# The Development of Agricultural Equipment Power Take-Off Mechanism

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ABSTRACT

A power take-off mechanism was developed for farm equipment. Its purpose was to transmit power from the tractor engine to the propelled implement. The propelled implement could then perform its functions by utilizing the tractor engine power.

The power take-off (PTO) development has involved a large variety of tractors and implements and has included recommendations and standards for safety, interchangeability, and reliability. This paper outlines some of the important steps in the power take-off evolution from the first known application to present day standards.

The power take-off has provided great versatility in the mechanization of the farm, and this has helped to lower the overall cost of food production.

THIS PAPER REFERS to present SAE Standards and Recommended Practices, and it reviews some early power take-off applications, developments leading to our present standards, some more evaluations to be considered and a summary.

Standards are very important to the agricultural industry to provide safety, interchangeability, and reliability at lower cost to the user. Before power take-off standards were attempted, the optimum drive line speed of tractors and power driven implements varied widely. The vertical and horizontal distances between the tractor drawbar hitch point and the tractor output shaft varied widely among all makes. The size of the output shaft varied and drive line dimensions on implements with respect to the drawbar hitch point also varied considerably.

Because of the lack of standards, the farm equipment industry had to provide an estimated 2500 special hook-up packages to match all makes of tractors with all makes of power driven implements. Customer complications can well be imagined:

(a) in selecting proper hook-up for tractor and implement combinations,

(b) in the added cost of many packages to adapt several different makes of implements to one or more makes of tractors, and

(c) in keeping the many packages properly matched to the various tractors and implements.

During the past 30 years, most tractors and implements have been manufactured according to the standards. There is no need to provide special hook-up packages to match these tractors and implements which are according to the standards.

The present SAE Power Take-Off

SAE/SP-80/470/$02.50

Standards and Recommended Practices for farm equipment are:

1. J1170 - SAE Standard (ASAE S203.9) "Rear Power Take-Off for Agricultural Tractors." (J1170 includes both 540 and 1000 RPM PTO standards, formerly J718 and J719). See Appendix "A".
2. J717 - SAE Recommended Practice (ASAE S333.1) "Auxiliary Power Take-Off Drives for Agricultural Tractors." See Appendix "B".
3. J721 - SAE Recommended Practice (ASAE S207.9) "Operating Requirements for Power Take-Off Drives." See Appendix "C".
4. J722 - SAE Recommended Practice (ASAE S205.2) "Power Take-Off Definitions and Terminology for Agricultural Tractors." See Appendix "D".

The American Society of Agricultural Engineers (ASAE) publishes the above standards and recommended practices in its Yearbook. ASAE also publishes some standards which affect only the implements. Implements are not considered within the scope of the Society of Automotive Engineers standards. These additional ASAE standards are:

1. ASAE S331.2 "Implement Power Take-Off Drive Line Specifications." This standard establishes 6 categories of universal joint drive lines with respect to static and dynamic torsional requirements. These 6 categories include a wide range of implements from low to high power requirements. The drive line to the tractor output shaft is the responsibility of the implement manufacturer.
2. ASAE S314 "Implement Power Take-Off and Drive Line Pedestal Shafts." This standard provides specifications for 1 3/8" and 1 3/4" PTO shafts for uniform driving means, retaining means and drive line positioning.

Since the late 1930's, most of the power take-off standards and recommended practices have been proposed by the Farm and Industrial Equipment Institute (Formerly Farm Equipment Institute) Engineering Committees. When these proposals are acceptable and approved, those affecting tractors and implements are published by ASAE in its Yearbook and those affecting tractors are published by SAE in its Handbook.

(Fig. 1) shows a typical power take-off mechanism of the late 1970's which is according to SAE J1170.

Now, let us go back to some early power take-off applications and then follow the important developments to today's PTO's.

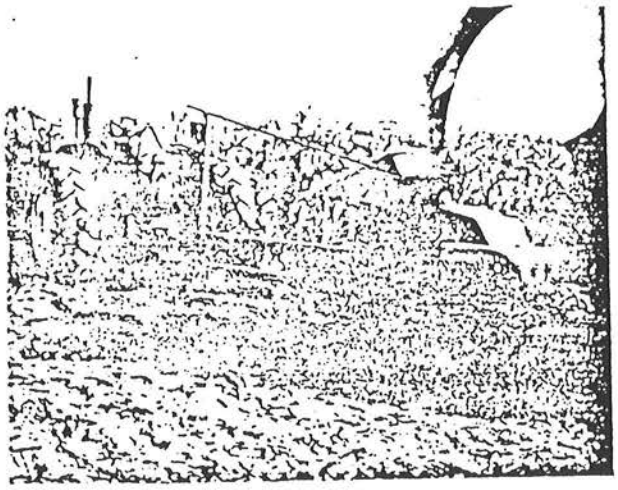

Fig. 1 - Typical application of J1170 PTO standard

## EARLY POWER TAKE-OFF APPLICATIONS

(Fig. 2) shows one of the earliest known tractor rear PTO applications in the United States. It was a Jeep-like machine shipped by Renard from England in 1904 around Cape Horn to the West Coast of the United States. It had a power take-off shaft from the tractor to a driving axle on each of three trailers. The ship encountered a storm, and one of the trailers on the ship's top deck was lost at sea. Along with the "20 Mule Team", the tractor and two trailers were used for many years to haul borax from Death Valley.

The beginning of the use of power take-off and the Society of Automotive Engineers was almost simultaneous. Also, we can declare a 75th Annivers-

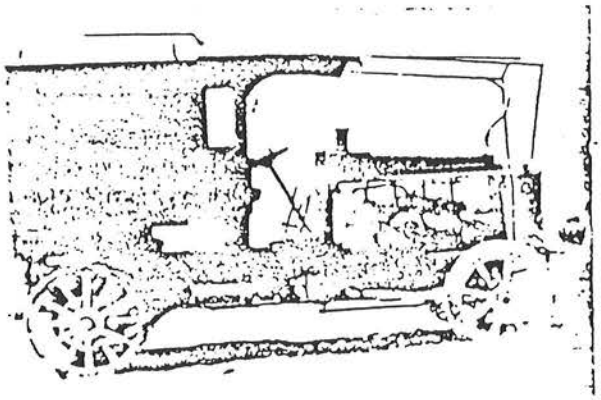

Fig. 2 - Renard tractor - 1904

ary for the power take-off.

In 1918, International Harvester introduced its 8-16 Kerosene tractor which had a power take-off as optional equipment. This was the first known American tractor to offer a practical rear PTO mechanism for propelling trailed implements.

(Fig. 3) shows the IHC 8-16 tractor.

In 1921, International Harvester was the first to provide the rear PTO as standard equipment on its new McCormick-Deering 15-30 tractor.

(Fig. 4) shows the IHC 15-30 tractor.

The PTO became popular in approximately 1923.

In 1928, Hart-Parr advertised the first independent power take-off on its Model 18-36. The 18-36 was tested at Nebraska, October 1926, Report #128.

(Fig. 5) shows the Hart-Parr 18-36. Hart-Parr became a part of a new company, Oliver Farm Equipment Company, in 1929. In 1970, Oliver became a part of White Farm Equipment Company, Division of White Motor Corporation.

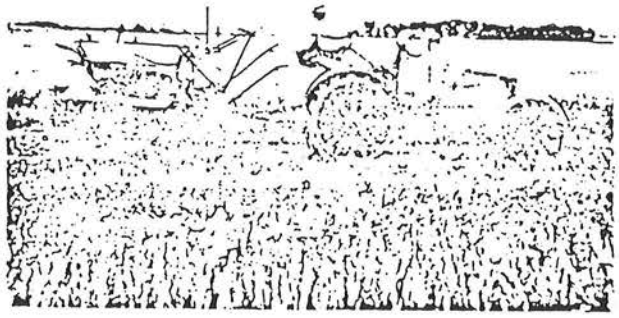

Fig. 3 - International Harvester 8-16 Kerosene tractor

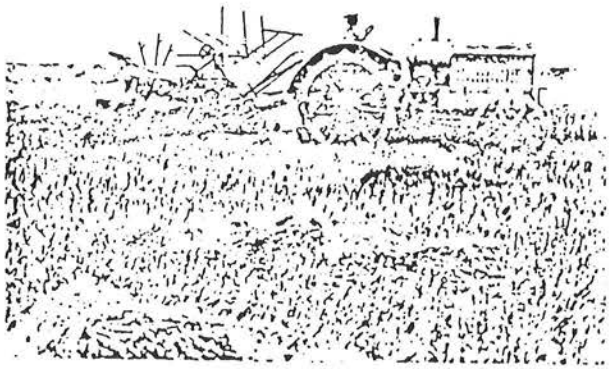

Fig. 4 - McCormick-Deering 15-30 tractor

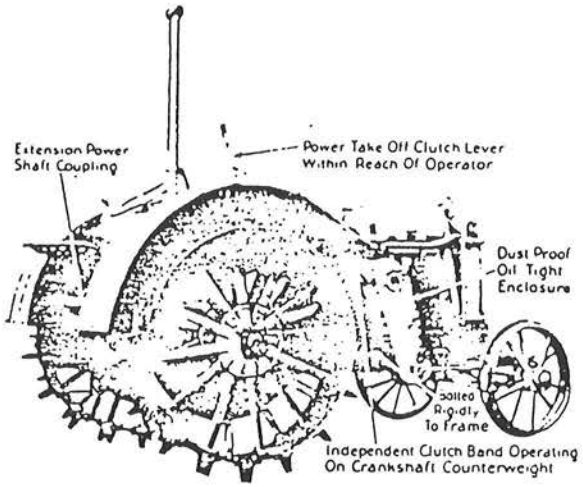


Fig. 5 - Hart-Parr 18-36 tractor

EARLY SAE PTO STANDARDS AND RECOMMENDED PRACTICES

1918 - Tractor drawbar standard height.

"Vol. 1 S. A. E. Data Sheet 55

HEIGHT OF TRACTOR DRAWBAR

S. A. E. Standard

The standard height of drawbar shall be 17 in. for both plowing and other work."

The drawbar is to become related to PTO standard at a later date.

1924 - June - A report from SAE Agricultural Power Equipment Division recommended 536 RPM as standard speed and with clockwise rotation when viewed from the rear.

"Vol. XIV June, 1924 No. 6

TRACTOR POWER TAKE-OFF SPEED

At the meeting of the Agricultural Power Equipment Division in April, the following recommendation was approved:

The normal speed of the power take-off of tractors designed for operating tractor-propelled agricultural implements shall be 536 r.p.m., the rotation to be clockwise when looking in the direction in which the tractor travels.

This recommendation was approved in view of the fact that the power take-off speed used throughout the industry has been practically constant for 30 years, this being determined by the speed of the sickles. It is be-

lieved to be advisable, however, to recognize this standard speed for the future guidance of tractor and implement designers. The Division therefore submits the proposal for adoption as S. A. E. Recommended Practice."

1924 - July - The report was approved for adoption as an SAE Recommended Practice with the addition of the tolerance of ± 20 RPM.

1924 - August - Tractor Power Take-Off Speed Recommended Practice was published.

"Vol. 1 S. A. E. Handbook E53

TRACTOR POWER TAKE-OFF SPEED

S. A. E. Recommended Practice

The normal speed of the power take-off of tractors designed for operating tractor-propelled agricultural implements shall be 536 plus or minus 20 r.p.m., the rotation to be clockwise when looking in the direction in which the tractor travels.

From the report of the Agricultural Power Equipment Division, adopted by the Society July 1924."

1929 - Recommended Practice was revised to include 6B spline, 3" long for 1 1/8" and 1 3/8" shafts.

"176

TRACTOR POWER TAKE-OFF SPEED

S. A. E. Recommended Practice

The power-take-off shaft on the tractor shall be provided with an S.A.E. 6B spline fitting. The straight length at the root of the spline shall be 3 in. Retaining means for securing the fitting shall not project more than 1 in. from the end of the spline.

The normal speed of the power-take-off shaft shall be 536 r.p.m., plus or minus 20, the direction of rotation to be clockwise when facing in the direction the tractor travels.

Two sizes of power-take-off shaft shall be used, as follows:

(1) The 1 1/8-in. splined shaft on tractors with engines developing up to 20 b-hp.

(2) The 1 3/8-in. splined shaft on tractors with engines developing up to 40 b-hp.

These ratings are based on the use of material having a minimum torsional yield-point of 65,000 lb. per sq. in.

From the report of the Agricultural Power Equipment Division, adopted by the Society July 1924. Revised February 1929."

1938 - The PTO Recommended Practice became a standard in January 1938. Also, it was revised to include shaft dimensions, 1 3/4" splined shaft, 3½" spherical clearance radius, drawbar relationship to output shaft, shielding of drive line and a reference to adaptor parts to hitch implements to standard tractor PTO.

In 1937, the American Society of Agricultural Engineers (ASAE) adopted the PTO Standard but included another shaft size of 1 3/4" diameter and additional data as to the location of PTO shaft with respect to drawbar and other requirements. Since this time, ASAE and SAE have coordinated and published basically the same PTO standards. The complete 1938 Standard is Appendix "E".

This was the first SAE report in the PTO development concerning shielding of the drive line. "The tractor manufacturer shall adequately shield the power take-off shaft and tractor universal joint, and provide protection for the operator against the telescoping member attached thereto, assuming connection between tractor and implement is according to recommended practice."

"The manufacturer of a power take-off driven machine shall furnish the power drive parts up to the tractor spline shaft, the necessary hitch parts to attach to the recommended drawbar location, and all shields, except the one attached to the tractor, covering the spline shaft fitting or universal joint."

"The tractor power take-off drive shall be provided with a throw-out clutch, operating independently of the tractor travel, of a design safe against accidental engagement and with a control located conveniently to the operator."

During the 1920's PTO drive lines were generally unprotected.

(Fig. 6) shows a typical PTO drive line in the 1920's.

During the early 1930's, some inverted "U" tunnel type telescoping

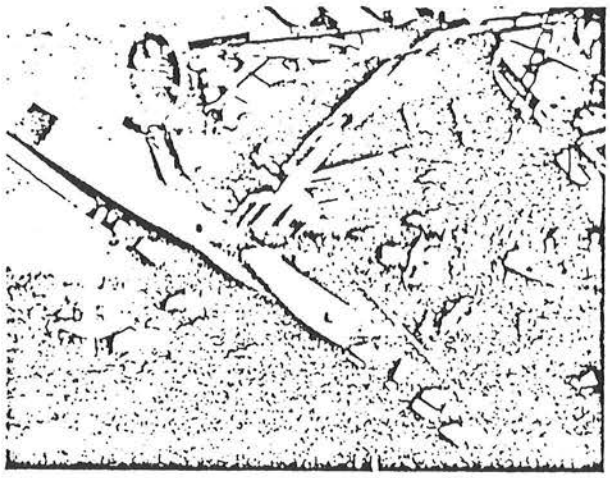

Fig. 6 - PTO shaft on grain binder of 192C's

shields were adopted.

(Fig. 7) shows the tunnel type shields and how they were attached with a latch to a tractor master shield and the implement shield. The tractor master shield was included in the 1946 SAE Handbook printing.

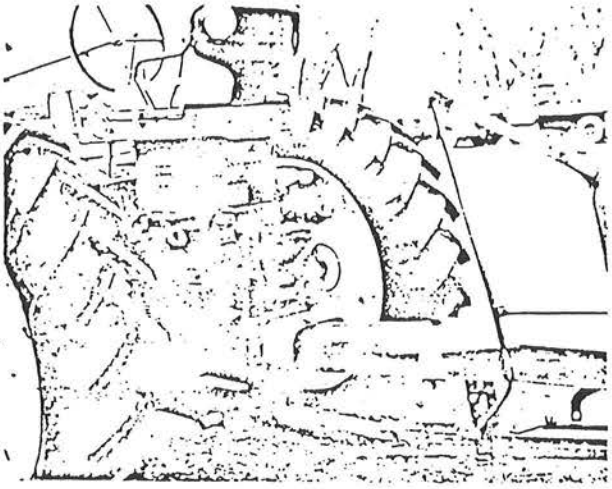

Fig. 7 - Inverted "U" tunnel type shield

IN 1946 - (Fig. 8) shows the revised standard to include views and dimensions of PTO master shield.

(Fig. 9) shows the agricultural tractor drawbar standard which established more precise drawbar and PTO output shaft relationship.

(Fig. 10) shows a drawing of PTO shaft and hub or coupling. Drawings

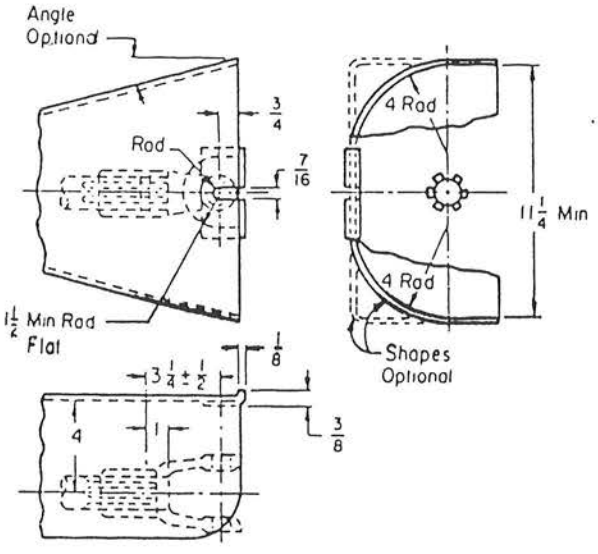


Fig. 8 - Tractor PTO master shield

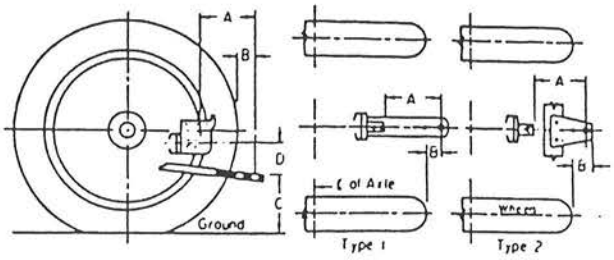


Fig. 9 - Tractor PTO output shaft and drawbar relationship

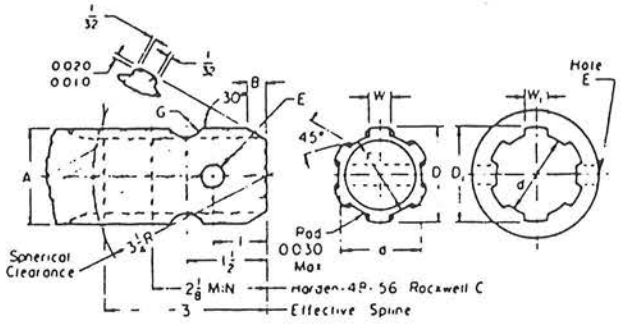


Fig. 10 - Outline drawing of 1 3/8" 6B splined shaft and coupling

of the power take-off and drawbar relationship were included in the drawbar standard. 1 1/8" shaft standard was discontinued. See appendices "F" and "G".

ENGINE POWERED DRAWN EQUIPMENT

By 1946, pull type implements, such as combines and hay balers, were driven by a separate engine on the implement and were pulled behind a tractor. An example is shown in (Fig. 11).

This photo of Allis Chalmers tractor and New Holland baler was taken in approximately 1948.

The reason for the separate engine was to permit stopping and starting of the forward travel without interrupting the power to the implement. When a sudden overload of material to the implement was encountered, it was necessary to stop forward motion so that the overload could be cleared without clogging the implement.

The extra cost and complications of adding an engine to the implement prompted the re-introduction of the independent PTO.

INDEPENDENT POWER TAKE-OFF

The independent PTO provided the

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