep.

Plowing: Factory representatives state that the Universal jeep has sufficient power to pull two 12-inch moldboard plow bottoms. Such a plow was not available for tests at the Texas Station but to get some idea of the maneuverability, hitching and general operation, the jeep was hitched to a tractor plow equipped with two 14-inch general purpose bottoms (Fig. 6). The land was quite weedy and the soil a little too dry for good plowing condition.

Under these conditions the drawbar pull was approximately 1,400 pounds, which was considerably more than the recommended maximum pull of 1,200 pounds. Because the jeep was overloaded only a few rounds were made.

It was found that the "land" wheels of the jeep slipped excessively on the green succulent vegetation. The maneuverability was poor on irregular shaped areas. The jeep operator could not reach the plow levers to adjust the plow from the jeep seat. Long plow levers interfered with turning. The draft of the plow out of the ground was enough to prevent the jeep's turning within the minimum turning radius of 18 feet over plowed ground.

When plowing is done with a small plow, under favorable soil type and moisture conditions and in lands where turns can be made across headlands many of the above difficulties would be eliminated.

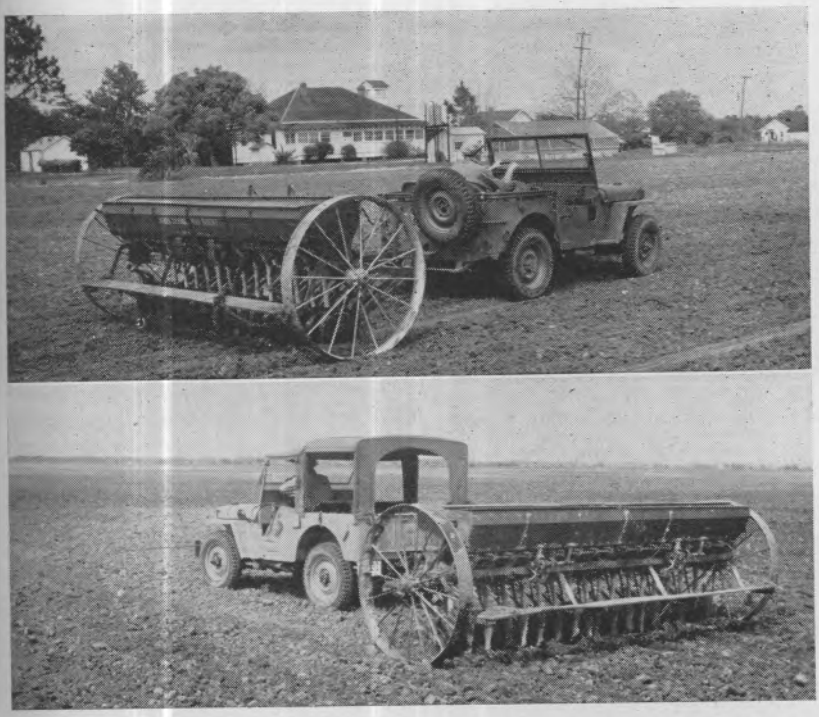

Fig. 7. Jeeps pulling rice drills. Top—The military jeep pulling a 16-7 fertilizer drill. Bottom—The Universal jeep pulling an 18-7 fertilizer drill.

Seeding With Grain Drill: The Universal jeep was used to pull an 18-7 fertilizer rice drill to seed 16.5 acres of rice on the farm of H. M. Cole near Beaumont, April 11, 1945 (Fig. 7). The sandy soil had been plowed, disk harrowed and freshly harrowed with a spring tooth harrow. The drawbar pull of the drill with seed and fertilizer hoppers full was 625 pounds (Table 7). The jeep pulled the drill under these conditions at some 3 to 4 miles per hour with a normal engine temperature of 170 degrees.

When drilling over the freshly harrowed soil without a plank drag attached to the drill it was difficult to distinguish the wheel track of the drill so that the drilled areas would not be overlapped or undrilled areas be left.

The military jeep was not used to pull the 18-7 fertilizer rice drill as it had previously been tried for pulling a 16-7 fertilizer rice drill (Fig. 7). It had also been determined that the engine would overheat when pulling a drawbar pull of 625 pounds in loose freshly harrowed soil.

In seeding rice it is common practice to attach a plank drag (3 or 4 planks wide) behind the drill to compact the soil about the seed. The drag

Fig. 8. The military jeep pulling a solid concrete roller weighing approximately 6,000 pounds over fairly firm soil. The drawbar pull was 750 pounds. On soft freshly disked land the pull will be much more.

could not be used when the jeep was used to pull the drill. In seeding oats, wheat and other small grains such a drag is not generally used. As the drag could not be pulled in combination with the drill the drag was pulled over the field by a tractor.

Land rolling: The military jeep was used to pull a double gang soil pulverizer weighing approximately 1,000 pounds over about two acres of bedded land. As the roller sections turned freely the draft of the machine was low and it could be pulled easily with the jeep. On bedded or ridged land, the ridges spaced 38 to 42 inches apart caused the wheels to "ride" up on the sides of the ridges as the

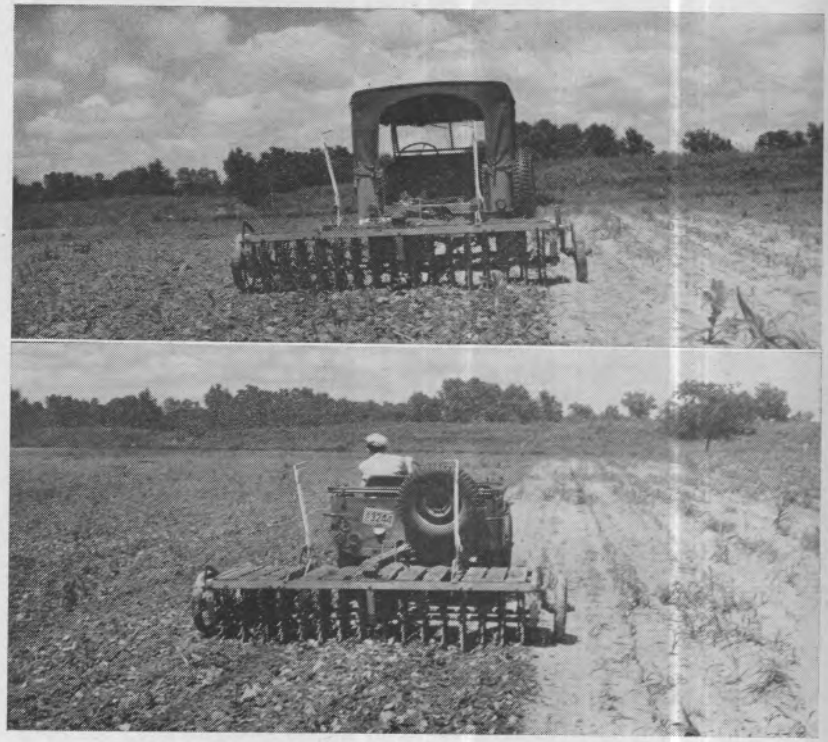

Fig. 9. The Universal (top) and military (bottom) jeeps pulling a rotary hoe to cultivate young corn. At speeds of 10 miles per hour the drawbar pull was 400 to 500 pounds.

distance between the wheels of the jeep is 48¼ inches. Trouble of this type would not be encountered when operating on flat land.

Fig. 8 shows a solid concrete homemade land roller weighing approximately 6,000 pounds being pulled over fairly firm soil with the military jeep. Under these conditions the drawbar pull was 750 pounds. When used over freshly harrowed soil the pull would no doubt be more and this type of roller would be too heavy to be pulled with a jeep.

Rotary hoe: Fig. 9 shows the Universal and military jeeps pulling a 7-foot rotary hoe over young corn. The rotary hoe was also pulled over several acres of young cotton two different times between emergence of seedlings and thinning with good results. When used on the young corn the hoe was pulled at about 10 miles per hour with a drawbar pull between 400 and 500 pounds.

In using the jeeps to pull the rotary hoe over crops where the rows were spaced 36 to 40 inches apart the wheels came within a few inches of the rows on each side of the vehicle. Therefore, it was necessary to drive carefully to prevent driving over a row of plants.

Mechanical chopping of cotton: Fig. 10 shows the Universal jeep pulling a one-row mechanical cotton chopper. The jeep could have pulled a two-row chopper with ease. The only trouble would be the track or width of the jeep not fitting the row spacing, and that of keeping the chopper on the row all the way to the end, and getting the chopper lined up with the rows for the return trip.

Fig. 10. The Universal jeep pulling a single-row cotton chopper. It could easily pull a four-row chopper.

Baling hay: The Universal jeep is shown pulling a small two-man pick-up hay baler in Fig. 11. The

Fig. 11. The Universal jeep pulling a small pick-up hay baler. A total of 100 bales of hay were baled in one hour.

jeep was used to pull this baler for about one hour during which time about 100 bales of hay were baled. The pulling of the hay press was a very light load, but there was considerable weight of the baler carried on the rear end of the jeep. The windrows were somewhat crooked and extra care had to be exercised in driving the jeep to keep the pick-up reel in line with the windrow.

Raking hay: The military jeep was used to pull a side delivery hay rake for about one hour. In the beginning, the rake was pulled with the transmission in first gear and the transfer case in low range. After about 15 minutes, the transmission was shifted into second gear, the transfer case remaining in low range, and the vehicle was driven at a speed of about 15 miles per hour. The temperature of the engine ranged from 190 to 200 degrees depending on whether the travel was toward or with the wind.

Stalk cutting: Fig. 3—left shows the military jeep pulling a two-row tractor type stalk cutter cutting cotton stalks, and Fig. 3—right shows the Universal jeep pulling a four-row homemade cutter over sorghum stubble. The jeeps had ample power to pull either the two- or four-row stalk cutters in fields dry enough that soil would not stick to the cutter blade. The cutters could be pulled at desirable speeds.

The average tricycle or general purpose row-crop tractor straddles two rows with the rear wheels, while the front wheel is in the middle between the rows. With this arrangement two- and four-row stalk cutters can be hitched to the center of the power and the cutters will be in correct position to cut the rows of stalks. As the jeep straddles only one row with the wheels in the middles on each side it is necessary to hitch the cutters as far to the side as possible on the jeep drawbar as explained above under hitches.

Even though there is a screen in front of the radiator to prevent trash collecting on the radiator grill trash will collect on the screen to such an extent that the cooling of the engine is affected. Consequently, when operating under such conditions frequent inspections of the screen are necessary.

Pulling trailers: Both the Universal and military jeeps were used to pull trailers in the field in connection with the harvesting of cotton, grain sorghum, rice, corn and hay. They were also used to pull trailers loaded with fuel oil and other supplies needed in servicing other farm equipment.

Fig. 12, bottom, shows the jeeps pulling four-wheel trailers in the field to handle grain from combines harvesting grain sorghum. The jeeps could easily pull loads of 6,000 pounds in dry fields. In harvesting corn, cotton and hay the jeeps did a satisfactory job of pulling two- and four-wheel trailers in the field and from the field to the barn or to the gin (Fig. 13).

When pulling loads over row crop land where there are ridges it is best to travel parallel or at an oblique angle to the ridges rather than straight across or at a right angle to the ridges, because in the latter case the 120-inch wheel base of the jeep makes the front and rear wheels drop in the depressions between the ridges or rise over the ridges at the same time. Such a condition makes rough riding and gives intermittent heavy and light pulling, causing severe jerking of the load.

The jeep can handle fairly heavy loaded trailers on land where small grain has been sowed with a grain drill and on hay land.

To pull rice carts from the combine to trucks parked on roadways it is necessary that the field be dry enough to be firm, and that soft areas be avoided (Fig. 14).

Moving equipment: The jeep is an excellent source of power for transferring or shifting equipment from barn to field, or vice versa, and from

Fig. 12. Jeeps pulling trailers. Top—The Universal jeep (in front) pulling a four-wheel trailer loaded with a knocked-down grain dryer, and the military jeep pulling a two-wheel trailer loaded with miscellaneous equipment. Bottom—Both jeeps pulling four-wheel trailers loaded with milo from the field.

Fig. 13. Jeeps are excellent sources of power for pulling two-wheel trailers.

one field location to another. Plows, grain drills, hay tools, pull type corn pickers and other pull type equipment can be moved rapidly from place to place with the jeep.

For example, the jeep was used to pull a two-row pull type corn picker from the College campus over the highway, across a one-way river bridge and into the field, a distance of approximately 10 miles in a much shorter time than it could have been done with a tractor.

Belt work: Fig. 15 shows the Universal jeep operating an ensilage cutter and a feed grinder.

The jeep was used on August 1 to operate a medium sized ensilage cutter. During 2½ hours of operation, approximately 10 tons of silage were cut and blown about 35 feet high into a silo. The governor was in

Fig. 14. Universal jeep used to pull rice cart (top) and trailer (bottom) to handle grain from combines in the field.

5th position and the throttle in 2nd position. At this setting the RPM of the 8-inch pulley ranged between 1270 and 1300.

The speed of the ensilage cutter ranged between 640 and 650 RPM. The maximum air temperature on August 1 was 100 degrees F. In operating between 2:00 and 3:00 o'clock in the afternoon, the temperature of the jeep engine went up to 190 degrees. When the hood over the engine was raised the temperature of the engine dropped to 185 degrees. Other than the heating of the engine no trouble was encountered in operating the ensilage cutter.

On November 7 the jeep was used to operate a roughage feed mill and grinder. The governor was set in 9th position and the throttle in 4th position. The RPM of the jeep pulley was approximately 1,500. The air temperature was 70 degrees. Under these conditions the engine heated to 185 degrees with the hood down and 180 degrees with the hood up. About ½ ton of dry alfalfa hay was chopped in 47 minutes and 1 ton of milo ground in 38 minutes.

The jeep was also used to operate a cotton bur extractor for 4 hours.

Fig. 15. The Universal jeep used for belt work. Top—Jeep furnishing power to operate feed mill to chop dry hay and to grind milo. Bottom—Jeep furnishing power to operate ensilage cutter.

As it was necessary to operate the extractor very slowly, about 150 RPM, the governor was set in 2nd position and the throttle in 3rd position. These settings gave a pulley speed of 800 RPM. At this speed the engine temperature was 150 degrees. Th air temperature was 68 to 70 degrees.

In all operations the transmission was in high gear.

The Jeep as a Truck

The rear springs of the jeep are designed to carry a normal load of 800 pounds with an average of 190 pounds deflection rate per inch at ¼ camber. The body space for carrying of pick-up loads is 40 inches from seat to tail gate. The tail gate provides a 14½ inch extension. The width of the body at the floor is 30 inches. Bench like fenders give an additional width of 10¾ inches on each side or a total inside body width of 51½ inches. These bench fenders may also serve as seats.

The capacity of the pick-up body on the Universal jeep is much less

Fig. 16. The Universal jeep used as a truck to haul a large fan weighing about 725 pounds.

Fig. 17. Top—Universal jeep used to pull trailer load of cotton over highway to gin. Bottom—Universal jeep and tractor at gin with trailer loads of cotton.

than the average ½ ton pick-up truck. Six 10-gallon milk cans can be carried in the 30 by 40 inch pick-up bed of the Universal jeep. If the passenger seat is removed, nine 10-gallon cans can be hauled.

Fig. 16 shows the Universal jeep hauling a large fan weighing 725 pounds. The rear section of the top had to be taken off to permit loading of the fan as it extended above the top as shown in Figure 16.

Even though the jeep does not have the body capacity of the pick-up truck additional loads can be transported easily on trailers pulled by the jeep, both in the field and over the road (Fig. 17).

The Jeep as an Automobile

Due to the short wheel base and stiff springs the riding comfort of the jeep does not compare with that of an automobile or pick-up truck. The spring cushions provided for the seats of the Universal jeep make this model more comfortable than the military jeep.

Several long trips were made ranging from 200 to 500 miles, using the jeep as an automobile. These trips were made in one day with two individuals taking turns at driving, without each being unduly tired at the end of the trip.

The jeep makes a very good vehicle for short trips about the farm or ranch and for making quick trips to town. Fig. 18 shows the jeep being used to check on a crew throwing up levees in rice fields. Fig. 19 shows a farmer and visitors following hay harvesting equipment in the field.

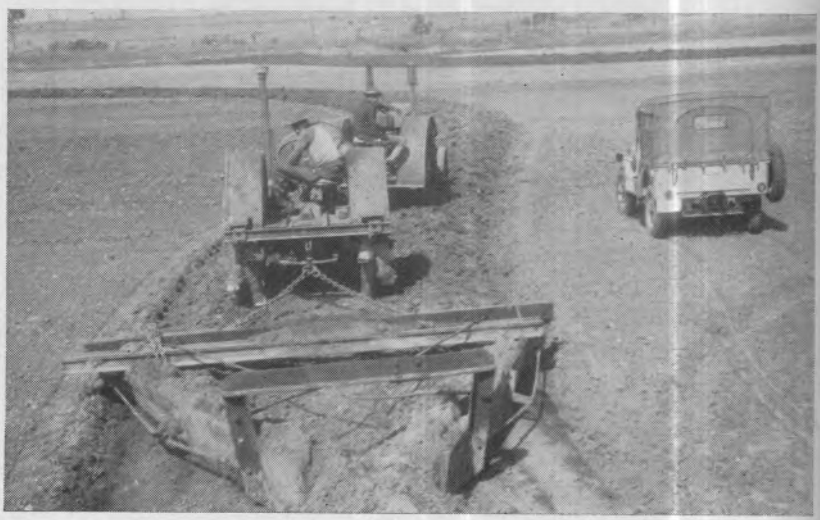

Fig. 18. The Universal jeep makes an excellent means of transportation to check field operations difficult to get to with regular automotive equipment.

The Jeep as a General Utility Vehicle

During the time the jeeps were being tested, both the Universal and military models were used extensively as general utility vehicles about the farm and ranch, much like the average family would use them.

The jeep on the farm: After observing the performance of the jeep in connection with rice farming, R. H. Wyche, superintendent of the Texas Agricultural Experiment Substation at Beaumont, stated, "The jeep would be useful in rice farming as it can get around in places that are too wet for a pick-up truck and will cross levees that cannot be crossed with a truck. It could also be used for trips to town for repairs and supplies. In some cases farmers carry a horse to the field in a trailer pulled by a truck. The jeep can do this and go places where the truck cannot go."

The jeep would also be useful in pulling trailers that are used for hauling fuel and seed to tractors, drills, and harvesting equipment.

The jeep proved to be useful in connection with cotton farming. Several trips were made about cotton fields and plantations when roads were so muddy that no other automotive equipment could get over the roads. Supplies of fuel and seed can be delivered by trailer to tractors and planters and other equipment in the field. At harvest time, many farmers, especially in the northwestern part of Texas, use their trucks, cars, and tractors to pull trailer loads of cotton out of the field and over the highway to the gin (Fig. 17). This could be done easily with a jeep. While harvesting cotton near Lubbock several quick trips for repairs were made to blacksmith shops 3 or 4 miles distance.

Fig. 19. A farmer with visitors using military jeep to inspect hay harvesting equipment.

Generally, farmers who saw the jeep perform about the farm felt that it would be very useful as a general utility vehicle, but visualized the jeep as a substitute for the tractor in farming operations only in an emergency.

The jeep on the ranch: The jeep makes a very good general utility vehicle about the ranch as it can get about over rough terrain, carry

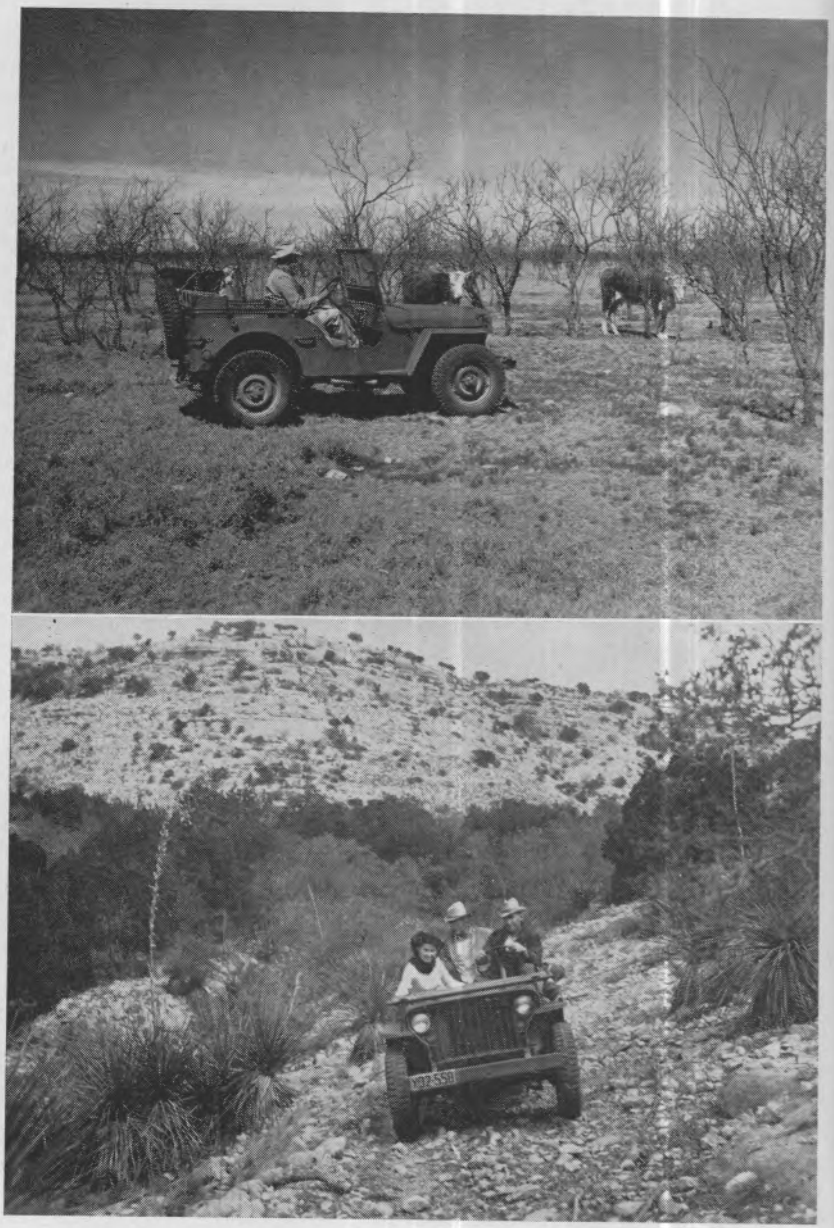

Fig. 20. Top—Military jeep used to inspect cattle on the range several miles from headquarters. Bottom—Ranchmen using jeep to travel over rough trails.

supplies to distant sections of the ranch, pull trailers, and in many cases be used as a substitute for the saddle horse as shown in Fig. 20—top.

On the Texas Agricultural Experiment Substation near Sonora, ranch boundary fences of a section of land were inspected where it was necessary to travel over rock strewn ground covered in places with thick brush in less than an hour. If necessary, a few posts, a spool of barbed wire and essential repair tools could have been carried along in the jeep. At another location, all fences and livestock were inspected in 30 minutes where ordinarily it would have required 2½ to 3 hours on a horse.

In rough country, the jeep was easily driven over a trail that wound among thorny brush, prickly pear, over rocks, down and across gulleys where a ranchman would try driving a truck only once (Fig. 20—bottom). The jeep was driven up a mountain trail that appeared to be used only for downhill travel with caution by local ranchmen.

The jeep was used to pull supply trailers and special horse trailers as shown in Fig. 21.

It was also found that with the top and windshield down the jeep would make an excellent hunting vehicle.

Fig. 21. Military jeep being used to pull horse (top) and supply (bottom) trailers.

Acknowledgments

The author is indebted to W. E. McCune, R. H. Wyche, and W. H. Dameron for their assistance in making these tests.

Thanks are due also to L. C. Hudson, service representative of the Willys-Overland Motors, Inc., for his work in maintaining the jeeps during the tests.

Summary and Conclusions

The data presented in this bulletin give results of tests to determine the adaptability of the jeep as a source of power on the farms and ranches in Texas.

A "Universal" or peacetime model jeep, equipped with power take-off, belt pulley, governor and other accessories, was furnished by the Willys-Overland Motors, Inc.

The War Food Administration arranged with the Army for the release of a "military" model jeep for test purposes.

Where possible both models were tested on the same kind of work.

The Universal model was capable of pulling heavier loads than the military model because the gear ratios for the former were reduced in the transmission, transfer case and axle.

The clearance at the axles of 8⅝ inches was adequate for road, ranch and field work in harvesting broadcast crops but not enough for the late cultivation of cotton, corn and other row crops.

The trailer hitch on the military model was not suitable for use of farm trailers and implements. A drawbar hitch for farm implements had to be constructed and attached to the military jeep.

The hitch and drawbar on the Universal model are adequate for most implements but drawbar extensions must be made when hitching to power take-off equipment.

Maneuverability of the jeep in the field does not compare favorably with the ordinary farm tractor.

When pulling heavy loads the cooling system of both models was not of sufficient capacity to prevent the engine from heating excessively.

Fuel consumption for travel over highways compared favorably with the regular pick-up truck.

Fuel consumption for heavy field work was considered high.

For field work the jeep did not compare favorably with the tractor.

As a truck, the jeep was an excellent source of power for pulling trailer loads of produce from farm to market and supplies to the farm, and for odd jobs about the farm, but it did not compare favorably in capacity with the pick-up truck for hauling.

As an automobile, the comforts of the jeep were not comparable to those of an automobile.

The jeep, however, makes an excellent utility vehicle for doing various chores about the farm and ranch.

Fig. 22. The jeep cannot go everywhere. An attempt was made to cross a drainage ditch on a rice farm. The soft mud in the ditch was too deep and the jeep sank to where the tops of the front wheels were almost covered.