Trusser and Binder

-

Knotter Replacement

Prepared by ***SCARLETT RESEARCH LTD***

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This is one of a series of thatching straw machinery technical guides prepared by Scarlett Research Ltd on behalf of Historic England and Historic Environment Scotland *(see Section 8 for further details)*. It is intended to provide an informative overview of procedures which **may** be followed: it is **not** intended to be a comprehensive reference.

Safety Warning

Some images and video clips shown in this guide for illustrative purposes have been obtained by remotely-operated cameras located close to moving machinery, sometimes with safety guarding removed. The viewing locations used are not necessarily safe for human presence during machine operation. Please therefore:

- **NEVER** approach any machine when it is under power / in motion
- **ALWAYS** disengage the drive to a machine **and** ensure its components are in a safe, stationary position **BEFORE** opening guards and attempting to clean or maintain/adjust it
- **ALWAYS** ensure that all machinery and drives are appropriately guarded, that safety guards are in good condition **and** are in place whenever the machine is under power / in use.

Disclaimer

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This guide is intended for users who are competent in the operation & adaptation of machinery. Users should take all necessary safety precautions and pay due regard to the safety warnings contained herein.

Information presented regarding legislation is based upon our current understanding of the law, which may change and is not definitive: only the courts may interpret legislation definitively. It may be necessary to seek advice on individual circumstances.

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We are particularly grateful to Chris Thomas for allowing his example *(converted Trusser)* machine to be the subject of this technical guide and for kindly sharing details of the conversion process he followed.

Contents

1 Introduction

Purpose

The harvesting and processing of thatching straw, either by 'Conventional' or more modern 'Alternative' methods, relies on packaging machinery: a Binder, a Trusser or a Baler. In most instances such equipment utilises twine which is tied by one or more mechanical knotters to secure the package *(the sheaf, truss or bale).* And few things have the ability to cause as much angst as a poorly performing knotter on a piece of harvesting machinery.

Thatching straw growers who employ 'Conventional' harvesting & processing methods tend to harvest the crop by Binder and, following threshing or combing, package the long straw or combed wheat reed by means of a Trusser. Binders and Trussers employ virtually identical sheaf/truss packaging & tying mechanisms, the main difference being that a Binder secures the *(lighter)* sheaf with a single band of twine, whereas most Trussers place two bands around the *(heavier)* truss.

Fig.1.1 Ruston & Hornsby high-wheel, double band straw trusser

Unfortunately, all Binders and Trussers in use today are 'vintage' machines which have seen many, many years of service. Automatic-tying, mechanical trussers were first developed in the 1880's and UK production ceased in the mid-1950s. Any replacement spares stock has long since been exhausted; the same being largely true of binders. Consequently, the crop harvesting & processing systems of the majority of UK thatching straw growers are reliant on old, often worn machinery for which there are very few replacement/spare parts.

Many growers have found that poor reliability of knotters on Binders or Trussers can seriously reduce output during crop harvesting & processing. That's not to say that a worn or poorly-adjusted knotter can be the sole cause of tying problems: poor or variable twine quality can also be to blame. However, twine can still be sourced from many alternative suppliers, whereas there are few available options by which to address a worn-out knotter.

With this in mind, the purpose of this technical guide is to show how the knotter mechanism of an existing Trusser or Binder can be upgraded *(replaced)* with that from a Conventional Baler. The key benefits of this modification are:

- Much more reliable knotter operation
- Ready availability of spare parts *(both now and for the foreseeable future)*
- Wider range of system adjustment, to suit operating conditions
- Ability to work *(reliably)* with a wide range of natural *(sisal)* and synthetic *(polypropylene)* twines

The overall *(machine modification)* approach and steps described by this guide are equally applicable to either a Binder or a Trusser. However, this document focuses on a Trusser, partly due to the availability of an example machine and partly because, should a trusser knotter mechanism malfunction during threshing/combing, the grower will not only waste their own time/money, but will also waste that of an idle threshing/combing team as they wait for the Trusser to be fixed. This soon becomes rather expensive. Far, far greater than the cost of fitting some new, reliable knotters to the Trusser!

Can I Do It Myself?

The steps involved in this machine modification require:

- A certain level of mechanical aptitude & an attention to detail
- A well-equipped *(farm)* workshop
- Access to *(metal)* machining capability *(i.e. either your own or the services of a third party).*

The tasks involved are not particularly demanding and, with the possible exception of the *(limited)* component machining, should be within the capability of most thatching straw growers.

However, remember, this guide is intended to provide an informative overview, **<u>not</u>** a comprehensive reference. Anyone following the procedures outlined must take a careful, responsible approach and follow good, safe engineering workshop practice. *(see Section 5.1)*

Conventions and Units Used by this Guide

Left and Right As viewed when standing in the trusser discharge area, facing towards the machine

Imperial or Metric? Trusser designs originate from a time when imperial units were used exclusively. It is possible that some *(baler)* replacement knotter components may feature a mix of imperial and metric components, but the former is likely to be most prevalent. This guide always shows both metric & imperial units: whichever is shown first is believed to be the original unit of measurement used.

Safety Precautions and Statutory Requirements

When Trussers were originally manufactured *(1880s–1950s)*, Workplace Health & Safety was not a particular priority, especially in agriculture. Few, if any, of the driveshafts, gears, chains, sprockets or other dangerous moving parts on these machines were guarded in any way.

This was not a particularly acceptable situation at the time and by the 1950s was considered unacceptable. A whole raft of new safety requirements for agricultural machinery were introduced in the early 1960s, applicable to both new and in-use machinery. Safety requirements for straw trussers were specified by:

- **The Agriculture (Threshers and Balers) Regulations (1960):** Applied to threshing machines and associated *(stationary)* balers & trussers. They specified particular requirements for the safety guarding of driving belts, chains, gears, shafts, the knotters & crop discharge mechanisms. Also, they required provision of a safe & convenient means of quickly stopping/disengaging drive to the machine when in work.

The introduction of these *(reasonable & sensible)* safety requirements coincided with a decline in use of these machines in mainstream agriculture, production having already ended. Under threat of prosecution, many of those still in commercial use were modified to comply with the regulations. However, unfortunately there is relatively little evidence of those required safety measures being present on many example machines used for processing thatching straw today.

These 1960 Regulations have since been replaced by other, more general safety legislation *(see below)*, but their safety requirements for these particular machines remain appropriate even today. They are discussed further on Section 6.1.

Today, the following safety legislation applies to the use of any kind of machinery in the workplace:

- **Health & Safety at Work Act (1974) *(HSWA)*:** Applies to anyone who supplies *(sells or hires)* equipment for use at work *(whether new or second-hand)*. It also places duties on the user/employer. Essentially, it requires that all equipment supplied to or used in the workplace must be safe for use.
- **Provision and Use of Work Equipment Regulations (1998) *(PUWER 98)*:** Primarily apply to the machine user *(employer, employee or self-employed)*. Require that any equipment provided for use for work must:
    - Be safe for use
    - Be suitable for the intended use
    - Be properly maintained in a safe condition
    - Feature suitable safety control measures *(i.e. guards, markings & warnings)*

  Additionally, the machine user must be adequately trained/instructed and be provided with appropriate information to enable safe use of the machine.

REMEMBER, the penalties for failing to comply with the requirements of safety legislation can be severe, but the human cost can be far higher.

SAFETY WARNING

The operation, maintenance, repair and modification of agricultural machinery create risks which need to be managed, so:

PLEASE BE AWARE OF THE RISKS, ASSESS THEM AND TAKE APPROPRIATE STEPS TO MANAGE THEM

- Basic safety precautions to take when working on farm machinery in a workshop environment are outlined in Section 5.1
- Practical safety control measures *(e.g. potential machine guarding options)* for Straw Trussers when in use are discussed in Section 6.2.

2 Background

Straw trussers were originally designed to package straw into twine-tied bundles or 'trusses' as it was discharged from a threshing machine or a reed comber, to aid subsequent handling and possible onward sale. Their use in the present day 'conventional' processing of thatching straw is little-changed.

Fig.2.1 Standalone, wheeled double band trusser packaging combed wheat reed from a reed comber

Trussers were usually constructed as standalone, trailed machines *(Figs 2.1, 2.3 & 2.4)* but, if used for packaging long straw from a threshing machine, they could instead be fitted to / suspended from the rear of the machine as an integral unit *(Fig.2.2)*. The adjustable chain suspension system permitted the trusser unit to be either 'in-work', raised up for road transport or lowered down below the path of crop flow, to permit the straw to bypass the trusser and be stacked loose or baled.

In almost every case, the manufacturers of trussers were also manufacturers of binders rather than threshing machines: no doubt a reflection of the similar crop packaging & tying mechanisms found on both machine types. The main (UK) manufacturers of straw trusser were:

- Richard Hornsby & Sons *(Ruston & Hornsby post-1918)*
- J. & F. Howard *(of Bedford)*
- Massey Harris
- Harrison, McGregor *('Albion')*

However, closer ties existed within the industry. In 1919, Ruston & Hornsby acquired a controlling interest in Ransomes, Sims & Jefferies, the UK's largest manufacturer of threshing machines. Thereafter Hornsby trussers were manufactured by Ransomes and sold alongside their own products. In 1932, Ransomes acquired the interests of Howard of Bedford, further consolidating the UK trusser market.

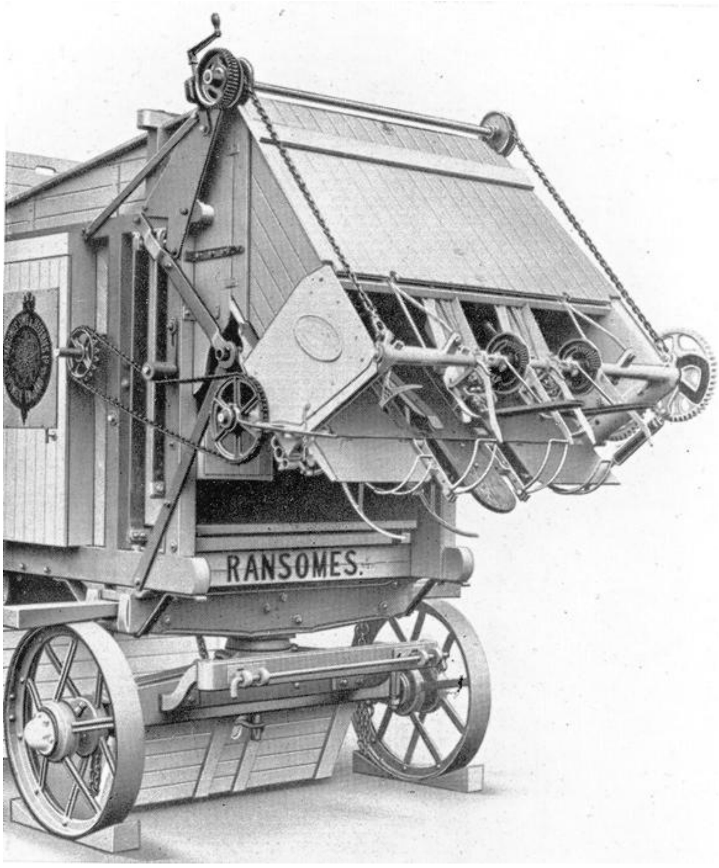


Fig.2.2 Integral / suspended double band Hornsby trusser mounted on a Ransomes threshing drum

(courtesy Ransomes, Sims & Jefferies Ltd)

Today, the majority of trussers used for packaging of thatching straw are:

- Double string/band models *(i.e. featuring two knotter units arranged in parallel)*
- Either Ruston & Hornsby or Massey-Harris machines. Howard and Albion machines are also in use, but tend to be in the minority.

Both Hornsby and Howard produced straw trussers in their own right for approximately 40 years, but their respective design features are extremely similar *(see Figs 2.3 & 2.4)*. This is because Hornsby machines incorporated a number of Howard-patented features under licence. The reverse may also have been the case.

Consequently, although this guide uses a Howard trusser as an example, in many respects the machine is similar to a Ruston & Hornsby. Also, whilst greater differences exist between a Howard and a Massey-Harris machine, the general principles and engineering steps required to replace/upgrade the knotters are very similar on either machine.

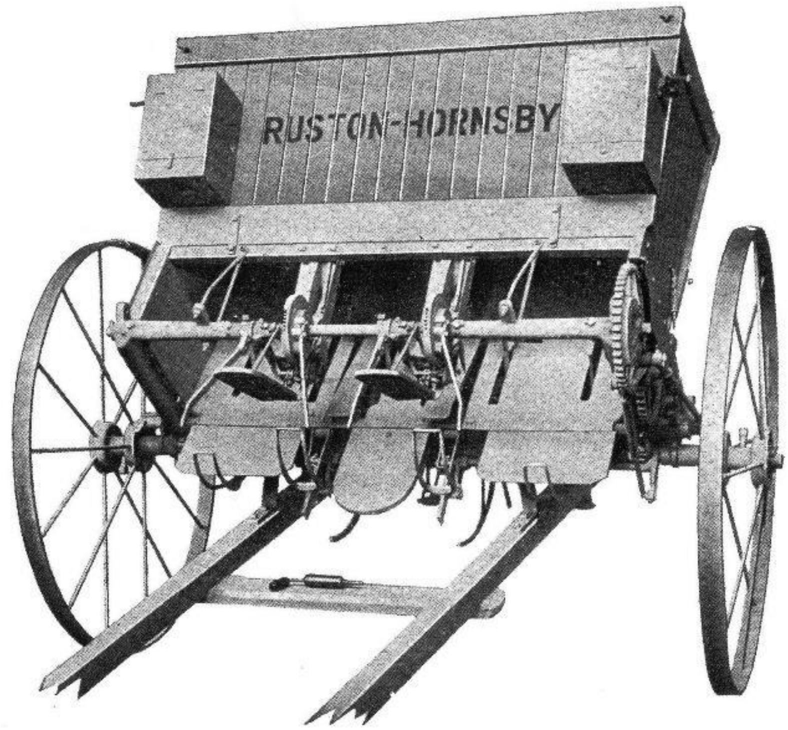


Fig.2.3 Ruston & Hornsby high-wheel, double band straw trusser

(courtesy Ransomes, Sims & Jefferies Ltd)

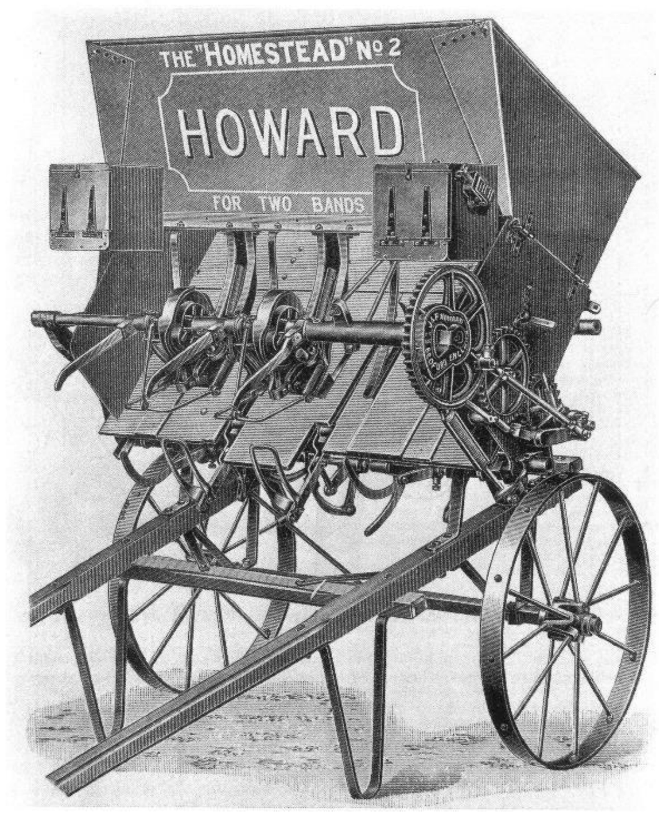


Fig.2.4 Howard low-wheel, double band straw trusser

(courtesy J. & F. Howard)

3 Straw Trusser – How It Works

The crop packaging & tying mechanism of a trusser is virtually identical to that found on a binder, the main difference being that a binder uses a single knotter unit to tie a single band of twine around the *(lighter)* sheaf, whereas most trussers incorporate two knotters to tie two bands around the *(heavier)* truss. Single band trussers were offered & were popular in certain regions, but they don't appear to be favoured for the packaging of thatching straw.

3.1 General Operation *(see Fig.3.1)*

The flow of threshed or combed straw from the threshing drum or comber is arranged to fall transversely into the trusser's hopper. Here it slides down a steeply inclined floor or Deck where a series of *(usually six)* crankshaft-driven Packers, which operate in a semi-rotary motion, compress the straw against two or more Compressor Arms and two pre-tensioned strands of twine. The Compressor Arms retain the crop in the base of the trusser's deck until a sufficient weight/volume of material has accumulated. The tying cycle is then automatically tripped; the Knotter(s) ties the truss and it is ejected from the machine by rotating Discharge Arms.

During the early stages of truss formation, the machine's operation can be observed quite easily. However, once the tying cycle is tripped, a number of carefully synchronised actions occur very rapidly, both within the knotter mechanism and elsewhere. In essence these are as follows:

1) **Tying Cycle 'tripped':** Drive is engaged to the Knotter *(drive)* Shaft, the Needles & the Compressor Arms
2) **Needles:** Rise through apertures in the Deck and place a band of twine around the truss & into each Knotter mechanism. The lower 'stem' section of each Needle also squeezes the crop bundle down the Deck, against the opposing Compressor Arm. The Needles retract once the knot is tied
3) **Compressor Arms:** Simultaneously lift up slightly, compressing the truss against the opposing Needle, whilst the twine is being tied by the Knotter
4) **Knotters**: Knotter Shaft rotates once, causing each Knotter to tie the twine while the truss is compressed between the Needles & Compressor Arms
5) **Discharge Arms**: Rotate with the Knotter Shaft, contacting the upper surface of the truss immediately after the knot(s) are tied. The Compressor Arms then retract/lower, enabling the Discharge Arms to eject the truss.

N.B. Depending on the specific design of knotter fitted, the 'ejection' action of the Discharge Arms can also serve to remove the completed knot from the Knotter's bill hook *(see below)*.

How Are the Knotters Tripped?

This depends on the machine make/model, but usually by two spring-loaded, pivoting Trip Levers or 'Paddles' which protrude through the trusser's Deck in the area where the truss will be formed *(see Fig.3.2)*. The accumulating crop pushes down on the levers against *(adjustable)* spring pressure until the Knotter Engagement Clutch is tripped. Some machines *(e.g. certain Hornsby models)* also sense the force exerted by the forming truss on to certain of the Packers, via spring-loaded mechanism. If this exceeds a given *(adjustable)* level, the Knotters are also tripped.

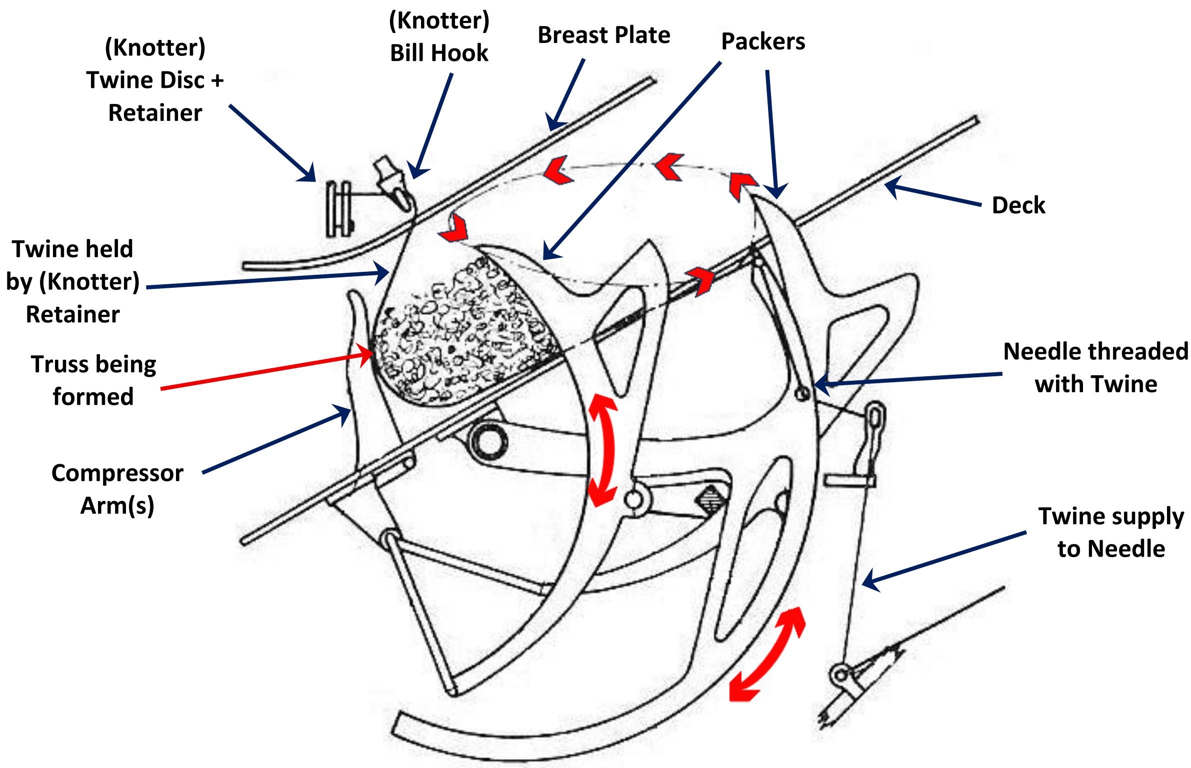


Fig.3.1 Straw Trusser – Key components *(schematic view)*

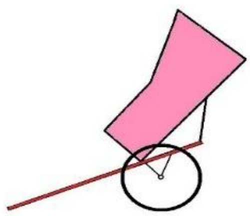
Trussers were originally chain-driven from the threshing machine's rear straw walker shaft, directly onto the crankshaft that rotates the packers. The knotters, needles, compressor & discharge arms are then driven *(intermittently)* from the opposite end of the crankshaft.

For convenience and greater safety *(particularly ease of guarding)*, some growers have subsequently converted machines from chain to hydraulic drive *(from a nearby tractor or hydraulic power pack – see Fig.6.2)*.

SAFETY WARNING

However, most/all trussers originally incorporated a lever-operated 'dog' clutch near the input drive sprocket, to enable drive to the machine to be disengaged from the threshing machine during work, should a problem or emergency arise. This subsequently became a legal safety requirement *(see Section 6.1)*. So, if a trusser is converted to hydraulic drive ***(and the original mechanical disengagement clutch is also removed)***, it is important to provide a convenient, alternative means of stopping / disconnecting drive to the machine when it's in use.

Click on the Trusser icon or scan the QR code for video of Trusser operation



How Big/Heavy is a Truss of Straw?

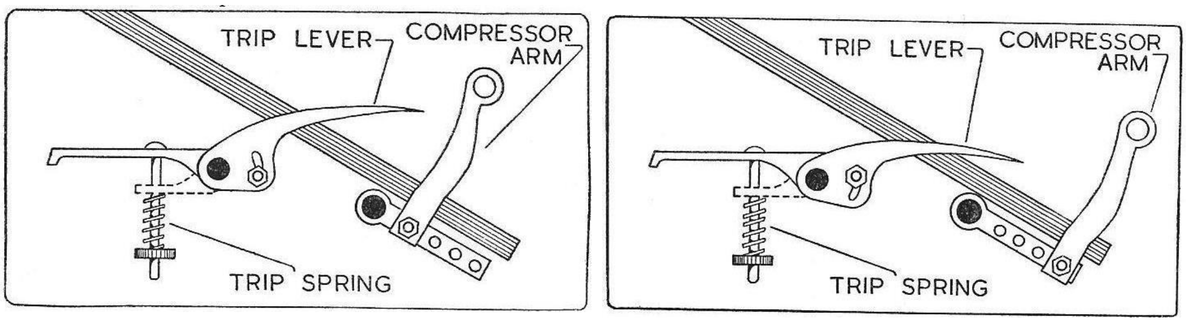
Trussers incorporate a range of adjustments both to vary the size of truss produced and also the tightness of *(or rather tension in)* the band of twine around the truss. The latter effectively controls the density of the truss which, together with truss size, determines its overall weight.

Hornsby trussers could be configured to tie bundles weighing 5-12lb, 12-25lb or 26-35lb, but unless otherwise specified, they were dispatched from the factory preset to tie trusses in the 12-25lb (5.4-11.3 kg) range. Today a truss of combed wheat reed for thatching typically weighs approximately 14lb (6.4 kg).

Adjusting Truss Size and Weight

Unlike some Binders, Trussers usually feature separate Compressor Arms and Trips Levers: a design configuration which affects the method of adjusting truss size.

To adjust truss size on such machines, the Compressor Arms can be moved closer to / further away from the Packers *(Fig.3.2)*. Similarly, the free end of the Trip Levers/Paddles can be raised or lowered to increase/decrease their protrusion above the deck surface. However, truss density *(band tightness)* is varied by adjusting the knotter trip mechanism spring tension *(**N.B. NOT** by adjusting the tension in the twine supply to the Needles / Knotters).*



Smaller Truss **Larger Truss**

Fig.3.2 Trusser settings to adjust truss size – Smaller truss *(left)* and larger *truss (right)*

- **For a Smaller Truss** - *(Fig.3.2 (left))*:
  - Move the Compressor Arms **closer** to the Packers / Needles, and
  - **Raise** the Trip Levers / Paddles.
- **For a Larger Truss** - *(Fig.3.2 (right))*:
  - Move the Compressor Arms **further away** from the Packers / Needles, and
  - **Lower** the Trip Levers / Paddles.

To adjust Truss Density *(twine band tightness)*:

- **For a Tighter Band *(a denser Truss)***: Tighten the Trip Spring
- **For a Looser Band *(a less dense Truss)***: Loosen the Trip Spring.

N.B. Depending on machine design the Trip Spring may act on the Trip Lever or on the Trip Stop Lever.

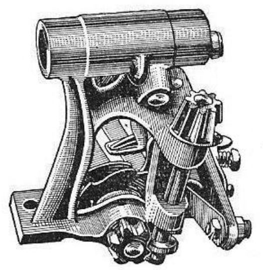
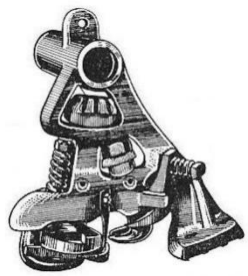
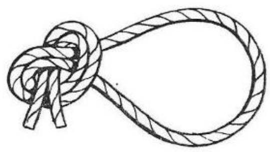
3.2 Knotter Design and Operation

The operation and adjustment of knotters is regarded by many as a mysterious 'dark art'. In fact, the knotters used on today's 'conventional' balers *(as opposed to large square balers)* are very much the same as those found on binders & trussers manufactured over a century earlier.

Unfortunately, understanding knotter operation & adjustment is made more complicated because there are two distinct designs of knotter: the 'Deering' and the 'McCormick'; so-named after the American binder manufacturers who popularised them. Other binder/trusser/baler manufacturers developed modifications to create their own variants of these two generic knotter types, but the original 'Deering' or McCormick' parentage still is clear to see.

Both knotter types work in a similar way, but their precise design & method of operation differs, particularly regarding the action of the Twine Knife & the way the completed knot is removed from the Bill Hook. The appearance of the knots they produce is also different *(see Table 1).*

Table 1 Principal knotter types – Key differences between designs

Knotter Type	**Deering** *(see Fig.3.3)* 	**McCormick** 
Knot Type / Appearance	 Overhand knot with both tails of equal length	 Overhand loop knot with one tail longer than the other
Key Features	• Bill Hook mounted at ~90° to crop flow • Twine cut by power-operated Moving Knife • Knot removed from Bill Hook by moving Knife/Stripper Arm • (Usually) produces short twine offcuts	• Bill Hook mounted at ~45° to crop flow • Twine cut by Stationary Knife • Knot pulled off Bill Hook as Sheaf/Truss is ejected by Discharge Arms • Doesn't produce twine offcuts
Used on Binders manufactured by:	Deering, Hornsby, Massey-Harris *(modified)*, Albion *(modified)*	McCormick, Lanz
Used on Trussers manufactured by:	Hornsby, Massey-Harris *(modified)*, Albion *(modified)*	Howard, Claas, Lanz *(modified)*
Used on Conventional Balers manufactured by:	New Holland, John Deere, Deutz-Fahr, Bamford, Jones/Allis-Chalmers, McCormick International *(later models)*	Claas *(modified)*, Welger *(modified)*, McCormick International *(modified)*

Steps in the (Deering) Knotter Tying Cycle

1) The **Twine Disc & Retainer** holds the *(fixed)* end of the twine during truss formation, having received it from the *(retracting)* needle at the end of the previous tying cycle. The twine runs from the **Retainer** to the **Needle**, but passes over the **Bill Hook** and around the forming truss *(see Fig.3.1)*

2) When the Knotter(s) are tripped, the **Needle** places the free-end of the twine around the truss, across the **Bill Hook** and into a 'notch' on the edge of the **Twine Disc** *(Fig.3.3(a))*

3) The **Twine Disc** rotates slightly into the **Twine Retainer**. This grips both strands of twine & also exposes another 'notch' in the Disc, to receive a new strand of twine from the **Needle** as it retracts *(Fig.3.3(b))*

At the same time the **Bill Hook** begins to rotate through one turn & winds the two strands of twine around its body, forming a loop *(Fig.3.3(b))*

As it rotates the **Bill Hook Jaw** opens & grasps the upper parts of both twine strands *(Figs 3.3(b) & (c))*

4) A power-operated **Twine Knife** cuts both strands of twine between the **Bill Hook** & the **Twine Disc & Retainer** *(Fig.3.3(d))*

Simultaneously, the **Stripper Arm** forms the **Knot** by pushing the twine loop off the end of the **Bill Hook**, over the two cut ends of twine held by the **Bill Hook Jaw** *(Figs 3.3(c) & (d))*

5) The retracting **Needle** lays a new strand of twine from the **Twine Disc & Retainer**, over the *(now empty)* **Bill Hook**, ready to bind the next package of crop.

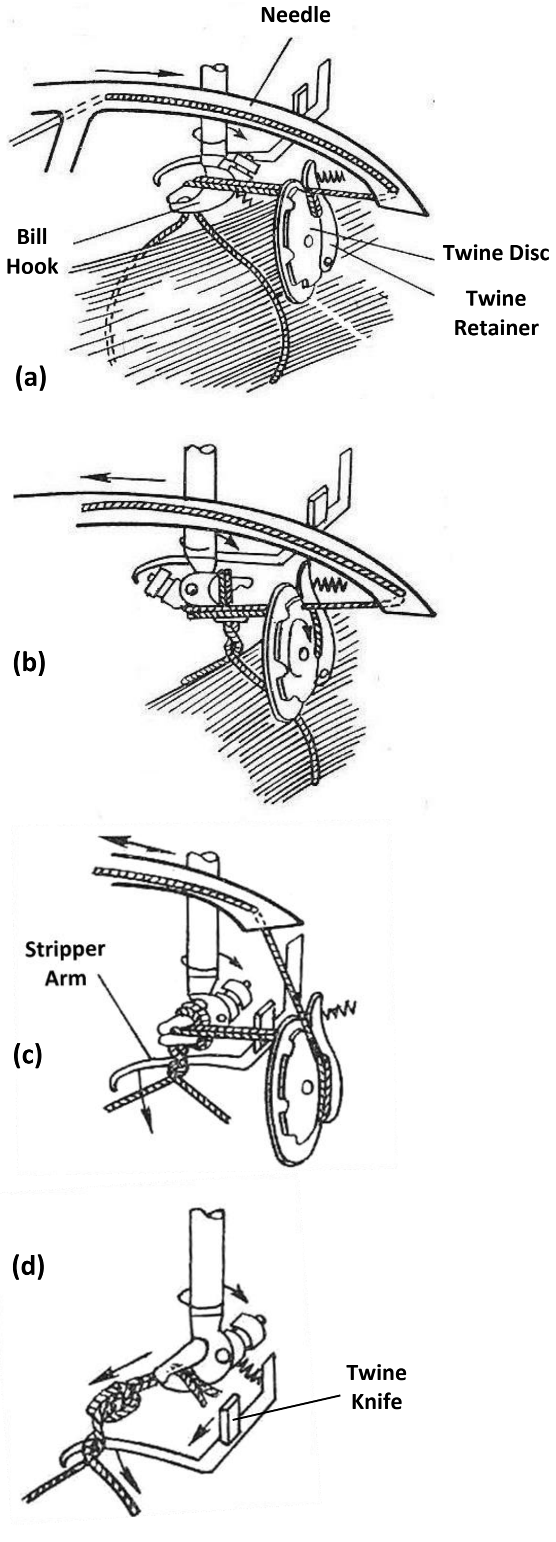


Fig.3.3 Deering-type knotter operation

Deering-type Knotter Construction

Figs 3.4, 3.5 & 3.6 show the key components of a contemporary Deering-type knotter unit, as fitted to conventional *(small, square)* pick-up balers. However, this general design has changed very little since the early 20th Century. The components are attached to the *(cast)* Knotter Frame and are driven by the Knotter Cam Gear *(Fig.3.7).* Both are mounted on the Knotter Shaft.

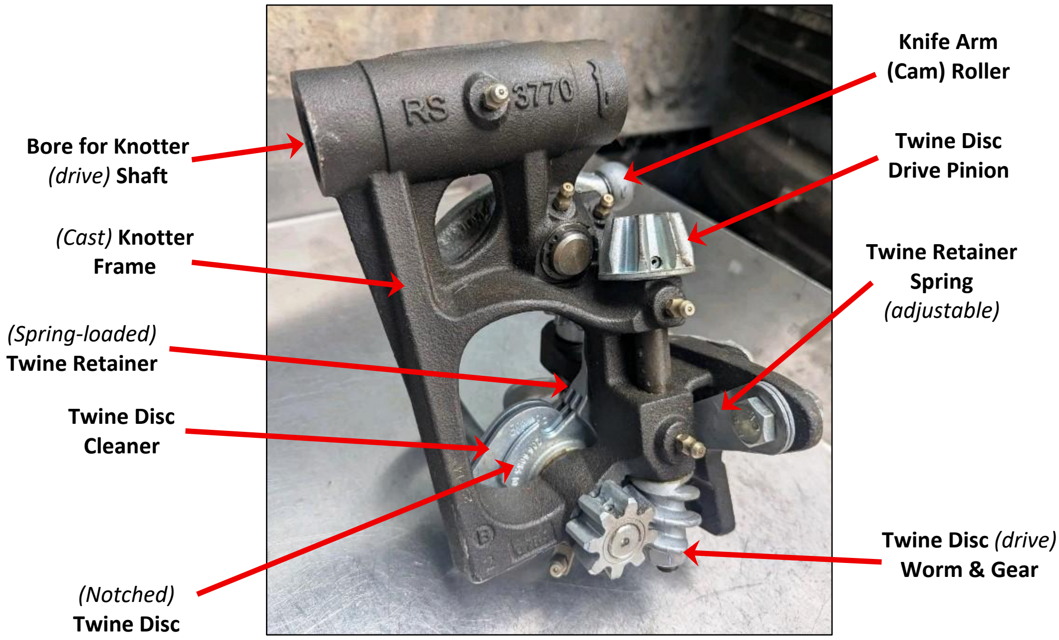


Fig.3.4 Deering-type knotter – Key components *(top view)*

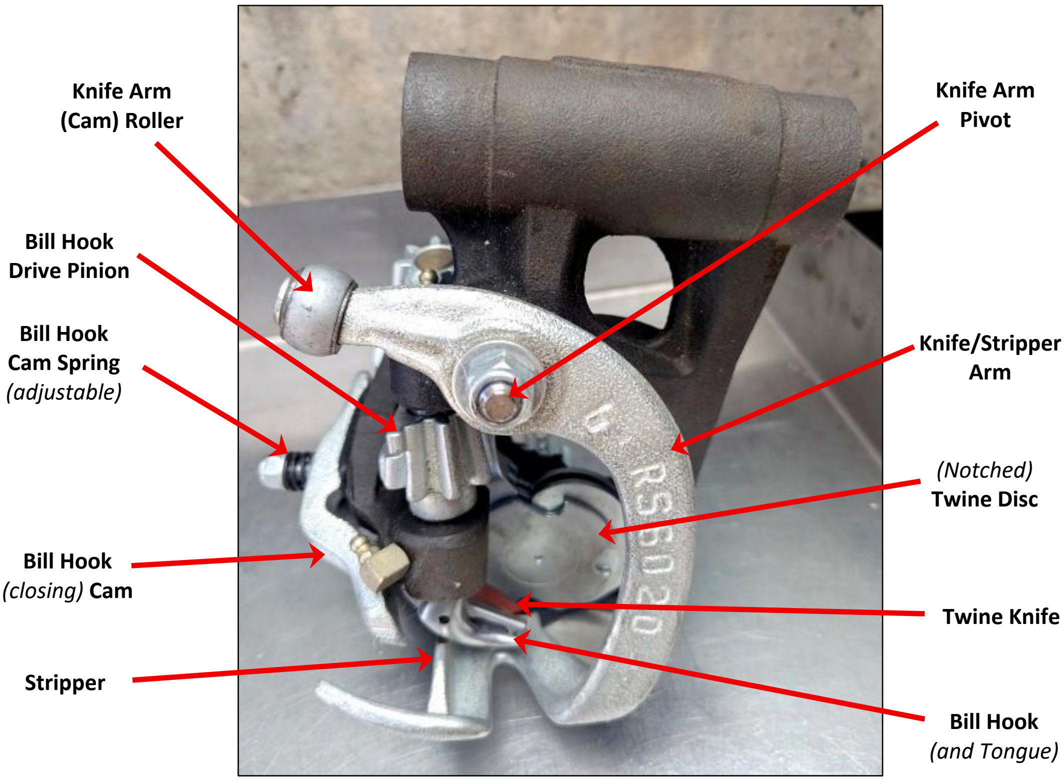


Fig.3.5 Deering-type knotter – Key components *(underside view)*

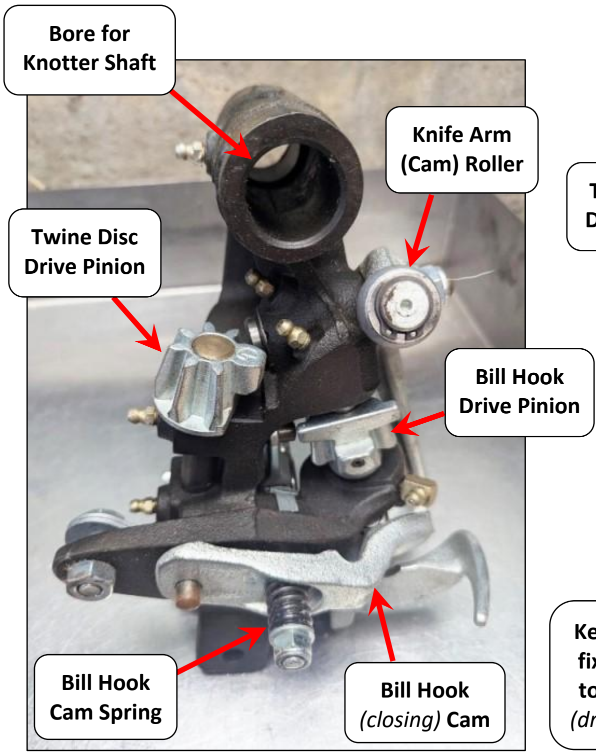


Fig.3.6 Deering-type knotter *(side view)*

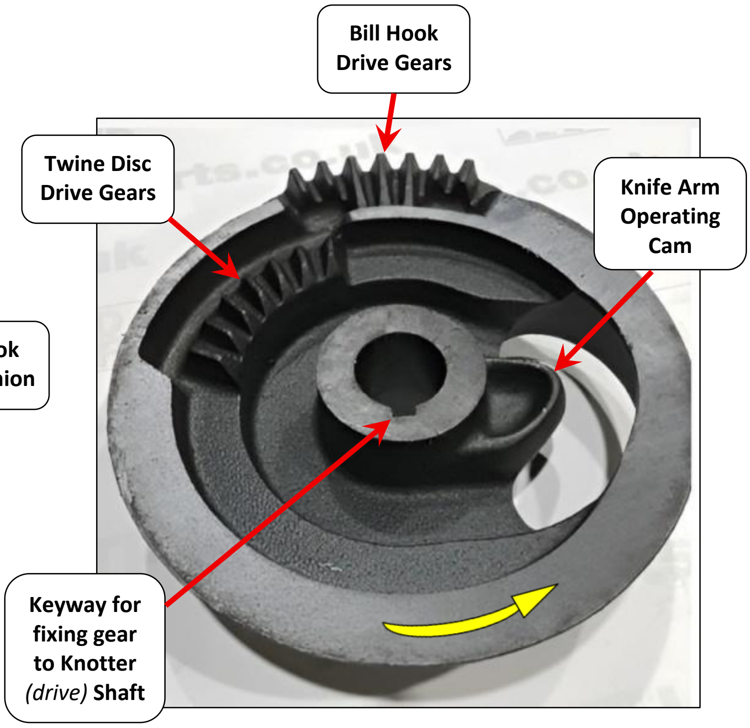


Fig.3.7 Cam gear for Deering-type baler knotter
(courtesy Woodfield Baler Parts)

So how do the components manage to perform their particular tasks in the right order & at the correct point(s) in the tying cycle? *(see Fig.3.3).* This is all controlled by the knotter's Cam Gear, which both drives and coordinates the actions of the knotter's components *(i.e. those mounted on the Knotter Frame).*

In the Case of a Deering-type Knotter:

- Whether on a binder, trusser or baler, the Knotter Unit(s) *(i.e. the Knotter Frame plus components)* are mounted on the Knotter *(drive)* Shaft, but the shaft is free to turn within each Knotter Frame
- A *(Knotter)* Cam Gear is also fitted on the Knotter Shaft, immediately beside each Knotter Unit. The Cam gear is fixed to *(and is driven by)* the Knotter *(drive)* Shaft via a central keyway *(Fig.3.7)*
- The Twine Disc drive pinion and Bill Hook drive pinion *(Fig.3.6)* engage with *(and are driven by)* different *(toothed)* sections of the Cam Gear
- The Knife Arm *(cam)* Roller also follows a cam profile on the Cam Gear *(Fig.3.7)* and this operates the Knife / Stripper Arm.

During each Tying Cycle:

- The Cam Gear rotates through one revolution. As it does, it causes the:
  - **Twine Disc** to rotate through ¼ turn *(⅙ turn on some older designs)*, to grasp the twine strands and also to expose its next 'notch' in the Disc, to receive the 'new' twine strand
  - **Bill Hook** to rotate through 360°, grasping the twine strands as it turns
  - **Knife / Stripper Arm** to sweep across the heel of the bill Hook, stripping & forming the knot and also cutting the twine strands, before returning to its 'at-rest' position.

4 Upgrading / Replacing the Knotters

4.1 Which Parts to Replace?

When faced with an old, misbehaving Trusser which could benefit from refurbishment, you must decide which parts to retain and which to replace? Not easy given that quite a lot may be well-worn. The tying mechanism of any trusser *(or binder)* is likely to incorporate a number of brand/model-specific components and also some more generic parts. Brand-specific parts are likely to be difficult to replace with something different: so in those cases 'repair' is probably the best option. However, more generic components should perhaps be considered for 'replacement', particularly where their operation & adjustment are critical to the correct operation of the machine.

Another thing to bear in mind is that whilst some of these components provide mechanical drive to the Knotters and coordinate the various actions of the tying mechanism, other parts determine the physical location of the Knotters & prevent their unwanted movement during trusser operation. This is important, because the Needle(s) need to place the twine into the Knotter Units with some precision, without colliding with anything *(see Section 4.3)*.

Fig.4.1 shows the general location of the key elements of a Trusser's tying mechanism, so we all know what we are talking about.

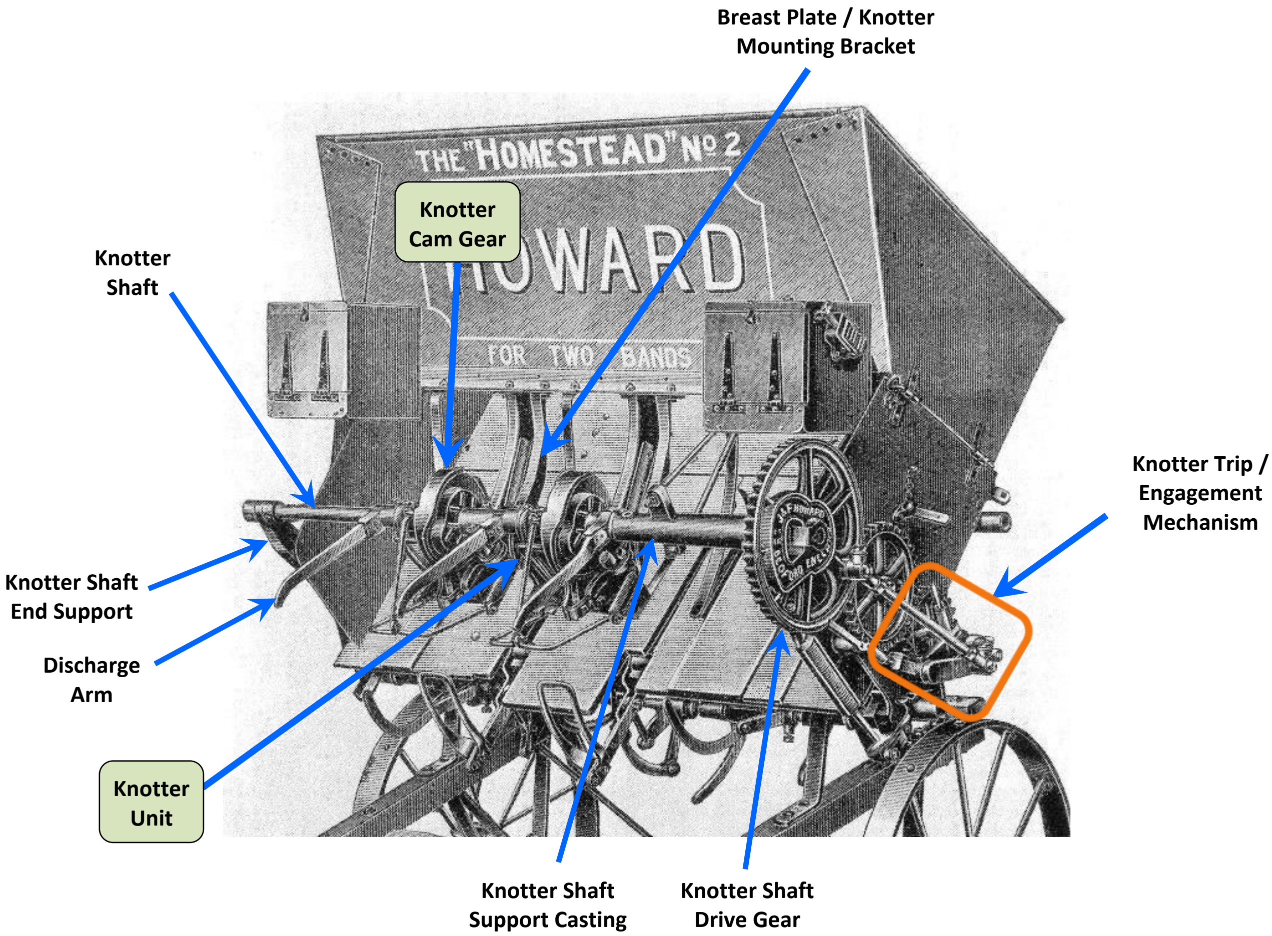


Fig.4.1 Typical trusser – Location of tying mechanism and associated components

Which Components Shouldn't be Replaced? *(Repair Instead) (see Fig.4.1)*

- **Knotter Trip Mechanism *(Trip Lever(s), etc)*:** Components which sense the size of the forming truss and subsequently trigger the Knotter *(drive)* engagement mechanism. These will almost certainly be 'brand-specific' **- *Retain / repair***
- **Knotter** *(Drive)* **Engagement Mechanism:** As operated by the Trip Mechanism to engage mechanical drive to the Knotters & other tying mechanism components. Again, likely to be 'brand-specific'. Will suffer from wear in-service and will probably require some refurbishment sooner or later **- *Retain / repair***
- **Knotter Drive Mechanism *(Gears, chains)*:** Depending on brand, drive to the Knotter Shaft is via a gear train or chain. A large gear wheel or sprocket is fitted to the *(input)* end of the Knotter Shaft. **This is an important component** because it performs a number of functions, namely it:
  - **Drives the Knotter Shaft**
  - **Operates the Needles** *(via a connecting rod & crank arm arrangement)*
  - **Operates the Compressor Arms** during the tying cycle *(via a cam track built into the gear wheel / sprocket)*
  - **Controls the overall 'timing'** of the tying mechanism
  - *(On some machines)* can incorporate features to prevent the tying mechanism from turning backwards between tying cycles.

  Given its range of functions and likely brand-specific design, replacement isn't an option *(other than with an identical component)* **- *Retain / repair***
- **Knotter** *(Drive)* **Shaft:** Not only provides drive to the Knotter Cam Gear(s) *(and so to the Knotter components)* and Discharge Arms: it also controls the physical location of these components. This role has to be fulfilled by something. The shaft is unlikely to have suffered from in-service wear and so, unless it compromises the overall conversion in some way, keep it **- *Retain / repair***
- **Knotter** *(Physical)* **Support Components:** Includes the Knotter Shaft Support Casting, the shaft End Support bracket *(or casting)* and the Breast Plates / Knotter mounting brackets. These are all bespoke components, are very unlikely to have suffered wear and so should be retained & 'accommodated' by the conversion if at all possible**- *Retain***
- **Needle(s):** A critical component which must interact precisely with the *(replacement)* Knotter units. The trusser's needle drive/operation mechanism will likely be based around the precise design & geometry of the existing needle(s), so replacement with something different isn't really an option. Instead, the 'new' replacement components must be arranged to suit the existing Needle(s) *(see Section 4.3)*. They will undoubtedly have suffered some wear in-service *(probably in the 'Eye' region)*, but this can usually be repaired **- *Retain / repair***

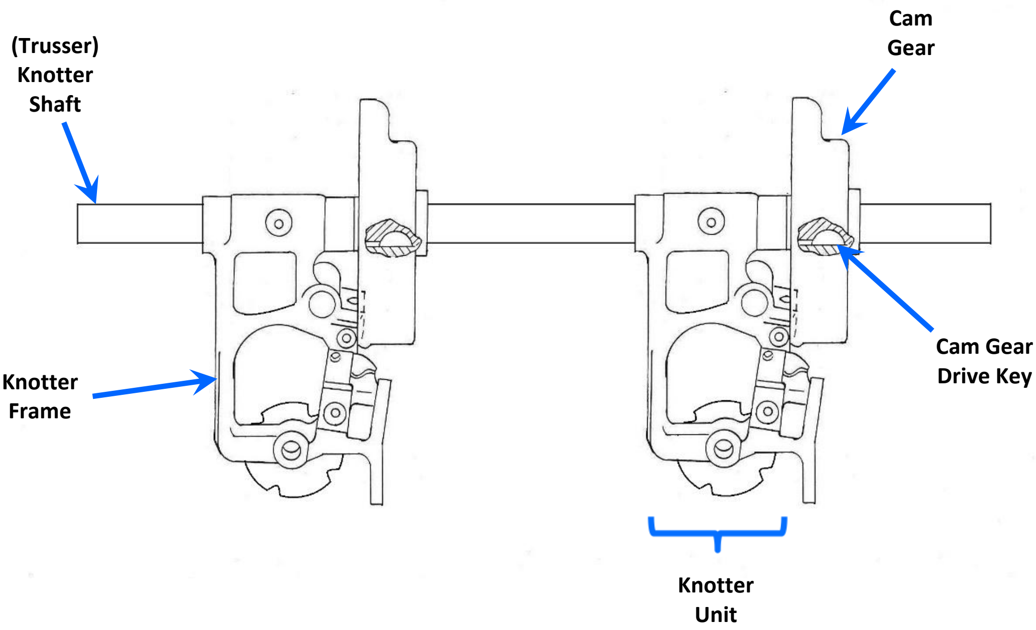


Fig.4.2 Likely basic arrangement of replacement knotter components on *(trusser)* knotter shaft

- **Discharge Arms:** Yes, these are part of the tying mechanism. Ejection of the truss is important. The Arms are likely to be serviceable and *(depending on design)*, their mounting bosses may be used to locate/hold the replacement Knotter Unit(s) on the shaft. **However, depending on the make of Trusser,** the Arms may mount solely onto the Knotter Shaft or some may attach to the Knotter Cam Gears *(see Section 5.3)*. If the latter arrangement, these mountings will require revision. ***– Retain or relocate (as necessary).***

Which Components Should be Replaced? *(see Figs 4.1 & 4.2)*

- **Knotter Unit(s)** *(i.e. Knotter Frames & all associated parts)*: These are the critical parts of the tying mechanism. They must be reliable & allow easy, precise adjustment. The trusser's original knotter components will almost certainly be worn *(and not particularly reliable)* after many years' service **- *Replace***
- **Knotter Cam Gears:** These mate with the Knotter Units and are make/model-specific to them. They must therefore also be replaced at the same time **- *Replace.***

Seeing as only the Knotter Units and associated Knotter Cam Gears are being replaced *(Fig.4.2)*, the job would appear to be an easy one. If only! The real challenge is to successfully install these replacement components into the machine, so that they interact properly with the existing/original parts which are being retained.

But what should you fit, where should you get them from and how do you know if they are likely to suit your particular machine?

4.2 Replacement Parts – What and From Where?

So where do you obtain some decent Knotter Units and corresponding Cam Gears from? Also, what particular type of knotters should you use? Which are most likely to suit your machine?

Deering or McCormick-type Knotters?

Both Deering and McCormick-type knotter units are still manufactured and they *(and their component parts)* are readily available, either from OEMs *(Original Equipment Manufacturers)* or agricultural machinery replacement parts suppliers. At one time baler manufacturers may have manufactured their own knotters, but today this is rarely the case. Most now source knotters from specialist manufacturers such as Rasspe *(part of the Schumacher Group)*, who design & build a range of both Deering and McCormick-type knotter assemblies.

So which knotter type should you go for? I would suggest your selection should be influenced by two factors:

- What generic type of knotter was originally fitted to your trusser or binder?
  'Moving knife' *(Deering)* or 'Static knife' *(McCormick)*? It's probably simpler ***(but not essential)*** to keep with the same basic type as was originally used
- Whether you intend to fit new or second-hand knotters *(i.e. how much money you wish to spend)*?

Back in the day, the majority of trusser manufacturers fitted Deering-type *(moving knife)* knotters *(see Table 1)*. Also, importantly, many more *(conventional)* baler manufacturers used Deering knotters and this is reflected in the cost & availability, of both second-hand *(ex-baler)* knotters and *(new)* replacement parts. The larger the number of machines still in operation which require parts, *(generally)* the more reasonable the cost of these parts.

Finally, it is generally recognised that, having suffered wear in-service, McCormick-type knotters are more 'temperamental' than comparable Deering-type knotters with a similar number of working hours under their belts.

Bottom Line: Unless you are a 'dyed-in-the-wool' Claas or Welger baler enthusiast with a collection of suitable scrap balers or spare parts at your disposal, a Deering-type knotter is likely to be the most prudent, replacement choice.

New or Second-hand?

Unless you've got money to spare, there is little point in buying new Knotter Units. They are readily available from aftermarket *(baler)* parts suppliers, but at a considerable cost. Far better instead to keep an eye open for a complete 'Knotter Stack' *(i.e. the knotter driveshaft, knotter units, cams gears & associated components)*, as removed straight from a scrap conventional *(small, square)* baler *(Fig.4.3)*.

Baler knotter stacks often turn up on internet auction sites, social media marketplaces, classified ads & at farm dispersal sales. Expect to pay something in the range ~£75 - £150. Alternatively, consider purchasing a complete 'spares or repair' baler *(often available for less than £450)*, remove the parts you want *(Fig.4.4)* and re-sell or scrap the rest: **BUT**, before you rush off, **read the 'Do's & Don'ts' box**.

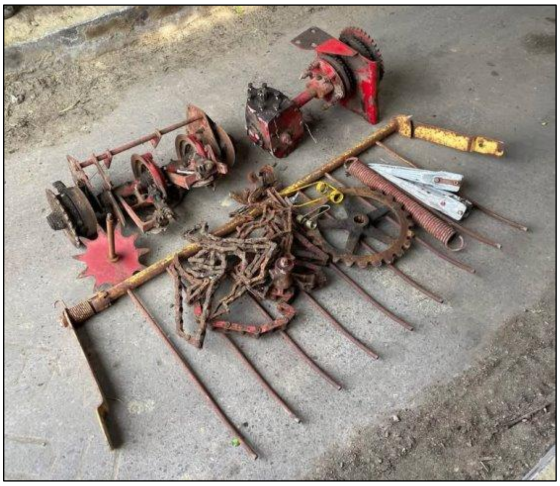


Fig.4.3 Second-hand New Holland baler parts *(£150)* – Knotter Stack top left

Fig.4.4 Knotter Stack on a second-hand 'spares or repair' New Holland baler

Sourcing Second-hand Baler Knotter Parts - Do's and Don'ts

- **ALWAYS** inspect parts carefully for wear & possible damage
  - **Knotter Frame:** Inspect for possible cracks. A robust component, but it can get damaged
- **ALWAYS** expect & budget to replace certain key components:
  - **Bill Hooks:** May be rusty & pitted
  - **Twine Discs and/or Retainers:** May be worn
  - **Stripper/Knife Arm *(Cam)* Rollers:** Will almost certainly need renewing – are cheap to replace
- **KEEP an Eye on the Bottom Line:** These spare parts are readily available & are not difficult to fit, **BUT** if the 'list' becomes too long, a new *(or a better second-hand)* knotter may be a better prospect
- **BEFORE removing the Knotter Stack from a Baler, ALWAYS mark the Cam Gear's position relative to the Knotter Frame** *(with the Knotter in the 'at-rest' position) (see Section 5.4.2 & Fig.5.14).*

Where to Source Second-hand Parts?

Deering-type knotters were used on Conventional Balers manufactured by New Holland, John Deere, Bamford, Deutz-Fahr, Jones/Allis-Chalmers and on later McCormick International machines *(see Table 1)*. Consequently, knotter units and cam gears obtained from any of these balers will probably fit the bill, **BUT** it is important to obtain **both** the knotters and the cam gears from the same machine, or ensure that you have the correct *(mating)* parts.

Of these manufacturers, New Holland machines are almost certainly the most numerous in the UK, many 1000s having been sold since the mid-1950s. This provides a ready supply of ageing 'spares or repair' machines from which suitable parts can be sourced. New Holland balers particularly suitable for supply of knotters would include the Hayliner 68, 78, 200 series, 300 series and 900 series.

4.3 Can My Machine be Upgraded?

A fairly important question! This guide shows the way in which the knotters on a Howard trusser were replaced with those from a New Holland baler. But what if you have a Ruston & Hornsby or a Massey Harris machine? Will the same approach still work on your particular machine?

The key requirements in order to replace/upgrade the knotter assemblies on a Trusser by this method are that the:

- Replacement Knotter assemblies (i.e. Knotter Units + Cam Gears) must mount on to the existing Knotter (drive) Shaft – and the Knotter Units be prevented from rotating
- Cam Gears must be driven by the Knotter Shaft *(the shaft rotates freely inside the stationary Knotter Units)*
- Trusser's existing/original Needles must be able to pass through the replacement Knotter Units:
  - Without colliding with anything
  - To place the twine in the correct location *(i.e. into the Knife Arm twine groove, over the Bill Hook jaws & into the Twine Disc notch)* to ensure reliable knotter operation.

This all might sound rather complicated. To simplify things, there are a few key questions you need to answer, to determine whether or not this upgrade will work on your machine.

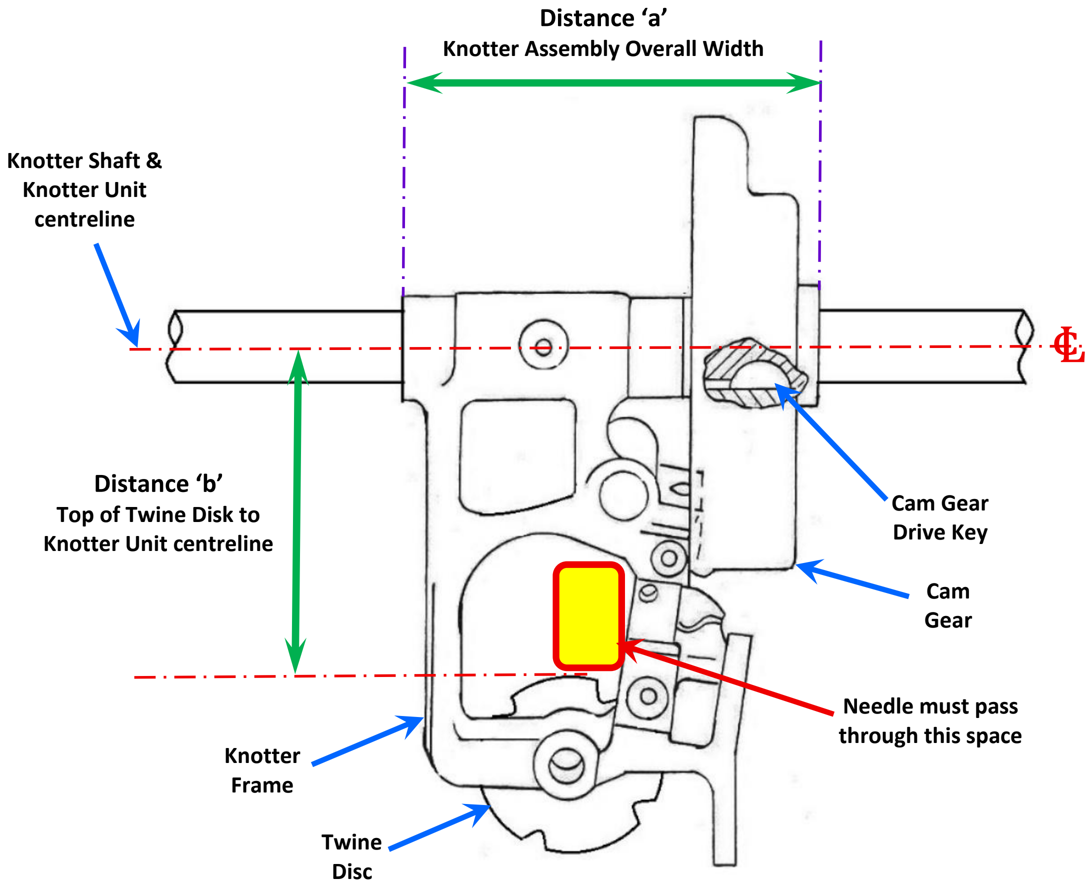


Fig.4.5 Replacing the knotter assembly – Important dimensions

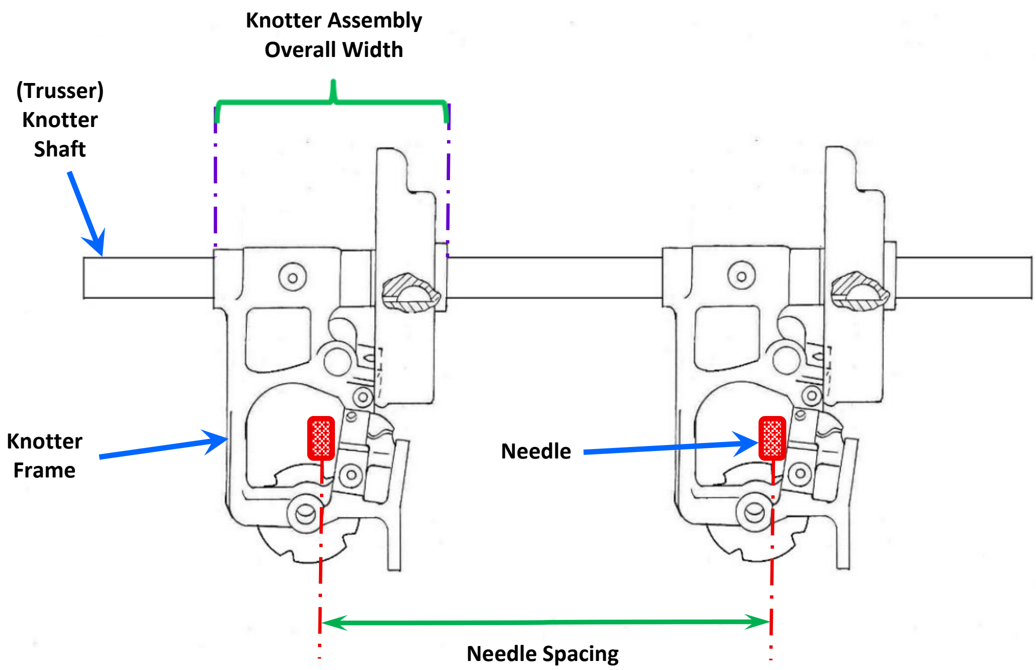


Fig.4.6 Arrangement of replacement knotter components on the knotter shaft – Important dimensions

Key Questions to Ask / Things to Check *(see Figs 4.5 & 4.6)*

- **Knotter Assembly overall width?** o Are the replacement Knotter Assemblies narrower / no wider than the original Knotters? ***(Distance 'a' - Fig.4.5)***

  o Will they fit in the space occupied by the old knotters?

  (N.B. A New Holland baler knotter assembly = 173 mm wide)

- **Knotter Assembly spacing?** o Can the replacement Knotters be arranged on the original/existing knotter shaft to suit the machine's existing:
  - Needle location?
  - Needle spacing?

- **Needle – Twine Disc clearance?** **THIS IS VERY IMPORTANT!**

  o Will there be enough clearance between the Twine Disc upper edge & the underside of the Needle? *(Ideally 3 - 5 mm)*

  o Is distance from Knotter Shaft / Knotter Unit centreline to top edge of Twine Disc ***(Distance 'b' - Fig.4.5)*** on the Replacement Knotter no smaller than on the old knotters?

  (N.B. Distance 'b' on a New Holland baler knotter = 130 mm)

- **Is the Knotter Shaft diameter too large?** Baler Knotter Frames can be bored-out to accept existing *(trusser)* shafts of up to approx. Ø35 mm *(see Section 5.4.1)*. Anything larger is pushing the limit

- **Are any of the Discharge Arms mounted on the existing Cam Gears?** This complicates things a bit, but it can be worked around *(see Sections 5.3 & 5.4.3)*.

Table 2 Popular Trussers – Suitability for upgrading with *(New Holland baler)* replacement knotters

Trusser type	***(Replacement)* Knotter Assembly Width OK?** *(Distance 'a')*	**Needle to *(Replacement)* Knotter Twine Disc Clearance OK?** *(Distance 'b')*	***(Existing)* Knotter Shaft Diameter OK?**	**Other Possible Challenges?**
Howard	YES	YES	YES	-
Ruston & Hornsby	YES	YES	YES *(just)*	• A Discharge Arm is mounted on each *(existing)* Cam Gear • Will require relocating
Massey-Harris	YES *(just)*	YES	YES	• A Discharge Arm is mounted on each *(existing)* Cam Gear • Will require relocating
Albion	Very probably	Not verified	Very probably	• A Discharge Arm is mounted on each *(existing)* Cam Gear • Will require relocating

To save you having find answers to the questions, Table 2 answers them for the popular makes of Trusser in use today ***(assuming that New Holland baler replacement knotters are fitted).***

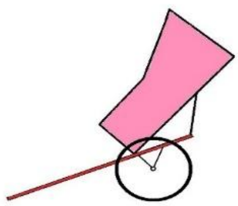
The key 'deal / no deal' question concerns the distance between the Replacement Knotter's Twine Disc and the Knotter Shaft centreline ***(Distance 'b' - Fig.4.5)***. Whilst it **may be possible** to move the existing Needles sideways slightly *(assuming they aren't seized on their shaft)*, it almost certainly won't be possible to modify the position of the Knotter Shaft.

The Needle must pass correctly through the Knotter Frame *(through the yellow-shaded area in Fig.4.5)*, to deliver the twine into the Knife Arm twine groove, over the Bill Hook & into the waiting Twine Disc 'notch'. So, **Twine Disc position is critical**, and this depends on the length of the replacement Knotter Frame ***(Distance 'b')***.

Fortunately, it seems that the Deering-type knotters fitted to New Holland conventional balers will 'fit the bill'; even being suitable for Trussers which originally utilised McCormick-type knotters.

It is possible to adjust the Needle's arc of movement very slightly. Binder & Trusser needles ***(N.B. Not Baler needles)*** are made of malleable cast iron and can be bent slightly upwards/downwards *(with care following gentle heating)* to correct minor discrepancies in the Needle-Twine Disc clearance.

Click on the Trusser icon or scan the QR code for video of (modified) Trusser Needle operation



5 Steps in the Knotter Replacement Process

5.1 (Workshop) Safety

SAFETY WARNING

The maintenance, repair and modification of agricultural machinery create risks which need to be managed, so:

PLEASE BE AWARE OF THE RISKS, ASSESS THEM AND TAKE APPROPRIATE STEPS TO MANAGE THEM

Hopefully it is reasonable to assume that you wouldn't even be considering performing the machine modifications outlined in this Guide, unless you are familiar with undertaking mechanical work in a workshop. If you are, that would indicate that you are also familiar with the safety risks present in such working environments and the steps you should take to manage those risks.

Unfortunately, little can be taken for granted in this modern world. So, for safety's sake, here are a few basic safety tips, just to try & ensure that you go home from the workshop at night with all the personal bits & pieces *(and faculties)* that you arrived with in the morning. Joking apart, it only takes one momentary mistake or lack of care/attention for something undesirable to happen!

Workshop Safety - Do's and Don'ts

- **ALWAYS** wear appropriate **Personal Protective Equipment (PPE)** for the job in question
    - **Clothing:** Wear appropriate overalls. Avoid loose clothing, jewellery or anything which could get caught in machinery
    - **Footwear:** Wear sturdy, steel toe-cap shoes or work boots to protect from falling objects
    - **Hearing Protection:** Use earmuffs or earplugs when working with loud machinery or tools
    - **Eye Protection:** Always wear safety glasses or goggles when working with tools, especially those which produce debris or sparks
- **KEEP** the Workshop clean & organised, clear of clutter & debris, particularly where 'hot work' *(i.e. welding or heating)* is undertaken or sparks are produced
- **ENSURE** adequate lighting in the work area *(to improve visibility & risk of accidents)* and good ventilation *(to remove dust & fumes)*
- **KNOW** the location of emergency equipment such as Fire Extinguishers & First Aid Kits
- **USE** the correct tool for the job & ensure that it is in good condition *(especially electrical power tools & extension leads)*
- **ALWAYS** chock the wheels of a wheeled machine, to prevent it from moving
- **NEVER** work under a machine if it is only supported by a jack. Use appropriate axle stands or stout wooden blocks to support it.

5.2 Observe, Plan and Prepare

It's much better to do this and avoid getting caught out with a machine in bits on the workshop floor and no clear idea of how to get it back together & working again. We've all been there at one time!

Observe Your Machine Before You Start to Modify It, both:

- When the Knotters are in the 'at-rest' position
- During a tying cycle, whilst the machine is turned over *(slowly)* by an assistant

Take Photos, Video Clips and/or make Sketches

- Take careful note of the relative positions & movement(s) of the various machine parts
- Take plenty of photos of key components *(see Figs 5.1, 5.2 & 5.5)*:
  - Knotter units, cam gears & means of knotter unit support / fixing to the machine
  - Discharge arms
  - Needles & their movement into & out of the Knotter Units. Particularly the needle's arc of travel & position(s) relative to the original knotter units
  - Knotter shaft & shaft support components
  - Knotter *(shaft)* drive gears/sprockets & knotter trip mechanism *(when 'at-rest') (Fig.5.2)*
  - Needle *(shaft)* crank arm & connecting rod *(attaches to knotter shaft drive gear/sprocket) (Fig.5.2)*
  - Cam follower & associated *(Compressor Arm)* operating linkage *(runs in a cam track in the rear face of the Knotter Shaft drive gear/sprocket)*
- *(Ideally)* record video clips of component movement & their relative positions during a tying cycle, whilst the machine is turned over *(slowly)* by an assistant. **Take particular care whilst doing this and beware of moving components!**

SAFETY WARNING

Measure/Record the Relative Positions and Orientations of Key Components

Measure the locations of the original *(existing)* knotter shaft components relative to suitable fixed datum points *(i.e. things which will remain on the machine & won't be moved)*. Pay particular attention to the:

- Knotter Unit *(Knotter Frame)* lateral location & spacing on the Knotter Shaft. Also, their lateral position relative to the Needles *(see Figs 4.6 & 5.1) (if this isn't being modified)*
- Knotter Unit *(Frame)* angular position/orientation on the Knotter Shaft with respect to:
  - The Trusser's Deck
  - The Needles as they pass through the Knotter Frames during the tying cycle
  - Discharge Arms:
  - Lateral position & spacing on the Knotter Shaft *(Fig.5.1)*
  - Angular position/orientation *(when 'at-rest')* relative to the Trusser's Deck.

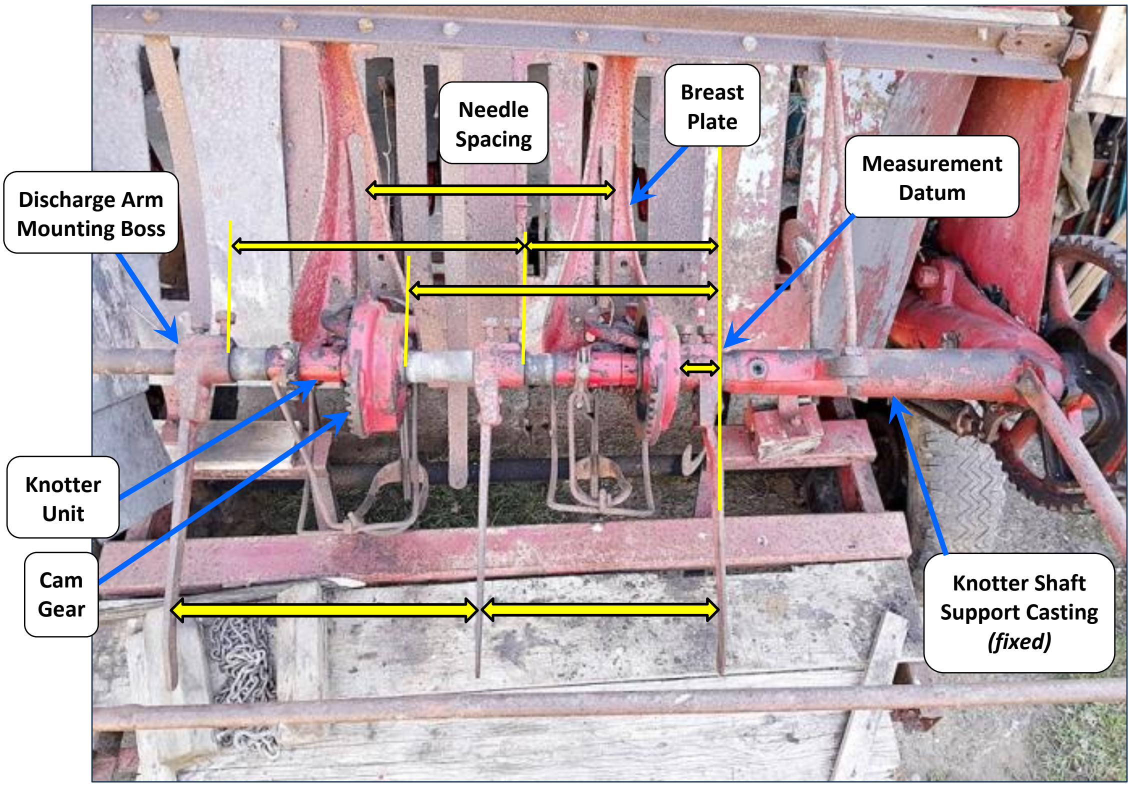


Fig.5.1 Howard trusser knotter shaft – Suggested component lateral location measurements to record

- **Note** use of end of knotter shaft support casting as a measurement datum *(fixed reference)* point

Plan the Work

What's the best order in which to perform the various bits of the work? Ask yourself the following questions to help work out a plan to follow:

- Which original components will be:
  - Removed *(to gain access)* & subsequently be refitted?
  - Removed and be replaced with something else? *(see Section 4.1)*
- Will any of the *(new)* replacement components require modification? If so, in what way?
- Which original components will require modification in order to interface with the new, replacement components?
  - How will they need to be modified?
  - Can it be done whilst they are on the machine or will they need to be removed?

Generally, try to disturb as few of the original components as possible. Chances are that their fixings will be seized and their attempted removal may cause undesirable damage. Think about different ways in which various parts may be removed & refitted/substituted whilst minimising the effect(s) on the surrounding parts of the machine.

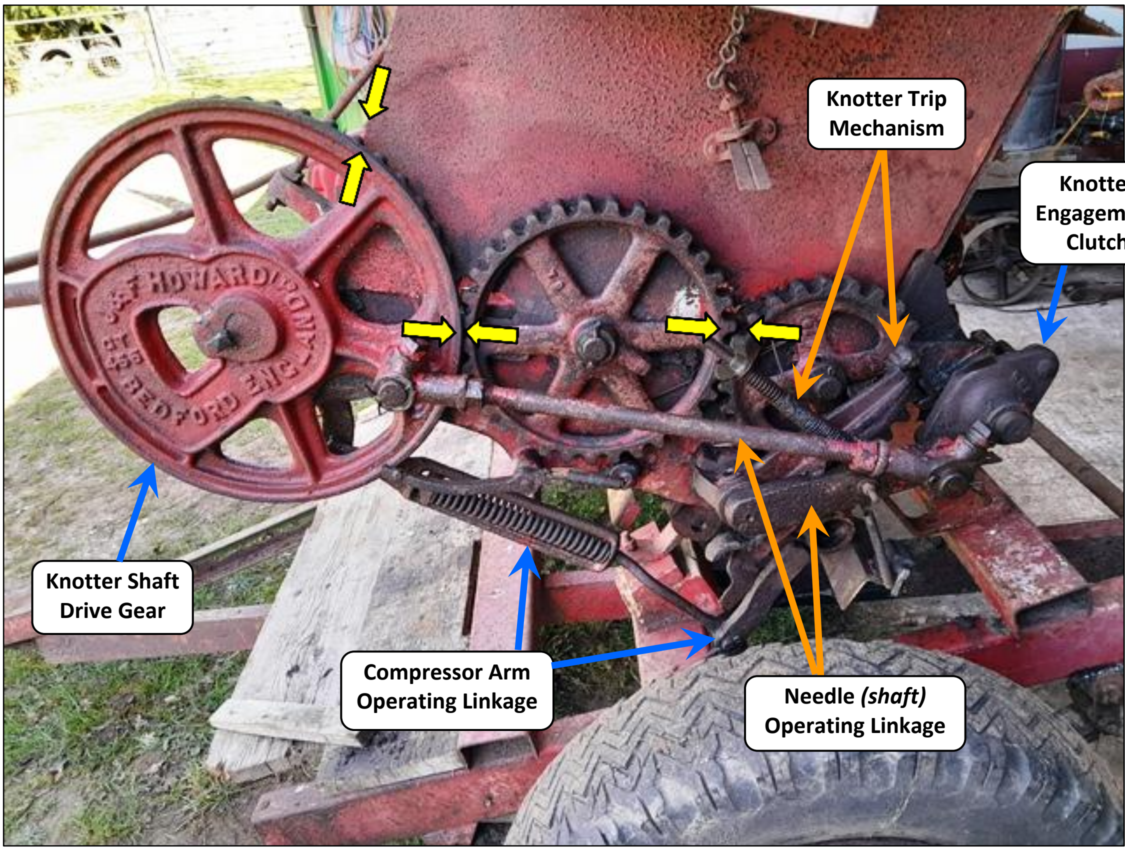


Fig.5.2 Howard trusser tying & discharge drive mechanism – Ruston & Hornsby machines are very similar

- **Note** the possible locations for adding reference/timing marks *(Yellow arrows)* prior to commencing machine disassembly/modification *(if timing marks are not already present)*

Prepare the Machine

Finally, before you start taking things apart:

- Ensure the Knotters, their drive mechanism & the Needles are in the 'at-rest' position *(i.e. following a tying cycle)*
  - This is also evident by the position of the Discharge Arms
  - Note the position of the *(Knotter Shaft & Needle)* drive gears/sprockets
  - Relative to each other and also to parts of the machine which aren't likely to be disturbed during the work *(Fig.5.2)*
  - If not already present, paint 'timing marks' on the meshing points of the gears/sprockets, so they can easily be replaced in the same position if they have to be removed
  - If possible, restrain the gears/sprockets to prevent undesired movement during the work.

N.B. **ENSURE** no attempt is made to rotate the knotter drive mechanism or pass loading through the restrained components during the modification process: otherwise, damage may result.

Fig.5.3 Non-return Pawl on a Howard trusser- Engaged *(left)* and disengaged *(right)*

- Engages in a notch on periphery of the knotter shaft drive gear *(arrowed)* at end of the tying cycle, to prevent the tying mechanism accidentally turning backwards. When engaged, it also provides a useful *(angular)* reference point for the knotter shaft when in the 'at-rest' position

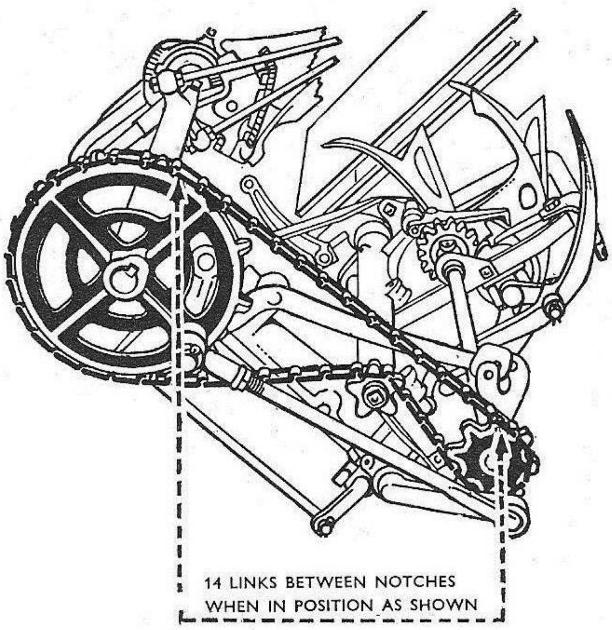


Fig.5.4 Correctly timed knotter & sheaf/truss discharge mechanism on a *(chain-driven)* Massey-Harris machine

When the Knotters & Truss Discharge Mechanism are 'at-rest' following a tying cycle:

- **Machines with a Gear *(or Gear & shaft)*-driven Knotter Shaft** *(e.g. Ruston & Hornsby, Howard, Albion)*
  - Timing marks *(found on each gear)* should coincide with each other *(Fig.5.2)*
  - Non-return pawl *(on Howard machines)* should be in notch on Knotter Shaft Drive Gear *(Fig.5.3)*
- **Machines with a Chain-driven Knotter Shaft** *(e.g. Massey-Harris)*
  - There should be 14 drive chain links between the timing marks on the driving & the driven sprockets *(Fig.5.4)*

5.3 Remove the Original Components *(see Figs 5.5, 5.6 & 5.7)*

Now before you start taking things apart, remember that you are only renewing the Knotter Units and their Cam Gears. Nothing else needs to be touched unless its removal is necessary to gain access to or allow removal of, the Knotters & Cam Gears *(see Table 3)*.

So, pause for a moment to figure out the smartest way of doing this on your machine, whilst disturbing as few of the surrounding bits as possible.

Table 3 Machine parts to be removed during trusser disassembly

Replace with New/Upgraded	Remove & subsequently Refit
• Knotter Units • Cam Gears	• Discharge Arms • Breast Plates *(Knotter mounting brackets)*

Remember:

- The Knotter Units & Cam Gears are mounted on the Knotter Shaft, **BUT** it may not be necessary to completely remove the Knotter Shaft and its drive gear/sprocket from the machine in order to remove the Knotter Units, Cam Gears & Discharge Arms**:**
  - On some trussers *(e.g. Howard, Massey-Harris and Albion machines (Figs 5.5 & 5.6))*, the left-hand *(undriven)* end of the Knotter Shaft is supported by a simple bracket & bearing
  - Removal of this support bracket and/or bearing and *(if necessary)* partial withdrawal of the Knotter Shaft towards the right-hand side of the machine, will permit the various components to be slid off the far *(left-hand)* end of the shaft
  - On certain other makes of trussers *(e.g. Ruston & Hornsby (Fig.5.7))*, the Knotter Shaft is supported at both *(left & right-hand)* ends by fixed support castings. The Knotter Shaft components are sandwiched between the ends of the Support Castings and *(where necessary)* held laterally by the Discharge Arm mounting bosses & other fixed components *(e.g. the left-hand Cam Gear)*
  - In these instances, the Knotter Shaft must be withdrawn much further in order to permit removal of the various components from the shaft.
  - Irrespective of machine design, if you have to partially withdraw the Knotter Shaft, it will be necessary to:
  - Remove the Needle & Compressor Arm operating linkages from the Knotter Shaft Drive Gear *(and the drive chain on chain-driven machines)*
  - Slacken & free-off all the Discharge Arm mountings on the shaft
  - Free off the existing Cam Gears, which are keyed to the shaft. On some machines *(e.g. Ruston & Hornsby)*, this may require the removal of an external 'gib-headed' key from one or more of the Cam Gears
  - **Look carefully & make sure that ALL the component fixings are loosened or removed BEFORE attempting to withdraw the Knotter Shaft.**

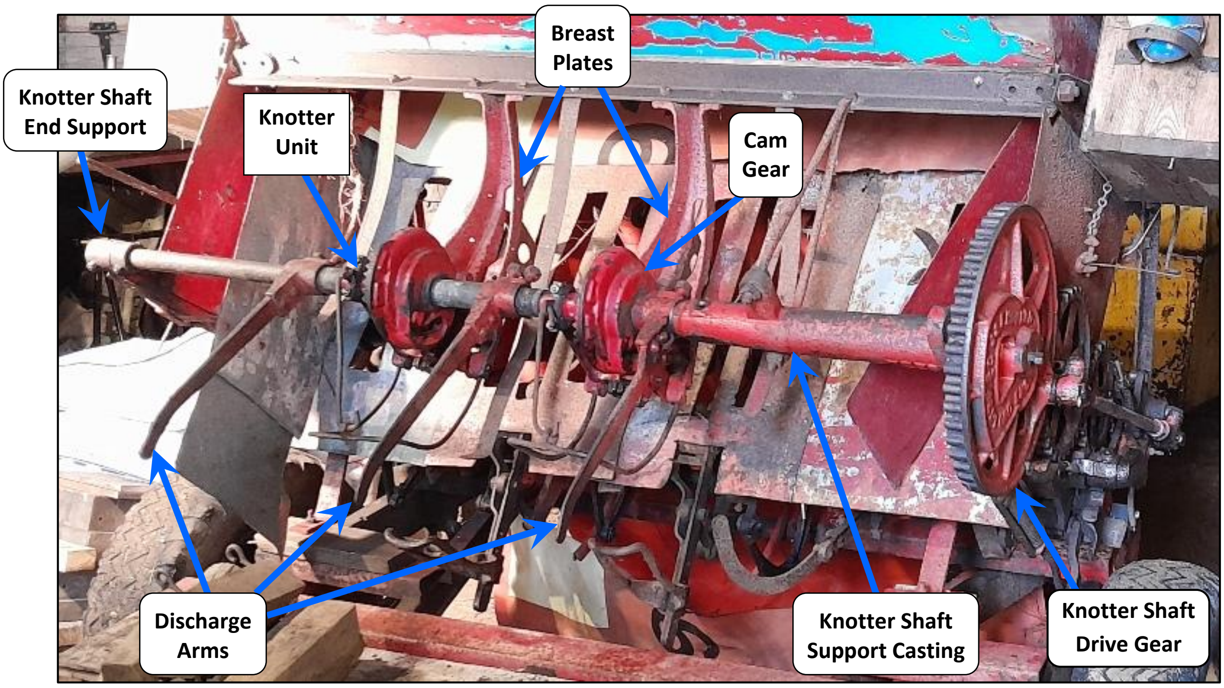


Fig.5.5 (Modified) Howard trusser knotter shaft components, shown in the 'at-rest' position

Fig.5.6 Massey-Harris double band trusser, showing arrangement of components & means of knotter shaft support.

- **Note** the support casting is only fitted on the right-hand end: left-hand end supported by a bracket

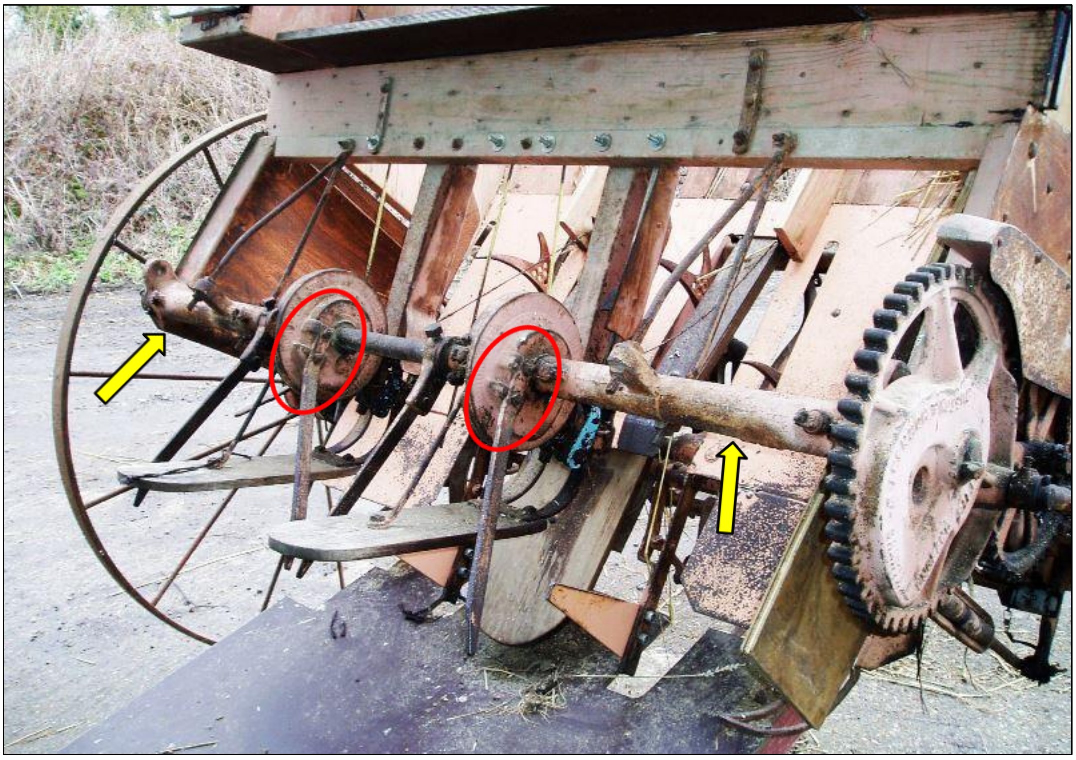


Fig.5.7 Ruston & Hornsby double band trusser, showing arrangement of components

- **Note** rigid support castings *(arrowed)* present on both right & left-hand ends of the knotter shaft
- **Also,** certain discharge arms *(circled)* attach directly to the knotter cam gears

Discharge Arms

- **Machines designs differ!** *(see Table 2).* The truss Discharge Arms can either be:
  - **a)** Attached to *(cast)* mounting bosses which are clamped to the Knotter Shaft by studs, which screw into recesses / holes machined in the shaft *(see Fig.5.11)*. The *(clamped)* mounting bosses also prevent other components from moving along the shaft
  - **b)** Attached to the outer *(non-drive)* side of the Knotter Cam Gears

  Howard trussers only use method (a) *(Fig.5.5)*, **BUT** Massey-Harris, Ruston & Hornsby and Albion machines use a mix of methods (a) & (b) – *(Figs 5.6 & 5.7).*

- Even if the Knotter Shaft can remain largely undisturbed during the knotter upgrade process *(e.g. Howard, Massey-Harris & Albion machines)*, some or all of the *(boss-mounted)* Discharge Arms must be slackened & removed from the shaft before the Knotters & Cam Gears can be removed *(Figs 5.5 & 5.6)*. The clamping screws may undo without issue, **BUT** the bosses will probably have been in place for many decades & may be seized to the shaft

- For Ruston Hornsby machines *(where the Knotter Shaft must be almost completely withdrawn from the machine to permit removal of the knotter components)*, the *(two)* boss-mounted Discharge Arms must be freed-off

- **Proceed carefully in order to avoid component damage.** Clean the exposed shaft, use penetrating oil *(allow time)*, and soft-faced *(copper)* hammers or drifts. If you do resort to 'heat', apply this gradually & evenly over the mounting boss, to avoid localised heat concentrations & possible cracking. A blowlamp is probably a safer option than an oxy-acetylene torch!

Knotter Units

- Are supported by the Knotter Shaft and should slide off it, **BUT** the Knotter Units *(knotter frames)* are also fixed *(usually bolted)* to the trusser's Breast Plates, which:
    - Secure the Knotter Units at the correct angle relative to the Needle's arc of travel
    - Prevent the Knotter Frames from rotating with the Knotter shaft
- The Breast Plates on most trussers are rather delicate castings, so, treat them with care! **Detach the Knotter Units from the Breast Plates BEFORE attempting to slacken or remove anything from the Knotter Shaft.**

Cam Gears

Once again, machine design & construction differs according to the manufacturer, so look carefully & work out how the components are retained **before** attempting their removal

- Knotter Cam Gears are always secured to the Knotter Shaft by a central keyway *(see Fig.3.7)*. **However,** this may receive a 'parallel' or, alternatively, a 'tapered' *(gib-headed)* key:
    - **Parallel *(or Woodruff)* Key:** *(as used on most trussers and all conventional balers).* The Cam Gear should slide over the key and along/off the Knotter Shaft
    - **Tapered Key:** *(used on the left-hand Cam Gear of Ruston & Hornsby & possibly some other machines).* This type of key is used to lock the gear to the shaft, **both** to transmit drive **and** to prevent it from moving sideways. **It must be removed** *(by use of a key drift)* **BEFORE attempting to remove the Cam Gear and/or withdraw the Knotter Shaft**
- **Remember** *(as with the Discharge Arm bosses)*, irrespective of their fixing key type, the Cam Gears will probably have been in place for many decades, may well be tight and require some 'encouragement' to move. **BUT** make sure that any form of 'locking' key is removed first!
- Again, employ the techniques recommended earlier and **proceed with care. These are fragile & difficult to replace components!**

Also Remember to:

- **KEEP** the (right-hand) Knotter Shaft Support Casting in place at all times and use its left-hand end as a *(lateral)* measurement datum / fixed reference point during the upgrade process *(see Fig.5.1)*
- **NOTE** the location, orientation and means of fixing of all components during the removal process.

5.4 Modify the Replacement Components

The components which need to be replaced *(see Section 4.1)* are the:

- **Knotter Units**:
  - The Knotter Frames & all associated components
  - Are supported & located by the Knotter Shaft, but aren't actually fixed to it *(the shaft rotates inside the Knotter Frame)*
- **Cam Gears**:
  - Which mate with & drive the Knotter Units
  - Are fixed *(keyed)* to the Knotter Shaft & rotate with/are driven by it

If 'conventional' baler parts are to be used, they will require the following modification to enable them to fit onto the Trusser:

Table 4 Modifications to make to replacement knotter components

Knotter Units	(Knotter) Cam Gears
• Enlarge *(bore-out)* Knotter Frame bore to suit diameter of Trusser Knotter Shaft • Devise suitable restraining methods to: ○ Keep Knotter *(frame)* in the correct lateral position *(relative to each Needle)* ○ Ensure Knotter to Cam Gear 'end float' clearance is correct ○ Hold Knotter in the correct angular position to: ▪ Suit the Needle's travel path ▪ Prevent it from rotating with the Knotter Shaft • Check & *(if necessary)* renew key knotter components *(e.g. bill hooks, twine knives, knife arm rollers. Perhaps twine retainers and/or twine discs)*	• Enlarge *(bore-out)* central hole to fit Trusser Knotter Shaft • (Re)-cut *(central)* drive keyway to suit: ○ Size & angular position of Knotter Shaft drive key, **and** ○ Angular position of new/replacement Knotter Unit *(frame)*

5.4.1 Knotter Units

Enlarge the Knotter Frame Bore

The Knotter Frames mount on the Knotter Shaft, so their bore is determined by the shaft diameter *(Fig.5.8)*. The knotter units of conventional *(small)* square balers are designed to suit ~Ø28-30 mm shafts.

Those of American or older UK-manufactured balers are usually designed to mount on a Ø1⅛ ins (Ø28.58 mm) knotter shaft and therefore have a bore of Ø28.6 mm. **Remember, a certain running clearance is required.**

Unfortunately, the knotter shafts of Victorian-era straw trussers are of a much larger diameter; typically Ø$1^{5}/_{16}$ - 1⅜ ins (~Ø33.3 - 35 mm).

Fortunately, conventional baler Knotter Frame castings are sufficiently thick to allow their bores to be machined-out to suit these much larger diameter knotter shafts *(see Table 2)*.

This requires accurate measurement of Knotter Shaft diameter and then use of a Lathe to enlarge the mounting bore sufficiently, to give a slight running clearance on the shaft.

This is a slightly challenging machining task so, unless you have the equipment & the experience, this may perhaps be best entrusted to a professional machinist.

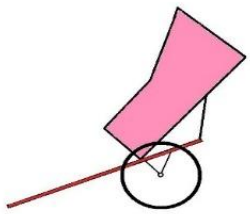
Fig.5.8 Deering-type knotter *(side view)*

Hold the Knotter Unit in the Correct Lateral Position

Each Knotter Unit must be held in the correct lateral position on the Knotter Shaft *(see Fig.4.6)*, so that when the Needle delivers the twine during the tying cycle, it is placed in the correct *(lateral)* location, into the Knife Arm twine groove, over the Bill Hook & into the waiting 'notch' in the Twine Disc *(Figs 5.10 & 5.19)*.

In order to do this, the Needle must pass precisely through the correct part of the Knotter Frame *(see yellow-shaded area in Fig.4.5)*.

This is an essential requirement for reliable knotter operation.



Click on the Trusser icon or scan the QR code for video of Trusser Knotter operation

Fortunately, the original design of trusser *(or binder)* knotter shaft assemblies makes the lateral spacing of replacement knotter & cam gear assemblies much less challenging:

- The *(sideways)* position of the right-hand Knotter Shaft Support Casting is always fixed. All the other components are spaced along at given distances from the inner end of the Support Casting *(see Fig.5.1)*
- The locations of the Discharge Arm Mounting Bosses on the Knotter Shaft are also fixed, because the boss securing bolts locate into holes / recesses machined in the shaft
- The Bosses therefore act as clamping collars *(with or without spacing tubes)* to:
  - Hold the Knotter Units in place against the Cam Gears (*on all trusser makes* – see Figs 5.1, 5.5, 5.6 & 5.7)
  - Keep the Cam Gears in place against the Knotter Units (on *Howard and all 'modified' machines* – see Figs 5.1 & 5.5)

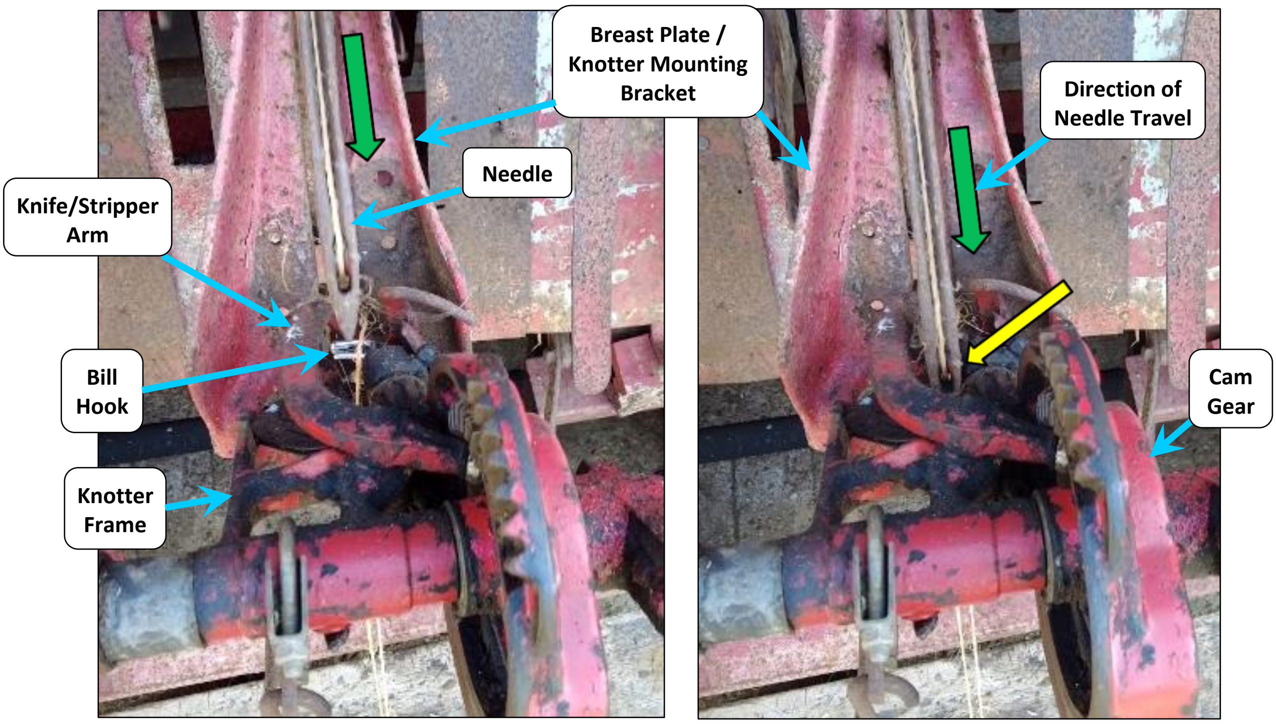


Fig.5.9 (Modified) trusser knotter assembly during early stages of the tying cycle *(viewed from above).*

- Needle is about to pass over the bill hook *(left image)* & through the knotter frame *(right image)*
- Side of needle should rub lightly on, or just clear the knotter frame at the indicated point *(Yellow arrow)*

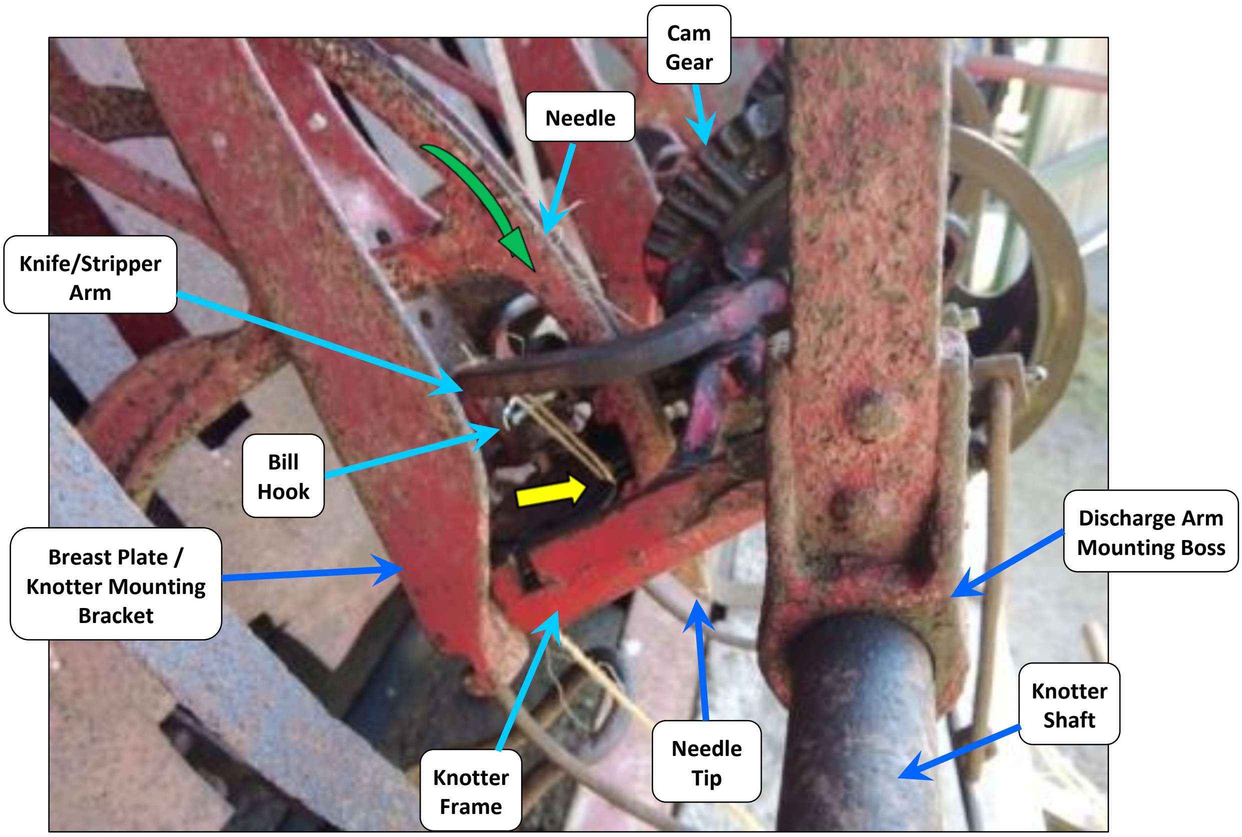


Fig.5.10 (Modified) trusser knotter assembly during early stage of the tying cycle *(viewed from the side)*

- Needle is passing through the knotter frame & delivering the twine into the Knife Arm twine groove, over the bill hook & into a notch in the twine disc *(Yellow arrow)*

- Although Ruston & Hornsby, Massey-Harris and *(probably)* Albion machines use a tapered key to fix the left-hand Cam Gear to the Knotter Shaft, thereby controlling both its angular and lateral position *(see Section 5.3)*, **when the machine is 'modified' this is replaced by a parallel key.** The left-hand Cam Gear is then secured *(laterally)* by either:

  a) A 'spacer tube' of appropriate length, fitted over the Knotter Shaft and butted against the previous Discharge Arm Mounting Boss *(see Fig.5.5)*

  b) An additional locking/clamping collar, which could also be keyed to the Knotter Shaft and *(if desired)* be designed to carry an additional Discharge Arm.

  These options are discussed further in Section 5.4.3.

Knotter Unit to Cam Gear 'End Float' Clearance *(see Fig.5.17)*

This is adjusted by inserting or removing shim washers on the Knotter Shaft, between the Knotter Frame & the adjacent Cam Gear. Similarly, shim washers are also inserted/removed *(as required)* between the outer faces of the Knotter Frames & Cam Gears and their respective locating collars and/or spacing tubes. See Fig.5.17 for further information.

Secure Knotter Units in the Correct Angular Position

Depending on your trusser's configuration, this might be a bit more challenging. Fig.5.10 shows the *(original)* Needle of a Howard trusser successfully placing twine into a *(replacement)* New Holland baler Knotter Unit, which had been fitted to the machine.

For the knotters to work properly, the replacement Knotter Units *(or rather the Knotter Frames)* must be mounted in the correct angular position, relative to the Needle's travel path. Otherwise, the twine won't be placed correctly into the knotter's Twine Disc & the knot won't be tied.

The position of the Knotter Shaft is fixed relative to the Trusser's Deck: the shaft controls the position of the Knotter Unit's 'bore end'. The length of the knotter unit/frame is also fixed *(see Section 4.3)*. So the only adjustment available is the angular position of the Knotter Unit relative to the Knotter Shaft and the Trusser's Deck and, in reality, this is constrained by the Needle's arc of movement. Fortunately, as summarised in Table 2, it will all work in the majority of cases.

Knotter (Frame) Angular Position - Tips

- Carefully observe & record the angular position of your trusser's original Knotters *(relative to the machine's deck or other suitable fixed reference plane)* prior to their removal
- Ideally the Replacement Knotters should be mounted at approx. 90 degrees to the Trusser's Deck *(Fig.5.11)*, **BUT ultimately:**
  - Knotter Frame angular position should be adjusted to best-suit the Needle's arc of travel, to ensure good twine placement & reliable knotter performance
  - This may require some adjustment and/or modification of the Breast Plates *(Knotter Mounting Brackets)*, whether to enable the securing tabs of the replacement knotters *(Fig.5.8)* to attach correctly or to obtain the correct knotter *(frame)* orientation.

(continued)

- In any case, this aspect *(Knotter Unit mounting & angular position)* **must be resolved before proceeding further with the modification.** Otherwise, it is not possible to determine where to cut the new *(drive)* keyway in each Replacement Cam Gear *(see Section 5.4.2).*

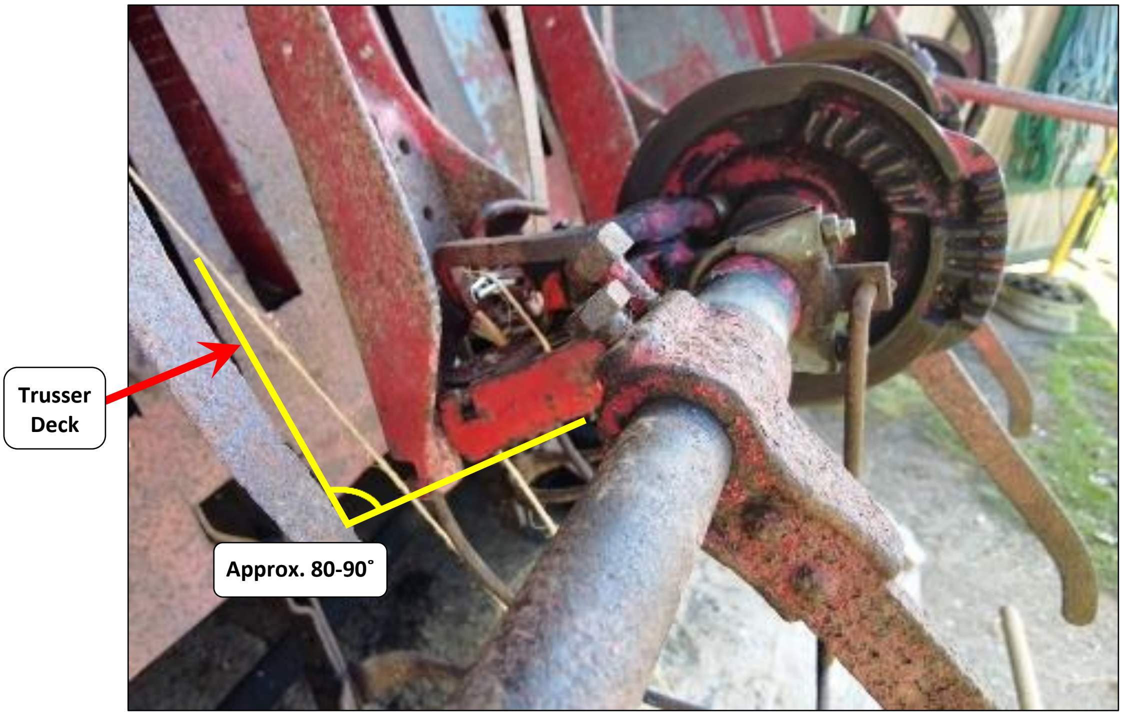


Fig.5.11 (Modified) Howard trusser fitted with New Holland baler knotters *(shown in 'at-rest' position)*

- Suggested angular orientation of the knotter frame(s) relative to the trusser's deck

N.B. The viewpoint makes the angle look greater than 90˚ - In fact it is slightly less than a right-angle

Check / Renew any Worn (Knotter) Components

As discussed in Section 4.2, if *(as suggested)* you utilise second-hand baler knotter parts for this upgrade, expect & budget either to replace or recondition any key components which may be badly worn. Knotter setup & adjustment is covered both by a separate Technical Guide in this series of publications *(see Section 8)* and also in Section 5.6 & Table 5 of this guide.

Still, before fitting the replacement knotters on your trusser, take a look at the following parts *(listed in order of importance & the likelihood of them requiring attention)*. It's a lot easier to sort many of them whilst they are on the Workshop bench, rather than after they are fitted to the Trusser!

- **Bill Hook:** Is critical to reliable knotter performance. Ensure its chrome-plated surfaces are not rusty or pitted. Can sometimes be retrieved by polishing with fine wet & dry paper, **BUT** if in any doubt, replace it. Also make sure that the jaw opens/closes freely & is not worn and the cam roller rotates freely
- **Stripper/Knife Arm *(Cam)* Roller:** Wear over time & will develop flat spots on its surface, resulting in insufficient Stripper Arm travel past the Bill Hook. The roller can also seize on the Knife Arm. Cheap component & easy to replace

- **Blunt or Worn Twine Knife:** Sharpen or replace if badly worn *(unlikely).*
- **Twine Disc & Twine Retainer:** Working surfaces can become worn after many, many years, but much less likely than the above-mentioned items. Replacement components are readily available, if required
- **Bill Hook or Twine Disc:** 'Variable' timing and/or excessive rotational free-travel. Caused by wear in the respective drive pinions. Simple & relatively cheap to replace *(if necessary)*

5.4.2 Knotter Cam Gears

Only two modifications are required to the Cam Gears. One is relatively simple; the other requires a little bit of thought.

Enlarge Cam Gear Central (Mounting) Hole

As noted in Table 4, the central bore of the replacement *(baler)* Knotter Cam Gear *(Fig.5.12)* must be enlarged *(by machining in a Lathe)*, so it can fit onto the Trusser's *(larger diameter)* Knotter Shaft.

The original bore will probably be Ø1⅛ ins (Ø28.58 mm) or Ø30 mm. However, because the Cam Gear is driven by the Knotter Shaft *(via a drive key)*, it will need to be **machined to be a close sliding fit on the Knotter Shaft** with the minimum of free play, as opposed to the slightly larger 'rotating fit' of the Knotter Units.

Enlarging the Cam Gear's bore will probably remove its original drive keyway *(Fig.5.12)*. However, this is helpful because a new keyway *(of a different size & location)* must be cut, to suit drive key(s) on the Trusser's Knotter Shaft.

Cut New Keyway in Cam Gear – and Ensure Correct Knotter Timing

Two important things to consider here:

a) The replacement Cam Gears require a new *(parallel)* keyway cutting in their internal bores, so they can be driven by the existing drive keys on the Trusser's Knotter Shaft, and:

b) The new keyways must be cut in exactly the right angular position inside the bore, to ensure that when the Knotter Shaft rotates during the tying cycle *(operating both the Needles & the Knotter Units simultaneously)*, the various parts of the Knotter Unit are 'timed' correctly relative to the movement of the Needle. If this doesn't happen, it won't produce a Knot and various parts may well collide!

This may all sound like rather too much hassle but don't be put off: it isn't that difficult.

You just need to know which component positions to mark *(or which angles to measure)*, and then make sure that when the replacement parts are installed on the Trusser, the various positions or angles between them are maintained. Here's how to do it.

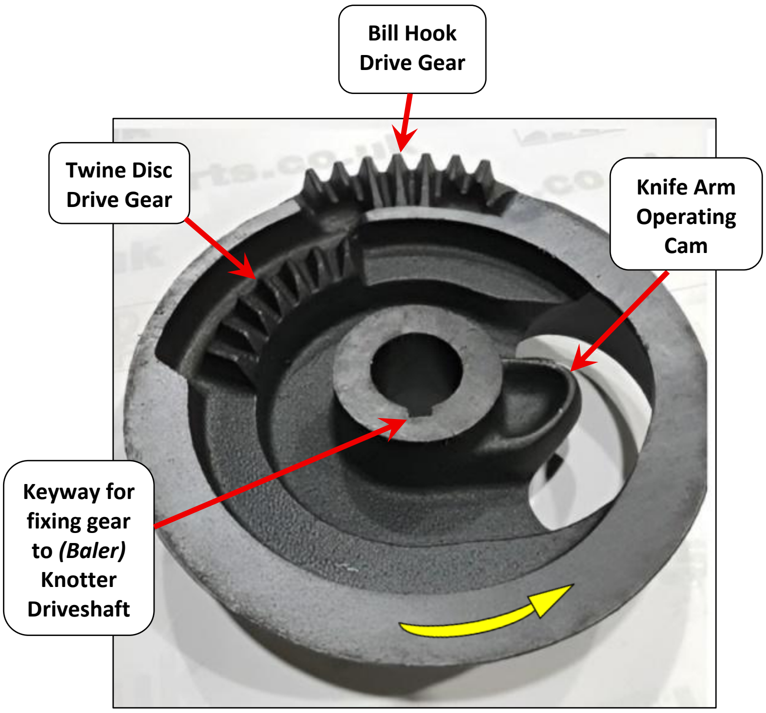


Fig.5.12 Cam gear for Deering-type baler knotter *(courtesy Woodfield Baler Parts)*

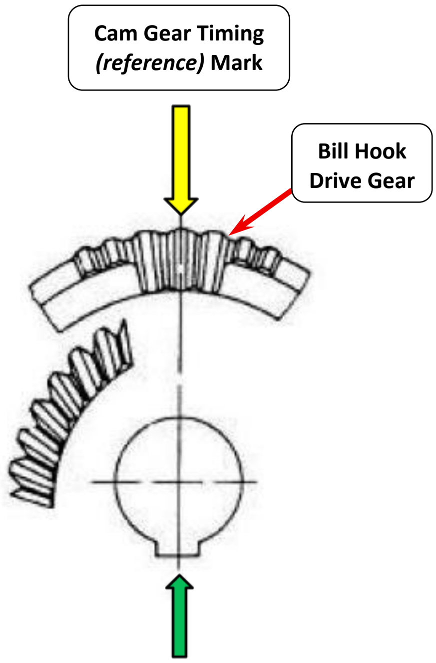


Fig.5.13 Baler knotter cam gear - Normal keyway position *(Green arrow)* is directly opposite the cam gear timing mark *(Yellow arrow)*

Deciding Where to Cut the New Keyway

The simplest way to do this is:

1) **BEFORE removing the Knotters from the donor baler,** mark the position of each Cam Gear relative to the Knotter Frame *(see Green arrows in Figs 5.14 & 5.15(a))*
   - **Ensure** the knotters are in the 'at-rest' position before doing this *(**N.B.** Cam Gear Timing Mark is usually at '12 o'clock' position when knotters are 'at-rest')*
2) Install each *(replacement)* Cam Gear & Knotter Unit on the trusser's Knotter Shaft and:
   - Rotate & hold the Knotter Frame in the correct angular position relative to the Trusser's Deck *(see Figs 5.11 & 5.15(b))*
   - **Ensure** the Cam Gear is still in the correct *(marked)* position relative to the Knotter Frame
3) Now mark the position of the *(original)* Knotter Shaft Drive Key on the side of the Cam Gear *(Fig.5.15(c))*
4) Remove each Knotter Assembly from the Shaft and:
   - Cut a new keyway in each Cam Gear *(in the marked location)* to suit the Drive Key *(Fig.5.15(d))*
   - Check for a good fit onto the Knotter Shaft & you're 'good to go'.

What If the Knotter Frame – Cam Gear Positions Weren't Marked Before Removal?

This complicates things, but the situation is retrievable. All Deering-type baler cam gears feature a Timing *(reference)* Mark: usually the centre tooth of the outer gear set which drives the Bill Hook *(Figs 5.13 & 5.14).*

(continued)

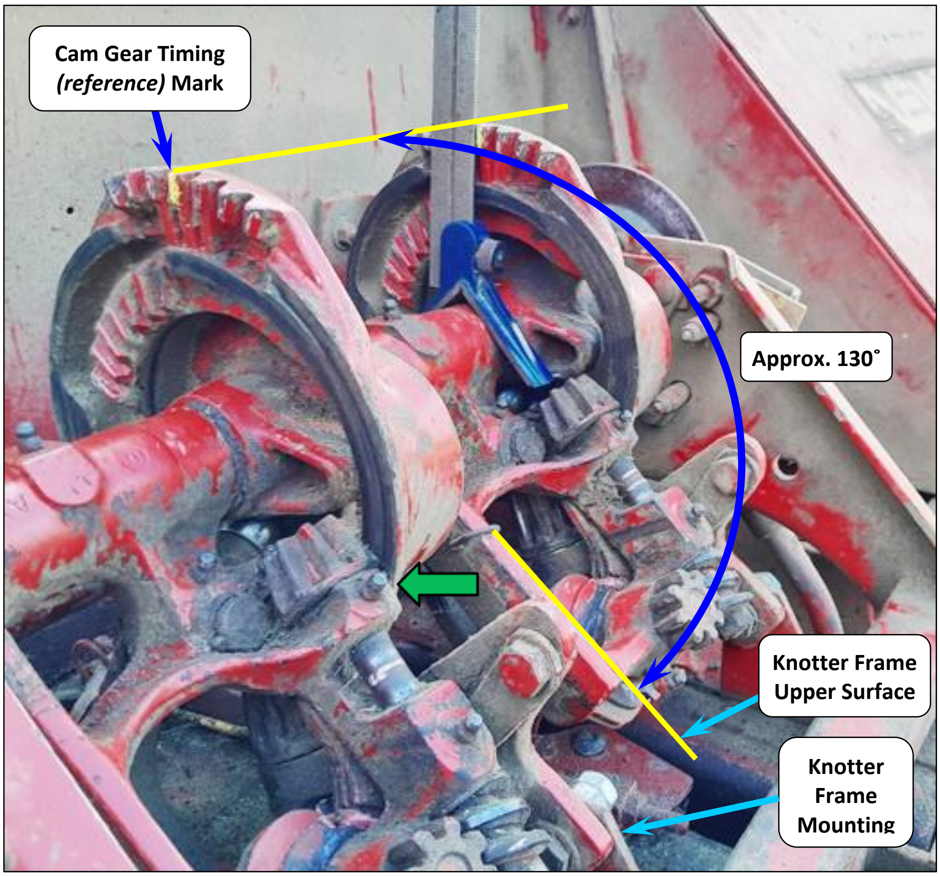


Fig.5.14 (New Holland) baler cam gear angular position relative to the knotter frames when ‘at-rest’

- **If possible**, mark position of the Cam Gear relative to the Knotter Frame *(at green arrow)* **before** removing the knotter assembly from the donor baler – It will save a lot of measuring!
- **Note** angular measurement is made to the Knotter Frame upper surface

For New Holland conventional balers *(and most others fitted with Deering-type knotters)*, when the knotters are ‘at-rest’, the:

- Cam Gear Timing Mark(s) will be in the 12 o’clock position *(i.e. directly above the knotter shaft)*
- Angle between the Timing Mark and the top of the Knotter Frame will be approx. 130 degrees *(Fig.5.14 & 5.15(a)).*

So, knowing this, with the Cam Gear & Knotter Frame both fitted to a suitable, convenient shaft:

- Identify the Cam Gear’s timing mark
- Rotate the Knotter Frame around the shaft until it lies at an angle of approx. 130˚ from the timing mark *(see Fig. 5.14)*
- Mark the Cam Gear’s position relative to the Knotter Frame *(Green arrow - Fig 5.14)*
- Proceed from Step (2) onwards *(as outlined on the previous page)*

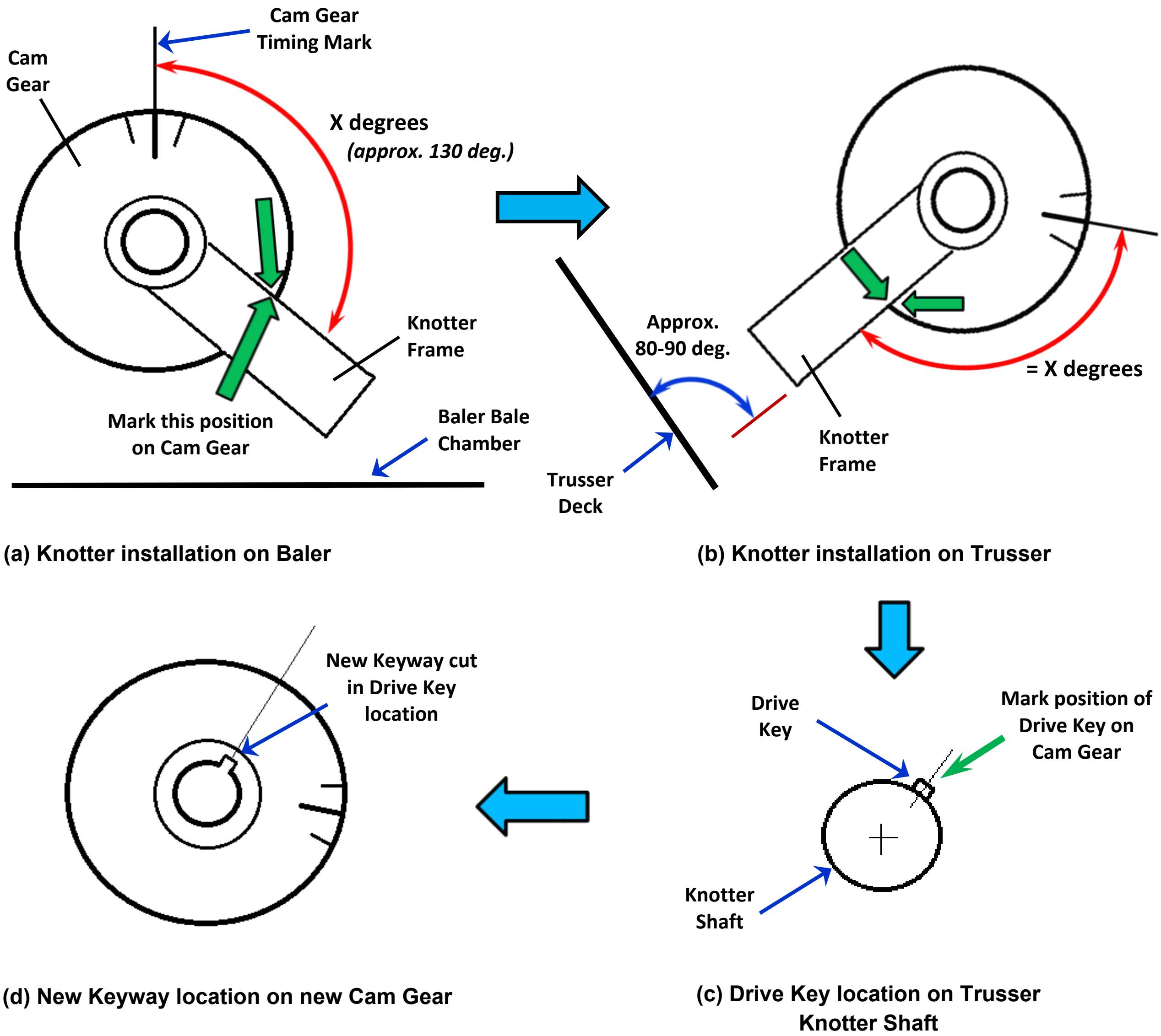


Fig.5.15 Approach to determine location of the new keyway in the replacement cam gear

Cutting the Cam Gear Keyway

Cutting a parallel keyway inside the Cam Gear bore may sound difficult, but it isn't …. You just use a hacksaw & file **and** some care. Sounds ridiculous? Simply measure the width & the vertical protrusion of the original Knotter Shaft cam gear drive keys with some Vernier Callipers. If the Keys are worn, replace them.

Mark the central bore of each Replacement Cam Gear to suit the key's width & protrusion. Make a hacksaw cut on each side of the intended new keyway, **slightly inside of the desired final width.** Then file out the waste material between the cuts to create the new keyway, taking care to keep the file both parallel to the centreline of the Cam Gear bore & 'square' to its edge. Perhaps practice on an old, scrap sprocket first; but the technique does work! ….. It just takes time & a little patience.

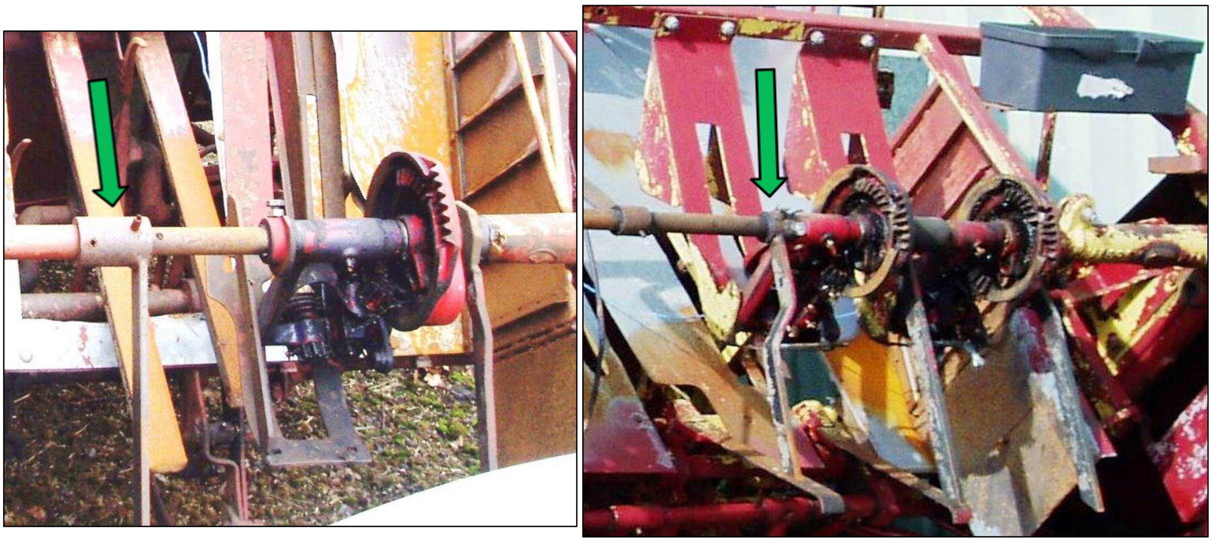


Fig.5.16 Alternative methods for mounting replacement discharge arms on a knotter shaft *(arrowed)* - Pinned *(left)* and Clamp Bolt *(right)*

5.4.3 Additional (Replacement) Truss Discharge Arms

As discussed in Section 5.3, on Ruston & Hornsby, Massey-Harris and Albion trussers, some of the Discharge Arms are actually mounted on the original Cam Gears *(see Fig.5.7)*. It isn't possible to re-attach these items to the replacement *(ex-baler)* Cam Gears, so an alternative solution is required to enable the Discharge Arms to be re-mounted on the Knotter Shaft, so they may rotate & discharge the completed truss at the end of each tying cycle.

Fortunately, the Discharge Arms are not heavily loaded components. It doesn't take too much force to discharge a truss from the machine and, also, the loading is shared across three or four individual arms.

It is therefore possible to re-mount the arms *(or equivalent replacements)* by welding them to a simple tubular sleeve *(Fig.5.16)* which is then either pinned to the Knotter Shaft or *(probably better)* clamped to it via a captive bolt which screws into a shallow recess *(dimple)* drilled in the surface of the shaft. This approach permits the revised Discharge Arm mounting to also be used to provide lateral location for other components on the Knotter Shaft.

5.5 Install the Replacement Components

If the advice provided so far by this guide has been followed & the replacement components have been modified appropriately to fit, their installation on the Trusser should be relatively straightforward. Having said that, the key things to check / address are:

- **Knotter Shaft Drive Mechanism**
  - **ENSURE** that before everything is re-assembled on the Knotter Shaft, the Drive Mechanism is in the *(previously marked)* 'at-rest' position *(see Fig.5.2)*

- **Knotter Assembly (Lateral) Spacing on Knotter Shaft**
  - **ENSURE** this matches the spacing/position of the original Needles *(see Fig.4.6)*
  - **Ideally** one side of each Needle should rub lightly against the inside of the Knotter Frame *(see Figs 5.9 & 5.18)*
  - **It may** be necessary to manufacture appropriate 'spacer sleeves' *(from steel pipe)*, to fit over the Knotter Shaft. These can then butt-up against the Knotter Assemblies & other fixed components and hold the new knotters in the correct lateral location *(see Figs 5.1 & 5.17)*

- **Knotter Unit – Cam Gear 'End Float' clearance**
  - **Adjust** by inserting or removing shim washers on the Knotter Shaft, between the Knotter Frame & the adjacent Cam Gear. Full details provided in Fig.5 17

- **Discharge Arms - (Lateral & Angular) position**
  - **Lateral Position:** Ideally replace in their original position, or as close to it as possible
  - **Angular Position:** With the Knotter Shaft & Drive Mechanism in the 'at-rest' position, set in the position noted before machine disassembly. If the Discharge Arms were secured via clamping studs/bolts, the location marks should be visible on the Knotter Shaft. Ensure all the Discharge Arms point in the same direction *(see front cover)*

- **Knotter Units/Frames – Angular position *(see Section 5.4.1)***
  - The bottom end of each original knotter will probably have been bolted to its corresponding Breast Plate. The Replacement *(ex-baler)* Knotter Frames will incorporate a mounting tab with a securing hole *(see Fig.5.8)*, but this almost certainly won't marry-up correctly with the Breast Plate
  - The correct angular position of the Knotter Assembly *(to suit the Needle's arc of travel)* has already been discussed *(see Fig.5.11).* So now you need to get a little inventive & develop a suitable 'fixing' to attach the Replacement Knotter *(frame)* to the Trusser's Breast Plate at the correct angle
  - The nature of this will depend on your make & model of Trusser. It may be an additional piece of metalwork or nothing more complicated than a modified hook bolt
  - **HOWEVER,** whilst each Knotter Unit should be held firmly & prevented from rotating, **the fixing method should not stress or load the Knotter Frame.** A little bit of free-play / movement is acceptable.

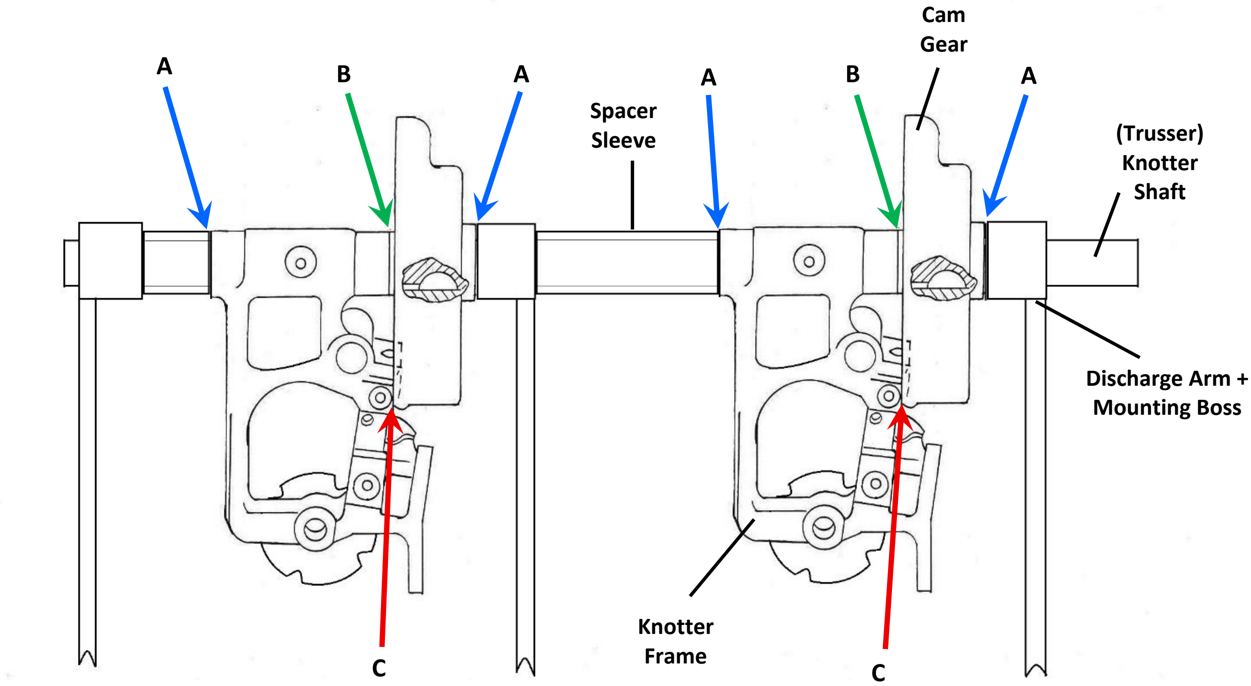


Fig.5.17 Knotter Unit – Cam Gear end float adjustment – Progressively add shims at Points 'A' and ***(very gradually)*** remove shims at Points 'B' until it is possible to rotate each knotter frame freely against the Cam Gear face with minimal clearance at Points 'C' *(less than 0.4 mm (0.015"))*

- **Don't overdo the adjustment!**

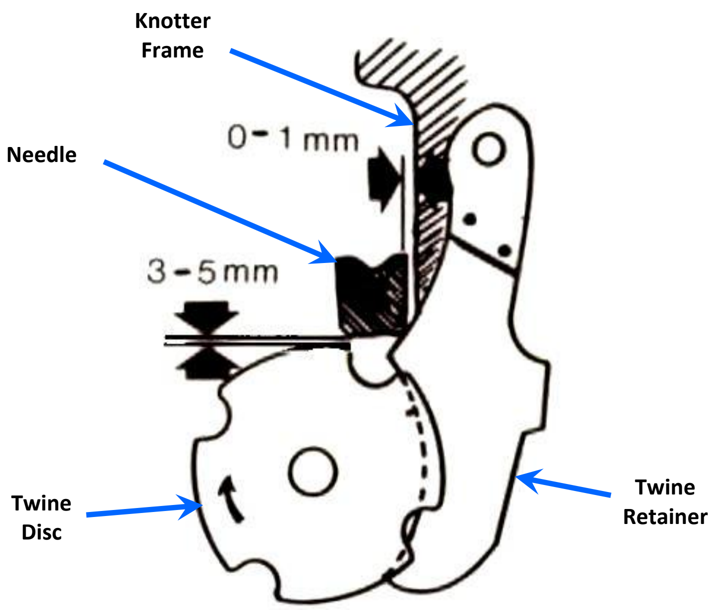


Fig.5.18 Ideal positioning of Needle in relation to Knotter Unit:

- Side of Needle should rub lightly against the Knotter Frame with minimal clearance

N.B. Needle – Twine Disc clearance should be at least ~3 mm. Can be adjusted slightly by bending the Needle upwards/downwards with care following gentle heating ***(N.B. Only Binder & Trusser needles made of malleable cast iron: NOT cast Baler needles!)***

5.6 Making Sure It Operates Correctly

DON'T be tempted to run the machine under power just yet. **Instead,** turn it over by hand through a few tying cycles *(with the aid of an assistant)* and make sure that everything operates correctly.

IMPORTANT things to check out include:

Take Care and Beware of Moving Components!

- **Knotter Shaft Drive Mechanism**
  - Does this operate correctly when tripped?
  - Does it return properly to the 'at-rest' position *(and disengage the drive)* at the end of the tying cycle?

- **Needles**
  - Do they operate correctly without hitting anything?
  - Do they rub lightly on the side of the Knotter Frames? *(see Figs 5.9 & 5.18)*
  - Is the Needle – Twine Disc clearance sufficient? *(Fig.5.18)*
  - Do they place the twine in the correct location in the Knotter Units? This should be:
    - Into the Twine Guide 'groove' on the stripper/knife arm *(Fig.5.19)*
    - Over the Bill Hook jaws
    - Into the Twine Disc notch *(see Figs 5.10 & 5.18)*

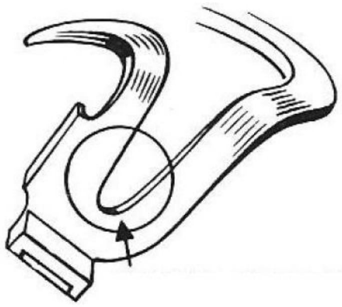


Fig.5.19 Twine guide groove on the Knife/Stripper Arm *(arrowed)*

- **Knotter Units *(see also Table 5)***
  - Is the Twine Disc timing correct? *(Fig.5.20)*
  - Does the Stripper Arm rub lightly across the Bill Hook's heel? *(Fig.5.21)*
  - Does the Stripper Arm travel far enough beyond the Bill Hook's tip? *(Fig.5.22)*
  - Is the Twine Knife sharp?
  - Is the Bill Hook jaw clamping pressure correct? *(Fig.5.23)*
  - Is the Twine Retainer pressure correct? *(Fig.5.24)*

- **Twine Tension and Twine Grade & Quality**
  - **REMEMBER** your *(ex-baler)* knotters may not have been set up to use the type & thickness of twine you're now using in your Trusser, **so make sure that the:**
    - **Twine Tension** is correct, when leaving the Twine Box, **but primarily** at the Needle eye *(Fig 5.25)*
    - **Twine Quality** is good/consistent. You'll never get reliable knotter performance with poor/variable quality twine
  - Is the machine threaded correctly? Is the twine following the correct path?
  - Are there any wear grooves in any of the twine guides *(or the Needle eyes)*? If so, they will affect the twine tension. Re-build & file/sand down to the original *(smooth)* profile.

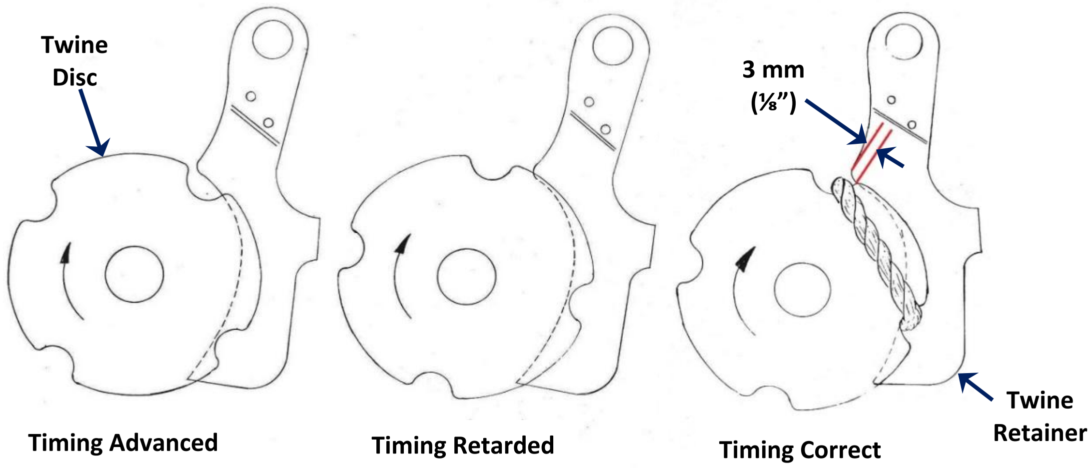


Fig.5.20 Twine Retainer Disc timing – Timing is correct if *(after each tying cycle)* the leading edge of the disc notch is 3 mm (⅛") past the front corner of the Twine Retainer *(right)*

N.B. *Ensure a piece of twine is gripped by the previous notch when checking the disc timing. Simply insert an inch-long offcut into the open notch, turn the knotter through a cycle & then check the timing of the next (empty) notch*

(courtesy New Holland)

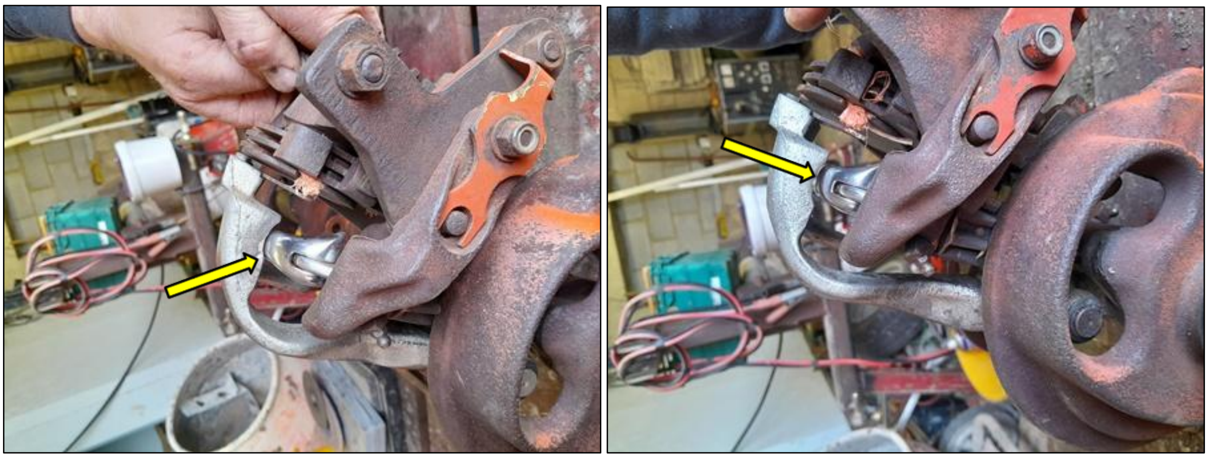


Fig.5.21 The Stripper Arm should rub lightly across the Bill Hook's heel *(left - arrowed)* **-** Excessive Stripper Arm – Bill Hook clearance *(right - arrowed)*

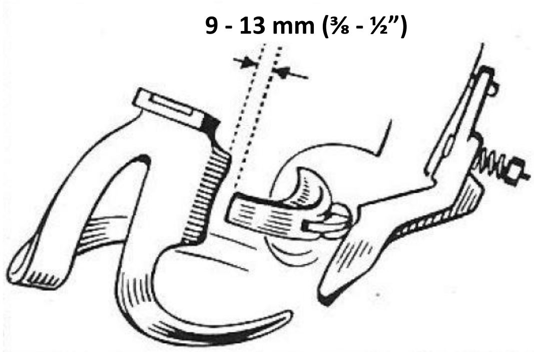


Fig.5.22 Correct Stripper Arm travel past Bill Hook tip

Table 5 Deering-type *(New Holland)* baler knotters – Likely issues and remedies

Knotter Component	Likely Issue	Remedy	See Fig. No.
Knife / Stripper Arm Travel	• Insufficient Stripper Arm travel beyond tip of Bill Hook • Should be 9 – 13 mm (⅜ - ½ ins) at max. travel	• Renew Stripper Arm cam roller • Renew Knotter Cam Gear if badly worn	5.22
Bill Hook – Stripper Arm clearance	• Stripper/Knife Arm shouldn't contact the Bill Hook at any point during Knotter operation **EXCEPT** to rub across the Bill Hook's heel	• Contact may occur between the Twine Knife & the Bill Hook tip • Gently bend Knife Arm with a suitable lever to ensure working clearance	-
Stripper Arm - Bill Hook contact	• Either excessive or insufficient Bill Hook – Stripper Arm clearance during Stripper Arm travel • Stripper Arm should rub lightly across the heel of Bill Hook	• **To Reduce Clearance:** Hit back of the Stripper Arm with a decent-sized hammer to bend arm & obtain correct clearance • **To Increase Clearance:** Bend the arm up slightly with a suitable pry bar • Try to make small adjustments & check clearance after each attempt • **Don't** try to heat & bend the Arm	5.21
Twine Knife	• Blunt Twine Knife	• Remove Knife Arm, sharpen knife & replace	-
Twine Disc	• Incorrectly timed	• Adjust disc timing • Loosen worm gear, rotate Twine Disc & re-tighten gear	5.20
Bill Hook	• Slightly rough or pitted surface	• Polish with fine 'wet & dry' paper • Always protect Bill Hooks against rust during winter storage	-
	• Very rough/pitted surface or damaged component	• Replace Bill Hook	-
	• Vertical free-travel in Knotter Frame	• Shim under Bill Hook drive pinion	
Bill Hook or Twine Disc	• Excessive rotational free-travel	• Check for excessive Cam Gear to (Knotter Unit) Drive Pinion clearance & re-shim if necessary • Replace worn Drive Pinion(s) • Replace worn Knotter Cam Gear	5.17
Twine Retainer or Bill Hook Jaw	• Insufficient clamping pressure • Excessive clamping pressure	• Adjust respective spring pressure(s) • Spring adjustments are very sensitive	5.23 5.24

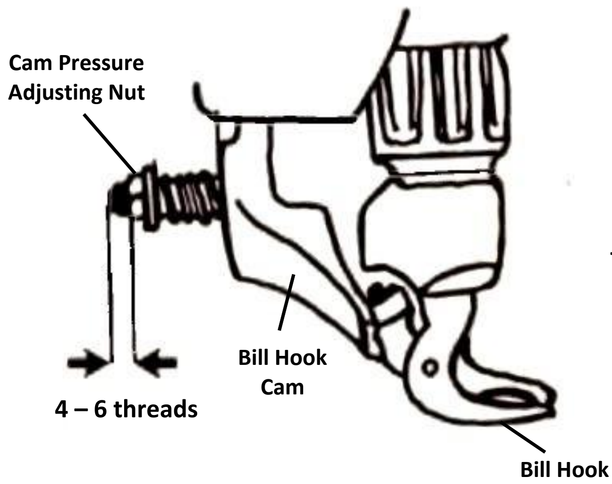


Fig.5.23 Recommended *(initial)* setting for *(New Holland)* Bill Hook jaw clamping pressure

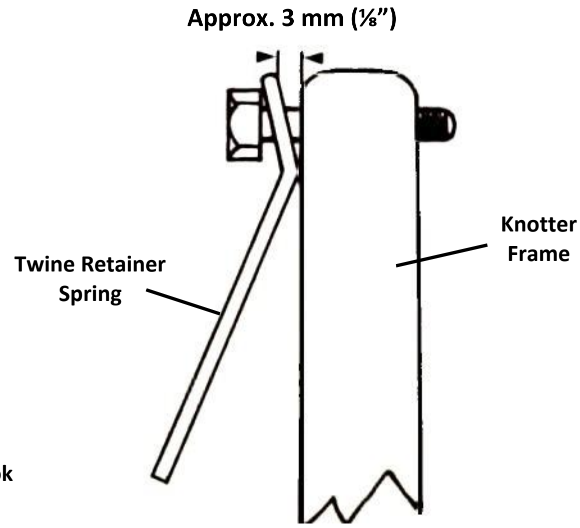


Fig.5.24 Recommended *(initial)* setting for *(New Holland)* Twine Retainer spring pressure

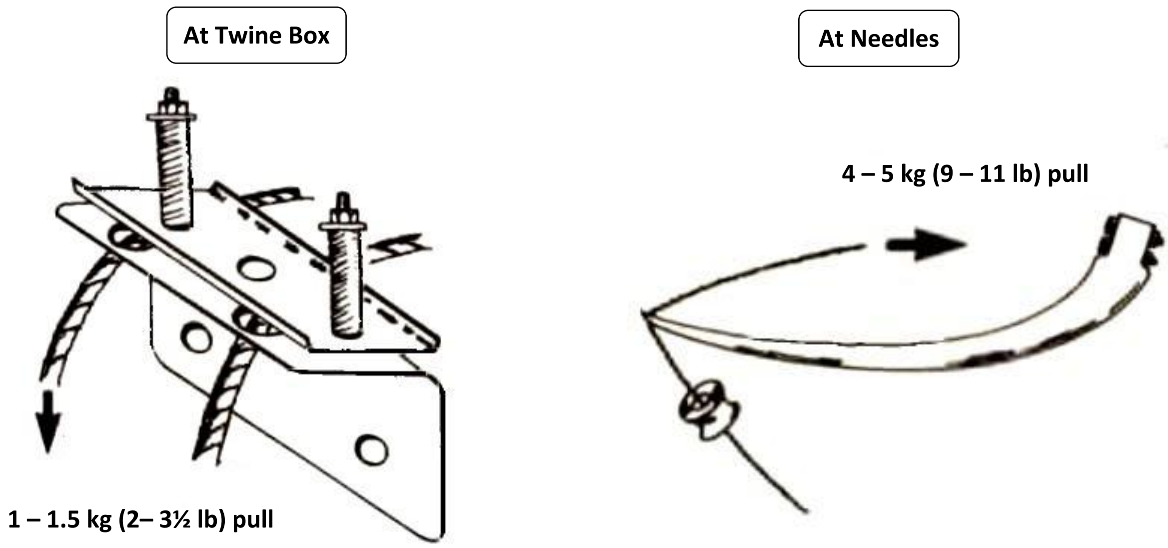


Fig.5.25 Recommended *(initial)* twine tension values for New Holland knotters when measured at the Twine Box *(left)* and at Needle eye *(right)*

N.B. If it's difficult to achieve both these values, Needle eye tension is more important

6 Machine Safety (Guarding)

6.1 Trusser (Legal) Safety and Guarding Requirements

So, by replacing its knotters, you should hopefully have improved the performance of your Trusser beyond all recognition. Great! But is it safe for you & your staff to use without the real risk of injury and/or prosecution? Serious words! But it's a very serious subject!

Section 1 briefly mentioned that, when trussers were originally manufactured, machine safety was given little or no consideration. Then the introduction of new, dedicated safety requirements for these machines in the early 1960s virtually coincided with their withdrawal from use in mainstream agriculture.

Unfortunately, this meant that not many Trussers were fitted with appropriate guarding back in the 1960s and today there is little evidence of appropriate guarding or other safety measures on the majority of such machines used for processing thatching straw. **This is a needlessly dangerous situation and could have very serious consequences for you, your staff & your business.**

So, what can you do about it? In reality, quite a lot; and it needn't be too difficult or expensive. This Section reviews the potential hazards on Straw Trussers which should be addressed: Section 6.2 goes on to look at practical safety solutions which could be implemented.

Modern Health & Safety legislation requires all equipment used in a workplace to satisfy Essential Health & Safety Requirements (EHSRs). To do this you must assess the possible safety risks posed by a machine and try *(wherever possible)* to reduce them. The accepted approach to follow is:

- Ask yourself what are the likely circumstances of the **Intended Use** and the **Reasonably Foreseeable Misuse** of the machine? How is it normally used? How could it potentially be misused? For example, if someone often stands near the discharge area of the Trusser, could they foreseeably trip & fall into contact with the revolving Discharge Arms?
- Also ask yourself what are the potential *(mechanical)* hazards posed by use of the machine? Estimate any safety risks which these could pose. Consider both the severity of any possible injury the hazards could cause & the likelihood of such an occurrence
- Now take appropriate steps to eliminate these hazards or *(where impracticable)* to reduce the risks associated with them by implementing appropriate *(protective)* safety measures *(e.g. install guards or other safety control measures)*.

That's the wording of current 'general' Health & Safety legislation. Whilst a machine designer may know what next to do, dealing with vintage farm machinery in a farm workshop isn't quite so easy.

Fortunately, **The Agriculture (Threshers and Balers) Regulations (1960)** specified some very sensible safety requirements for threshing machines and associated *(stationary)* balers & trussers. Not only were they realistic, the regulations provided machine-specific guidance regarding what particular measures to implement. These regulations have since been withdrawn, having been replaced by modern *(less machine specific)* general safety legislation. However, the requirements of the previous regulations are still appropriate today and, if applied properly *(with a few updates)*, will ensure that a trusser satisfies Essential Health & Safety Requirements (EHSRs).

Regarding Straw Trusser safety, the key requirements of the 1960 Regulations were:

- **Guarding of Dangerous Parts**
  - A trusser must be fitted with a suitable guard to protect a worker *(or their clothes)* from coming into contact with the Discharge Arms
- **Protection from Moving Components**
  - Any *(rotating or reciprocating)* shafting, pulley, flywheel, gearing, crank, sprocket, belt or chain must be guarded *(or located)* to protect a worker *(or their clothes)* from coming into contact with it
  - The only occasion when such components don't require guarding is when they are located more than 6 feet 6 inches away from any location a worker might have access to

    *(**N.B.** This dispensation has since been superseded)*
- **Guarding of the Main Drive *(belt or chain)***
  - Assuming the Trusser works in conjunction with & is driven by a threshing machine; **<u>IF</u>** the trusser & thresher are not permanently fixed together *(i.e. a portable trusser rather than an integral/suspended trusser)*, the Trusser's main drive belt/chain need only be guarded at the 'run-on point' *(i.e. the on-running point of contact of the belt/chain with the pulley/sprocket)*
  - **N.B.** Whilst this dispensation was granted in 1960, **today, the entirety of the belt/chain must be guarded.** Alternatively, access to the hazard area must be prevented or the hazard be eliminated by machine redesign. *(Not quite so difficult as it may sound)*
- **Means of Quickly Stopping the Machine *(Disconnection of main drive)***
  - A readily accessible device must be provided to quickly stop / disconnect drive to the trusser *(in an emergency)* when it's in work
  - The *(drive disconnection)* device must require positive, manual operation to re-connect drive to the machine
- **Condition of *(Drive)* Belts**
  - Belts & their fasteners must be maintained in good condition
  - No belt fastener should constitute a danger to a worker
- **Condition of Safety Guards**
  - Must be of adequate strength and be properly maintained *(in good condition)*
- **Workplace Lighting**
  - There must be adequate natural or artificial lighting provided in the vicinity of the machine.

All these basic safety requirements from the 1960 Regulations still make a lot of sense today **BUT**, as indicated above, in some cases it is now necessary to even do a bit more in order to satisfy current machine safety requirements. Still, in reality, meeting these requirements isn't too onerous and appropriate safety measures can be designed, constructed & installed in most farm workshops. Very good, detailed guidance is provided by the PD 5304:2019 – 'Guidance on Safe Use of Machinery' publication produced by British Standards, but it is very expensive to purchase. Alternatively, Section 6.2 indicates the guarding & safety measures which should be implemented in this particular application.

6.2 Potential Trusser Guarding / Safety Control Measures

So, what practical machine guarding approaches and/or safety control measures can be easily implemented in order to make your straw trusser both safe & legally compliant? Before you reach for the angle iron & weldmesh, give a little thought to what is and what isn't required in this particular application.

- Consider the practical, operational requirements of the machine. How does the Trusser normally operate? The design of guarding/safety measures must not restrict the:
  - Flow of crop into the Trusser
  - Discharge of bound trusses from the machine
  - Ability to observe the operation of the machine, **BUT only if this is absolutely necessary**
  - Ability to access the machine for servicing, adjustment & clearance of blockages, **BUT not whilst it is under power / in-motion.**
- Where will the Trusser be positioned in relation to adjacent machines *(e.g. the threshing machine/reed comber and/or an elevator?)*
  - Will the presence of any of these machines either:
    - Prevent 'inadvertent' operator contact with certain areas of the Trusser?
    - Pose an additional safety hazard which must also be addressed?
- Whereabouts around the machine could people potentially be either:
  - During normal operation & servicing or unblocking of the machine?
  - When using & accessing or servicing adjacent machines?

The guarding and other safety measures which you install must:

- Prevent 'inadvertent contact' with any machine parts which pose a potential hazard to a person and that:
  - Aren't directly involved in the Trusser's 'work process', or
  - Are involved in the work process, but can be guarded without unduly restricting the Trusser's normal operation
- Provide means of immediately stopping/disconnecting drive to the machine, until manually reset.

Keeping all this in mind, attention can be focussed on four key areas of the Trusser, namely:

1) Machine main drive – Guarding & drive disconnection
2) Knotter Shaft & Needle Drive Mechanism *(e.g. gears, chains/sprockets & connecting rods)*
3) Knotter Shaft & Discharge Arms
4) Machine underside *(Packer & Needle operating crankshafts)*

Fig.6.1 Portable trusser chain-driven from a threshing machine / reed comber

- Some attempts have been made to guard the Trusser's key components **BUT** the main drive chain *(arrowed)* is inadequately guarded

N.B. Unsecured ladders or steps should **NEVER** be used for foreseeable/regular access to a machine

6.2.1 Trusser Main Drive - Guarding

If the machine is driven mechanically, whether by chain or belt(s), **the entire chain/belt run and the associated sprockets/pulleys must be guarded.** It's not sufficient to only guard the 'run-on' points of the chain onto the sprockets *(Fig.6.1 - arrowed)*. There's simply too much chance of someone walking into or tripping & falling against the moving chain and being injured and/or entangled.

Barriers to prevent access to a 'hazard zone' can be an alternative to fixed guards in some circumstances, but almost certainly not here because regular access is required between the thresher & trusser **during normal operation of the machine**, to remove chaff & other threshing waste. Suitable barriers would need to be located on either side of the drive chain, at least 1 metre *(horizontally)* away from it, but these would obstruct removal of the material. So either guarding or an alternative safety solution must be employed.

Fixed guards can be of steel mesh or sheet construction, but must be rigidly mounted and be strong/rigid enough to withstand a person's weight without deflecting excessively towards the underlying drive components. Steel 'weldmesh' is a good guarding material, when attached to a strengthening angle or box-section steel framework. However, choice of appropriate mesh size is critical for the guard to satisfy legal requirements *(see Section 6.2.6).*

(continued)

It’s usual for ‘fixed’ guards to be removable or *(more usually)* hinged to allow access for machine servicing & adjustment: but if hinged rather than rigidly fixed, **the guard must both**:

- Require the use of a ‘tool’ to open it. This could be a spanner to undo a securing nut from a bolt or a screwdriver to turn a spring-loaded catch. This might seem unnecessarily complex, but it’s a legal requirement. Look for suitable proprietary panel catches on eBay: they are easy enough to build into a DIY guard
- Incorporate some means of preventing it from closing inadvertently on a person when it’s open. This could be a hinged stay or a check-chain. If the guard opens up & lifts ‘over-centre’ with no risk of falling back or blowing closed, such a measure isn’t required.

Fig.6.2 Trusser converted to hydraulic drive

N.B. The drive chain entanglement hazard has been removed ***(Good)***, **BUT** the trusser is still unsafe due **both** to absence of any safety guarding **and** a convenient means to stop the machine in an emergency

An alternative way to avoid the need to guard the Trusser’s *(mechanical)* main drive, is to modify the machine & dispense with the chain or belt drive. Trussers can be converted to hydraulic drive by attaching a low-speed hydraulic motor directly to the main drive shaft, in place of the original drive sprocket or pulley *(Fig.6.2).* The motor may then be powered either from a hydraulic power pack or the hydraulic external services of a nearby tractor. A suitable hydraulic flow control valve may be used to adjust trusser operating speed to suit the working conditions.

This can be a neat, convenient and inherently safe solution, but it is important to remember that:

- Any exposed part of the motor’s *(rotating)* drive shaft and/or the Trusser’s main driveshaft will still require guarding *(not evident in Fig.6.2)*
- Unless the Trusser’s original mechanical drive disconnection device is retained *(see below)*, some convenient method of stopping the *(hydraulic)* drive to the machine must be provided for everyday & emergency use. Plumbing a simple lever-operated flow diverter valve into the hydraulic pipework near the machine would be fine. **It is not acceptable to expect someone to run & stop a nearby tractor in the event of an emergency!**

6.2.2 Trusser Main Drive – Disconnection Device

This is an essential safety feature. Fortunately, most Trussers were fitted with such a device as standard equipment: usually a lever-operated ‘dog’ clutch on the main drive shaft, close to the main drive sprocket. Operation of the clutch lever enabled the Trusser’s mechanism to be stopped independently of the Threshing Machine. This was both a desirable operational feature & a sensible safety measure. On most machines the clutch lever can be mechanically retained in the ‘disengaged’ position, to prevent inadvertent drive re-engagement. **It’s a legal requirement that re-engagement of drive to the Trusser must require a positive/intentional action by the operator.**

If a Trusser is converted to hydraulic drive *(Figs 6.2 & 6.3)*, either the original mechanical clutch should be retained, or its ‘drive disconnect’ function be incorporated in the hydraulic circuit, say by by the installation of an appropriate lever-operated valve *(Fig.6.3)*. **The drive disengagement control MUST be easily accessible by the Trusser’s operator.**

Fig.6.3 Ruston & Hornsby trusser converted to hydraulic drive with retrofit hinged steel mesh guard fitted over the Knotters and Discharge Arms

- Lever-operated hydraulic valve on side of machine *(Green arrow)* provides convenient and legally-required means of main drive disconnection
- Knotter/Discharge Arm guard *(Yellow arrow)* is a good design and doesn’t restrict truss discharge, **BUT** the mesh aperture size and the side slot spacing is too large *(Yellow arrows)*

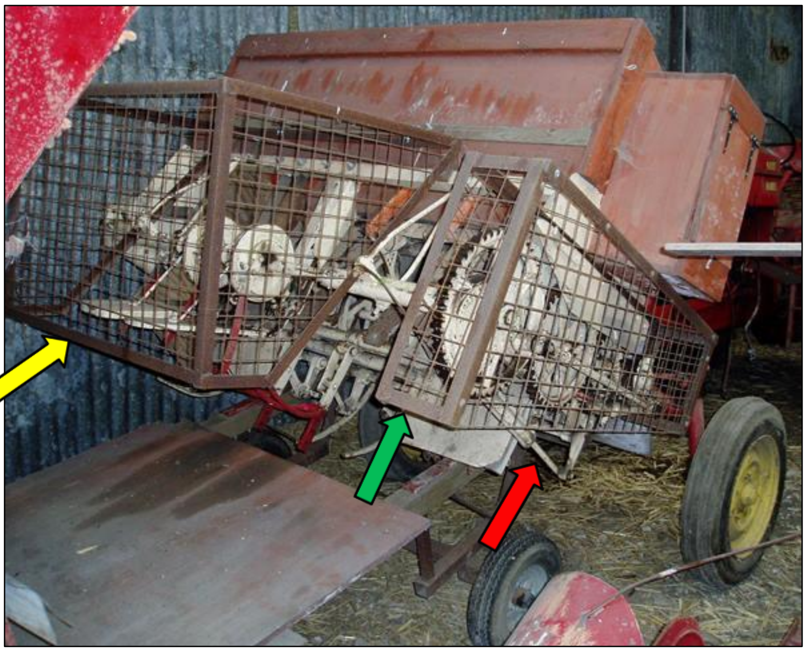


Fig.6.4 Ruston & Hornsby trusser with hinged steel mesh guards fitted over key components

- Knotter/Discharge Arm guard *(Yellow arrow)* is a good design, **BUT** the mesh aperture size is too large
- Knotter Shaft/Needle drive mechanism guard *(Green arrow)* doesn't extend low enough to shield the Compressor Arm operating linkage *(Red arrow)*. The guard mesh size is also too large

6.2.3 Knotter Shaft and Needle Drive Mechanism

This can be either a series of gears *(see Fig.5.2)* or a chain & sprocket drive *(see Fig.5.4)*, but it's important to remember that this area of the machine also contains operating/connecting rods for the Needles & the Compressor Arms, and possibly also a remote 'trip' lever to manually trigger the tying mechanism.

A suitable guard should be installed to prevent anyone coming into contact with any of the moving *(or intermittently moving)* components. The 'reach' distance to contact the dangerous/moving parts, whether around the edges of a solid *(panel)* guard or through the gaps in a mesh guard, **MUST** satisfy internationally accepted safety standards *(see Section 6.2.6).* If operation of the manual 'trip' lever is to be retained, this control will require modification so that it can be safely operated with the guard in position. **Reaching through an access slot in the guard is NOT acceptable.**

Fig. 6.4 shows a good attempt at Trusser guarding, **BUT** unfortunately the guard does not extend low enough to prevent possible contact with the Compressor Arm operating linkage. **Also,** given the distance between the mesh surface and the hazardous moving parts underneath, the steel mesh size used is too large *(see Table 6)*. However, both these shortfalls could be easily addressed.

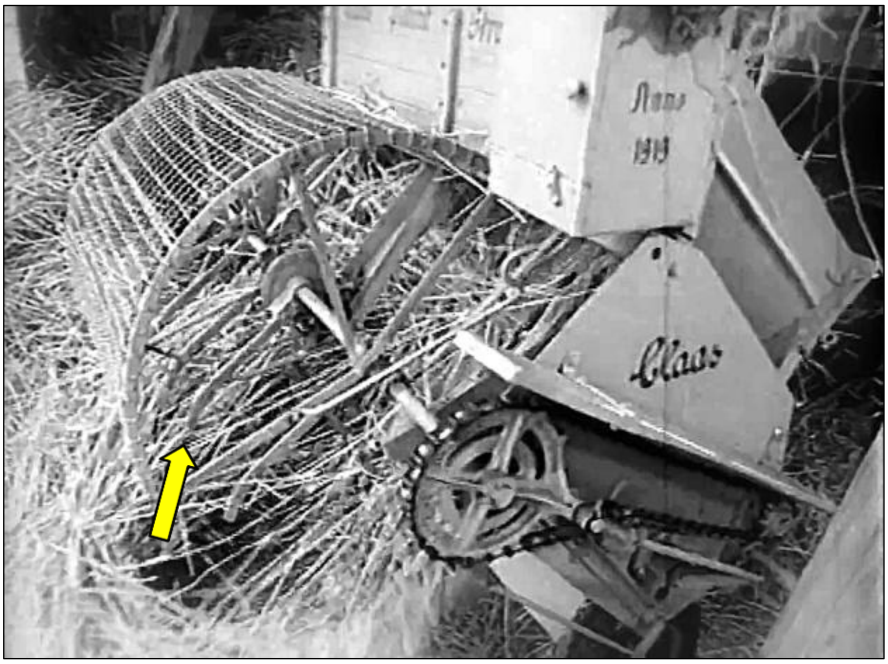


Fig.6.5 Top-hinged steel mesh safety guard fitted over Knotters & Discharge Arms of a (*c.* 1920) Claas trusser

N.B. Machine shown as manufactured at that time

- Guard design does not restrict discharge of trusses
- Mesh aperture size appears to be appropriate for the guard – hazard reach distance
- Guard will prevent operator contact with Knotter components & Discharge Arms **IF** falling from above **or** approaching from truss discharge area, **BUT it does not protect** against dangerous contact with moving parts via either end of the Knotter Shaft *(Yellow arrow)*
- Guard will require means of support when raised for access *(e.g. servicing Knotters)*
- Knotter Shaft drive chain & Needle drive mechanism are inadequately guarded

(courtesy CLAAS GmbH)

6.2.4 Knotter Shaft, Knotters and Discharge Arms

All rotating or occasionally rotating components on the Knotter Shaft require guarding: particularly the Discharge Arms which, due to their large radius of rotation, pose a significant risk of entanglement & injury. There is nothing new about this risk or the need to protect against it. All Claas trussers were fitted with guards over this area at time of manufacture *(Fig.6.5)*.

Figs 6.1, 6.3 & 6.4 illustrate practical guarding solutions: a top-hinged steel-framed mesh guard which prevents inadvertent access to the moving components, but doesn't impede the discharge of trusses from the machine. However, if the *(rotating)* left-hand end of the Knotter Shaft is uncovered *(e.g. Massy-Harris, Howard & Albion machines)*, this will also require some form of guarding.

If the guard lifts up to permit access for machine servicing & debris removal, some appropriate stay or catch must be incorporated to prevent it from falling *(unless it opens 'over centre')*. Also, ideally, it should not be possible to operate the machine with the guard in the 'raised' position.

This may seem difficult to achieve, **BUT** a possible neat solution would be to use a door bolt-type catch to secure the guard in the raised position. This could be connected to the Trusser's 'drive disconnect' lever, via a simple mechanical 'interlock' linkage, so that the drive cannot be re-engaged until the guard has been lowered.

Fig.6.6 Underside of a portable trusser – Highlighted area will require guarding or use of other appropriate safety control measures

6.2.5 Trusser Underside *(Packer & Needle Operating Mechanisms)*

The underside of the trusser contains plenty of revolving & intermittently moving components, all of which pose an entanglement risk. Like it or not, this area either needs to be guarded or personnel must be prevented from going near it *(e.g. by installation of suitable barriers)*.

Unfortunately, access-restricting barriers aren't really a suitable option in this instance because access is required:

- **Regularly during normal operation:** To remove chaff & short straw discharged by the threshing machine or reed comber
- **Occasionally for servicing:** For debris removal, machine lubrication & re-threading of twine

Consequently, a suitable guard is required, which:

- Doesn't impede normal operation of the trusser
- Ideally, can allow the trusser's components to be seen, to identify any accumulations of debris
- Can allow access to the area for servicing ***(N.B. ONLY when the machine is not under power)**.*

A simple top-hinged, sloping mesh guard, whose lower edge is fixed/secured against the ends of the trusser's 'horse shafts', will probably fit the bill. But remember to ensure that:

- Hand or finger access isn't possible around the guard's sides/edges
- The guard is fitted far enough away from the moving components to provide a sufficient 'reach distance' for the mesh size used *(see Section 6.2.6).*
- A physical catch or catches must be undone *(ideally with a tool)* before the guard can be opened.

6.2.6 Other Machine Guarding / Safety Considerations

Safety or 'Reach' Distances

This is the closest distance a guard or barrier may be sited from a potentially hazardous area or particular component. Essentially the safety distance considers how easily a person could manage to reach through a gap, contact an identified hazard & be injured, whether by reaching:

- Around the edge of a fixed guard
- Through the gaps in a mesh or slotted guard *(e.g. with a finger, hand or arm)*
- Over or past a barrier *(e.g. with an arm or leg)*

International Standards[1] specify minimum safety or 'reach' distances for various situations. Standards are costly to obtain & aren't the easiest of things to interpret, **BUT any machine guarding MUST comply with their requirements: otherwise, it's considered inadequate & it's illegal.**

In the case of slotted or mesh-type guards, as might be retro-fitted to older agricultural machinery, the size of the opening/mesh determines how far away a guard must be located from any potentially hazardous area/component *(i.e. the minimum reach distance)*.

Table 6 Minimum safety distances for guards with square openings *(after BS EN ISO 13857[1])*

	Size of (square) Opening in Guarding (mm)				
	10 or less	12 or less	30 or less	40 or less	120 or less
Minimum Safety Distance *(Guard to Hazard)* (mm)	25	80	120	200	850

Given the popularity of steel 'weldmesh' for guard construction in this application, Table 6 summarises the minimum safety distances for guards with square openings. In essence, if the mesh opening is any larger than 12 mm *(i.e. less than ½ ins)* the guard must be sited at least 120 mm (4¾ ins) from the hazard. If the mesh aperture exceeds 30 mm, the reach distance increases to 200 mm & then jumps to 850 mm for a > 40 mm mesh. **Also, remember,** these are the perpendicular or 'square' dimensions of the opening, **NOT** diagonal measurements.

Consequently, it's recommended that, if constructing a weldmesh guard for a Trusser *(or any other similar machine)*, **don't use anything larger than 25 mm / 1 ins mesh and ensure the guard is at least ~125 mm / 5" away from any component you're attempting to guard.** If a part of the guard needs to be closer, use a smaller mesh size or sheet steel for that particular section.

If you construct a solid guard, this limitation disappears, but remember you must also assess how easy it may be to reach around the side(s) of the guard and whether an adequate safety distance has been allowed for that scenario.

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[1] **BS EN ISO 13857:2008** Safety of machinery – Safety distances to prevent hazard zones being reached by upper and lower limbs

Safe (Intentional) Access to Machines

Agricultural machinery safety standards[2] recognise that access will be required to a machine both during:

- **Normal Operation:** Moving components into/out of working position, replenishing materials consumed by the machine *(e.g. twine)*, machine setting/adjustment, clearing of blockages in the crop flow and/or accumulations of debris
- **Servicing:** Machine lubrication, adjustment & *(wearing)* component replacement.

SAFETY
WARNING

N.B. All of the above activities would ONLY be undertaken IF THE MACHINE WAS STOPPED / NOT IN MOTION.

So, there are a range of circumstances when access to the machine would be required. A Trusser isn't a large machine: in most instances adequate access can be gained from ground level. **HOWEVER,** if this is not possible and higher-level access is required *(e.g. to remove a crop blockage from the Trusser's hopper)*, then a safe means of access must be provided.

This needn't be so very demanding or costly to do *(see tips below)*; but if someone were to slip/fall from an elevated position & be injured, all sorts of very awkward questions & costly inspections could follow: which could so very easily be avoided.

Higher-Level Access to Equipment - Do's and Don'ts

- **NEVER** use portable, unsecured steps or ladders for regular/foreseeable access to machines *(see Figs 6.1)*
- **ENSURE** all access steps, ladders and/or platforms:
  - Are securely attached to the machine or other rigid structure(s) & cannot slip or fall away during use
  - Incorporate sufficient handholds and/or railings to allow three-point contact at all times *(**N.B.** Parts of the machine may fulfil this requirement)*
- **Three-Point Contact** permits a person to simultaneously use two hands & a foot or two feet & a hand, when boarding & dismounting from a machine
- **ENSURE** any access platform incorporates a slip resistant surface **and** is not prone to accumulation(s) of crop debris which could pose a slip or trip hazard.

[2] **BS EN ISO 4254-1:2021** Agricultural machinery – Safety – Part 1: General requirements

Warning Signs/Decals

Don't underestimate the potential usefulness of ***(and the legal requirement for)*** warning signs on workplace machinery; particularly power-driven machinery.

Just because a machine may be adequately guarded, doesn't mean that you don't need to warn people of the potential hazards which lie behind the guards; and especially why they should never open the guards when the machine is under power / in-motion.

Unless there is no other practicable option, **Warning Signs are not a substitute for effective safety guarding, BUT they should be used to complement it.**

Processing thatching straw is a labour-intensive activity: it's likely that you will need extra hands to help. But remember that these *(Casual)* staff may not be so familiar with potential machine hazards as yourself. Unless you take demonstrable steps to train you staff, and inform them of & protect them from these hazards, legally you are at fault.

A wide variety of self-adhesive vinyl warning decals are readily available from eBay sellers for a few £s each *(Fig.6.7)*. It really is a no-brainer! Assess which hazards are present on your machine(s), chose the appropriate warning decals & place them in locations on the machine where they can be clearly seen *(e.g. on the sides or front of the hopper).* **However,** don't use too many signs in one place, otherwise they might tend to be ignored!

Fig.6.7 Example Warning Decals potentially suitable for use on a trusser

7 Summary

This guide has hopefully shown that:

- Upgrading/replacement of Trusser *(or Binder)* knotters is not a particularly complex or costly process
- The process is within the scope of a well-equipped farm workshop, **BUT** some *(limited)* in-house or 3rd Party machining capability will be required
- The ‘upgrade’ will incur some engineering time/effort & cost, but this can be minimised by use of second-hand *(conventional)* baler knotter assemblies. However, some new, replacement knotter parts may well be required
- The techniques outlined are equally applicable to Trussers or Binders
- The upgrade will:
    - ‘Future-proof’ the machine in terms knotter *(replacement)* parts availability
    - Permit more precise adjustment of the Knotter Units
    - Almost certainly lead to more reliable tying performance.

BUT:

- The modified machine will still rely on the original *(old)* knotter trip & drive mechanism, which could still be a weak point & a source of future trouble
- It’s therefore wise to:
    - Ensure that these components are correctly adjusted
    - Regularly inspect them for wear & tear
    - Maintain, repair & where necessary, rebuild them to:
        - Minimise any free play
        - Extend their working lives
        - Avoid breakages.

Fig.6.7 Howard trusser knotter trip & drive engagement mechanism *(highlighted)*

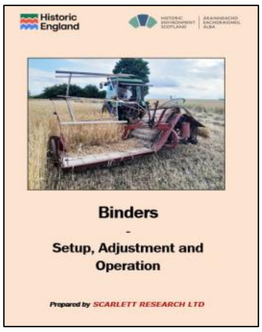
8 Thatching Straw Harvesting Machinery – Technical Guides

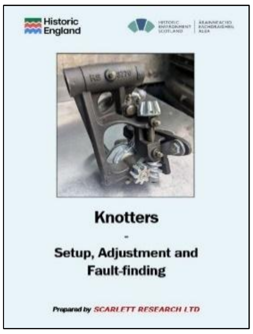
This publication is one of a series of technical guides prepared by Scarlett Research Ltd, on behalf of Historic England and Historic Environment Scotland. These guides are intended to illustrate machine adjustments, modifications & operating techniques which are likely to improve the efficiency & productivity of certain types of equipment when used for harvesting of cereal straw for thatching.

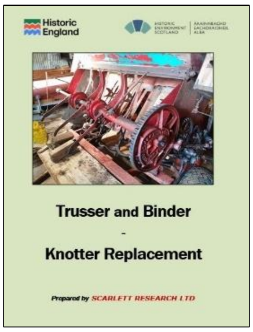
Technical Guides in this series include:

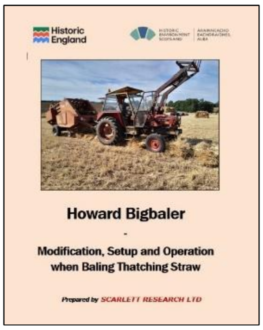
- **Binders – Setup, Adjustment & Operation**
- **Knotters – Setup, Adjustment & Fault-Finding**
- **Trusser and Binder – Knotter Replacement**
- **Howard Bigbaler - Modification, Setup & Operation when Baling Thatching Straw**

The guides may be downloaded by scanning the relevant QR code *(above)*, 'clicking' on the relevant image *(below)* or from the Historic England website.









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