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Knotters

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Setup, Adjustment and Fault-Finding

***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 knotter design, operation & setup/adjustment procedures which **may** be followed: it is **not** intended to be a comprehensive reference.

Safety Warning

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

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

- **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, maintain or adjust it
- **ALWAYS** ensure that all safety guards are in good condition **and** in place whenever the machine is under power / in use. **ALWAYS** replace safety guards following machine adjustment.

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.

Acknowledgements

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We are particularly grateful to the Vintage Harvesters Group (Witton) for sharing their knowledge and providing access to numerous pieces of equipment during the preparation of this guide.

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1 Introduction

Purpose of this Guide

Most types of packaging machinery used in the harvesting and processing of thatching straw rely on mechanical knotter mechanisms to secure the package *(the sheaf, truss or bale)* with twine. Whether it's a Binder, a Trusser or a *(square)* Baler, the machine cannot function unless the knotter(s) operate reliably. And few things can cause so much angst as a mis-behaving knotter in the middle of harvest.

Even though they were developed in the late-19th Century, twine knotters are quite precise mechanisms, especially for agricultural machinery of that era. To operate properly, a knotter's components have to perform a certain sequence of actions, precisely timed in relation to one another, and all very quickly. It's rather like a mechanical equivalent of the 'Argentine Tango' on Strictly Come Dancing.

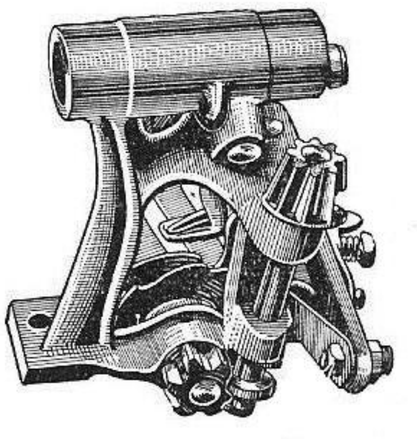


Fig.1.1 Deering binder knotter

For this reason, the operation and adjustment of knotters is often regarded as a rather mysterious, 'dark art'. If a knotter works more-or-less reliably, it is often considered best to 'leave well alone' and not to touch it, for fear of altering an adjustment & causing a bigger problem.

In fairness this perhaps isn't such a bad idea. If you don't know what you are doing and the knotter(s) are working OK, it's best to leave well-alone. But the trouble is that, like it or not, sooner or later mechanical wear and/or lack of appropriate maintenance or adjustment will cause tying issues which can no longer be ignored: and then someone has fix it.

All Baler Operator's Manuals, and also some for Binders & Trussers, suggest remedies/adjustments to address particular (mis)-tying faults. Frequently these refer the *(slightly-panicking)* reader to illustrations of various types of mis-tied or broken knots and suggest that a quarter-turn of the 'spurgle-spring' will have you up & running again in no time. That's all very helpful if you already know where the spurgle-spring is located and are fairly familiar with the highly undesirable consequences of over-tightening it. ***(P.S.** Don't waste too much time hunting for the Spurgle Spring because it doesn't exist!)*

It's not really that bad, but unless you know:

- Your particular machine's knotters *(there are many different types)*?
- What the particular *(knotter & related tying mechanism)* components are each meant to do?
- The way in which they should be adjusted to correct various faults?
- The likely consequences of incorrect adjustment?

… then I'm afraid that you're starting from a distinct disadvantage.

This Technical Guide takes a different approach to most Operator's Manuals. Instead of focussing on the *(tying)* problem once it has occurred and then trying to correct it, instead it:

- Explains which tying mechanism/knotter components are which *(on various types on knotter)*
- Explains what they are each meant to do *(during the tying cycle)*
- Shows how they should be setup and *(ideally)* should operate
- Shows what scope there may/may not be for system adjustment in-service, to correct common faults.

Hopefully, if everything is setup properly from the outset *(and that you appreciate/understand the correct setup)*, the chances of things going wrong will be far, far lower. Also, if a problem should then arise, with a much greater understanding of the knotters on your machine, you'll be in a far better position to identify the cause and sort it.

Understanding and adjusting knotters is made more difficult by the different designs produced by different manufacturers, **BUT** don't worry! Ultimately all mechanical knotters perform the same sequence of actions *(see Fig.2.1)*: it's just that the components which perform those actions may look slightly different *(see Section 5)*.

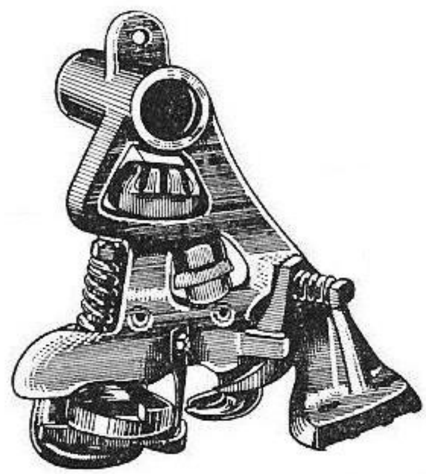


Fig.1.2 McCormick binder knotter

Conventions and Units Used by this Guide

Left and Right As viewed when standing behind the machine, facing towards the front

Imperial or Metric? Binders, Trusser and many Balers come from a time when imperial units were used exclusively. It is possible that some 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.

2 Knotters – How They Work – The Basics

Before things get complicated, let's remind ourselves of a few basic facts *(see Summary Box)*:

Mechanical (Twine) Knotters – A Few Facts

- **All** Knotters must perform the same sequence of tasks/actions in order to tie a knot *(Fig.2.1)*
- Different Knotter designs/makes may use different-looking components to perform these tasks, and they may perform them in slightly different ways, **BUT ultimately the operations performed are the same**
- Once engaged / 'tripped' the Knotter *(and the associated Tying Mechanism)* must perform a number of carefully synchronised actions very rapidly *(in less than 1 second).* These are almost impossible to observe by eye with any real accuracy
- The Knotter Unit's various components are each driven & synchronised *(timed relative to one another)* by a Cam Gear, mounted beside the Knotter. This rotates once every time the Knotters are tripped
- Depending on the machine *(and crop feedrate)*, when in work the tying mechanism will potentially operate:
    - **Binder:** every 1½ - 2 seconds
    - **Trusser:** every 12 - 15 seconds *(when packaging Longstraw)*
    - **Conventional Baler:** every 10 - 15 seconds
    - **(Howard) Bigbaler:** every 60 – 90 seconds

  So the Knotter's trip clutch & other components work hard & are likely to wear over time
- Whilst correct operation of the Knotter Units is very important, to work properly they rely on other components in the tying mechanism functioning effectively:
    - **Needle(s):** for correct twine delivery & placement into the Knotters
    - **Twine tensioners / twine guides:** for correct twine supply during the packaging & tying cycles.

That's painted rather a complex picture, but if you break the operation of the tying mechanism *(i.e. the knotters, needles & twine supply system)* into its distinct tasks/actions, it all becomes much easier to understand. In simple terms the sequence of actions performed is:

1) **'Engage'** *(Knotter)*
2) **'Deliver'** *(Twine)*
3) **'Hold'** *(Twine)*
4) **'Twist, Grab & Hold'** *(Twine)*
5) **'Cut'** *(Twine)* **and 'Eject'** *(Knot)*
6) **'Re-thread'** *(Knotter)*

These actions *(and the tying mechanism components which perform them)*, are explained in Fig.2.1.

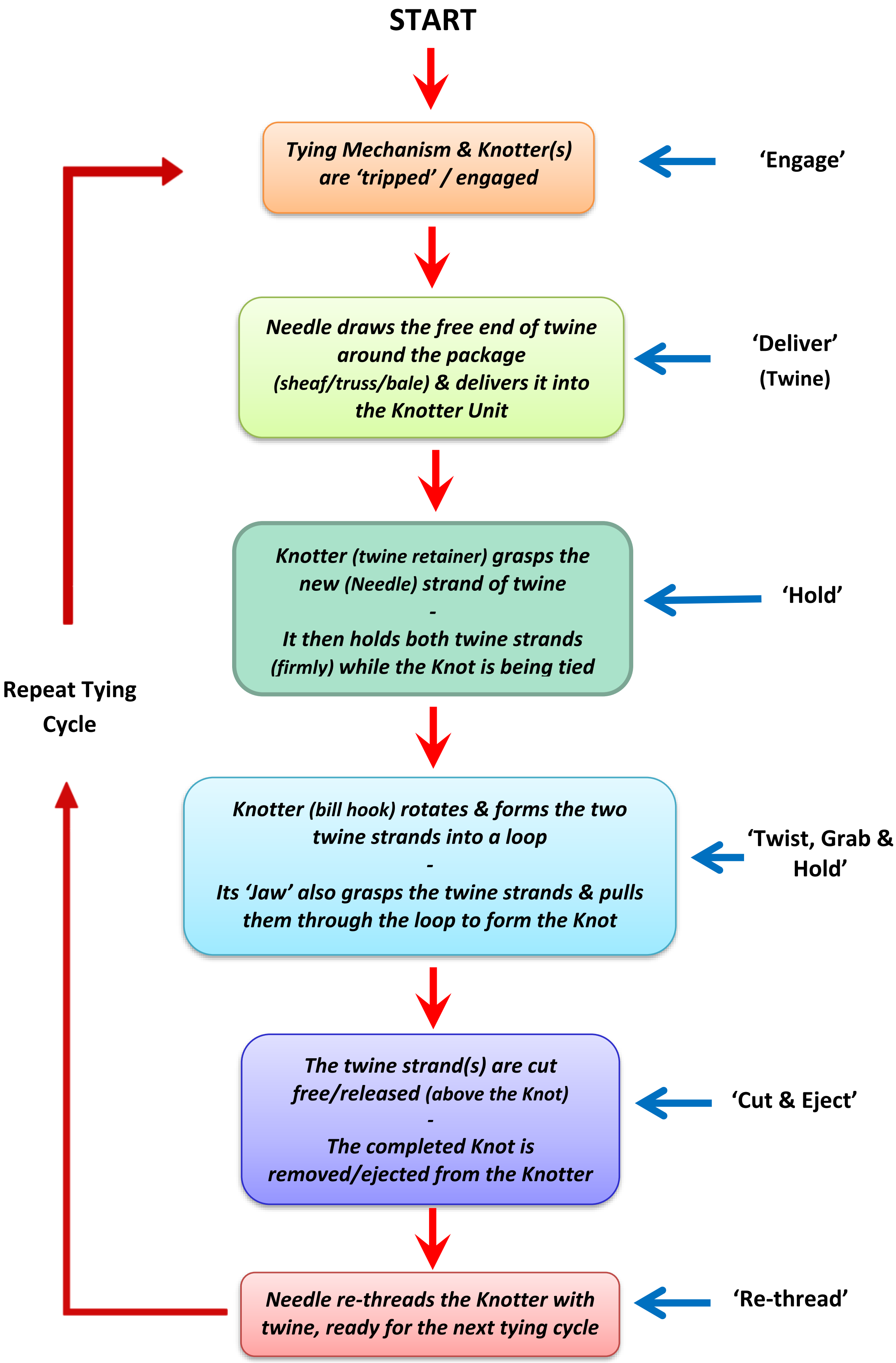


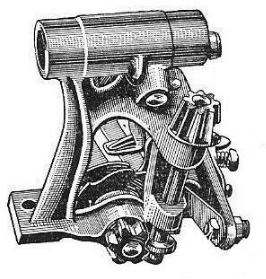
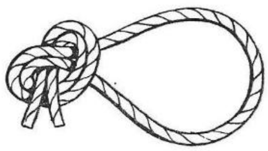
Fig.2.1 Sequence of knotter / tying mechanism tasks / actions during each tying cycle

3 Principal Knotter Types – Design and Operation

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 principal knotter types, perhaps to overcome patent restrictions, 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. Both feature a Twine Retainer / Holder which holds the strands of twine while the Bill Hook rotates & grabs them to form the knot *(see Fig.2.1)*. However, the knotters differ regarding the action of the Twine Knife, the initial angle/orientation of the Bill Hook and the way the completed knot is removed from it. 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** 	**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 *(modified)*, 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)*

3.1 Deering Knotters

Steps in the Deering Knotter’s Tying Cycle

1) The **Twine Disc & Retainer** holds the *(fixed)* end of the twine during sheaf/truss/bale 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 package

2) When the Knotter(s) are tripped, the **Needle** places the free-end of the twine around the sheaf/truss, across the **Bill Hook** and into a ‘notch’ on the outside edge of the **Twine Disc** *(Fig.3.1(a))*

3) The **Twine Disc** rotates slightly into the **Twine Retainer**. This grips both strands of twine in one ‘notch’ & also exposes another ‘notch’ in the Disc, to receive a new strand of twine from the **Needle** when it retracts *(Fig.3.1(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.3.1(b))*

   As it rotates the **Bill Hook Jaw** also opens & grasps the upper parts of both twine strands *(Figs 3.1(b) & (c))*

4) A power-operated **Twine Knife** cuts both strands of twine between the **Bill Hook** & the **Twine Disc & Retainer** *(Fig.3.1(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 3.1(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 around the next package of crop.

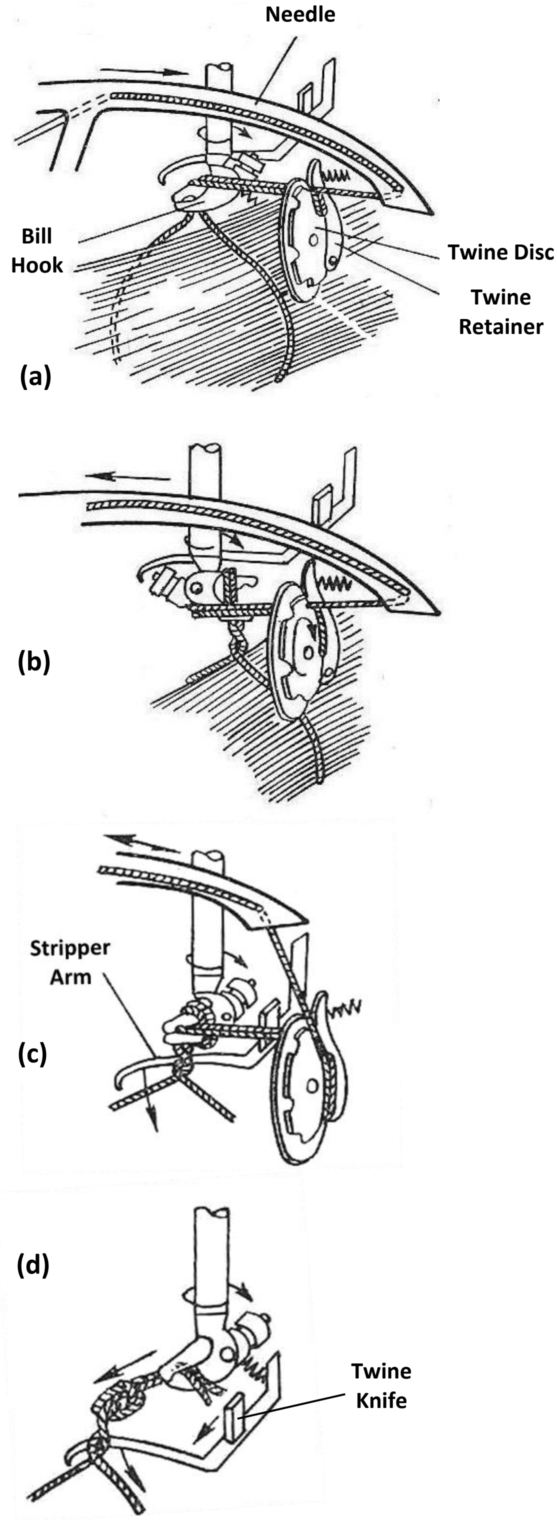


Fig.3.1 Deering-type knotter operation

Deering-type Knotter Construction

Figs 3.2, 3.3 & 3.4 show the key components of a contemporary Deering-type knotter unit, as fitted to a conventional *(small, square)* pick-up baler. 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.3.5)*. Both are mounted on the Knotter Shaft.

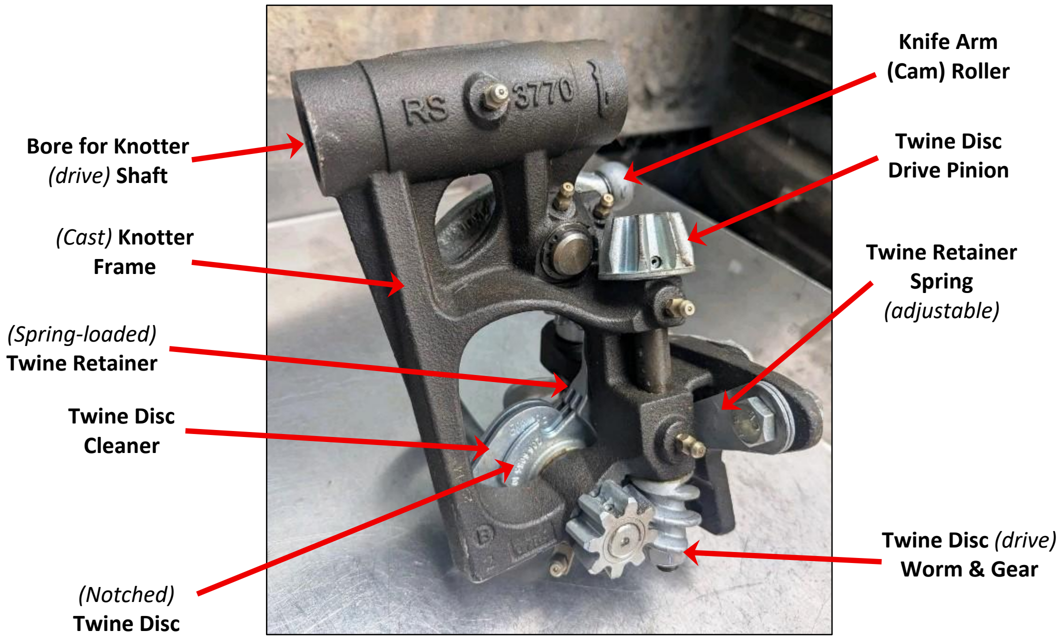


Fig.3.2 Deering-type knotter – Key components *(top view)*

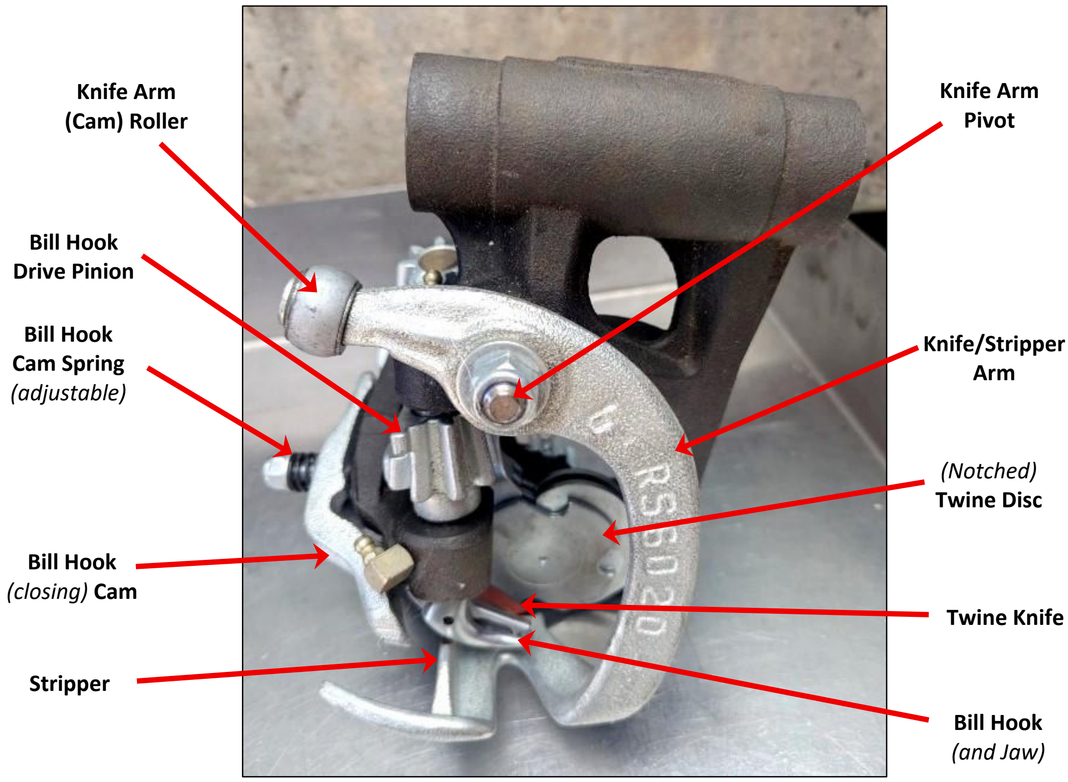


Fig.3.3 Deering-type knotter – Key components *(underside view)*

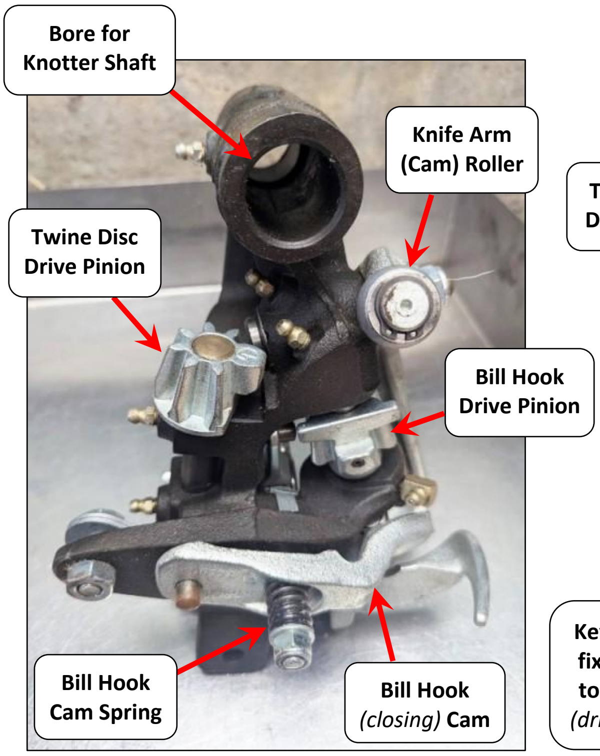


Fig.3.4 Deering-type knotter *(side view)*

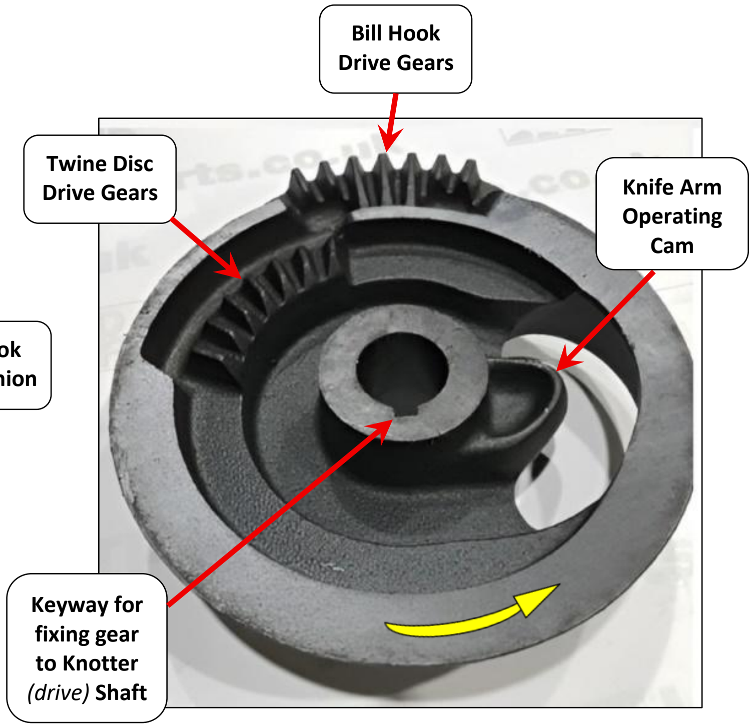


Fig.3.5 Cam gear for Deering-type baler knotter
(courtesy Woodfield Baler Parts)

Deering-type Knotters – Characteristic Features *(see also Table 1)*

The immediate identifying feature of a Deering-type knotter is its power-operated, moving knife which cuts both strands of twine towards the end of the tying cycle *(see Fig.3.1(d))*. However, there's more:

- The Bill Hook is mounted with its jaw / tip pointing at 90 degrees to the direction of crop flow through the machine. Consequently, a positive, mechanical mechanism *(i.e. the Stripper/Knife Arm)* is required to push or pull the twine loop off the end of the Bill Hook & form the Knot
- The Twine Disc is orientated with its underside at 90 degrees to the Needle's direction of travel. So, during twine placement, the Needle passes over the outside edge of the Twine Disc at 90˚ to it *(see Fig.3.1(a))*
- An *(adjustable*) spring-loaded Twine Retainer which presses against the side of the Twine Disc, to squeeze *(and hold)* the twine. Early Retainer designs were a slotted shoe or simple plate which either fitted over the edge of the Disc or simply pressed against its side. Later designs *(for balers)* utilise a double or triple-plate Twine Disc together with a comb-type Retainer which presses between the Twine Disc's plates; this enables greater *(twine)* retaining tensions to be achieved
- A Bill Hook with a pivoting, cam-operated 'Jaw' which grasps the twine strands during the tying cycle. A roller on the opposite end of the Jaw successively follows two cam tracks as the Bill Hook rotates. A track on the underside of the Knotter Frame causes the Jaw to open: an *(adjustable*) spring-loaded 'closing' cam *(Fig.3.4)* then causes it to close & grasp the twine. The *(spring)* adjustment permits the Jaw's clamping pressure to be varied to suit operating conditions …. **BUT this is a very sensitive adjustment!**

- As the (moving) Twine Knife cuts both strands of twine at the end of each tying cycle, a short piece of twine remains in the Twine Disc & Retainer. This 'twine offcut' is eventually ejected as the Twine Disc rotates during subsequent tying cycles. The short offcuts don't normally affect knotter operation, but they can build-up & become a nuisance in certain circumstances.

Deering-type Knotters - Operation

So how do the individual knotter components manage to perform their particular tasks in the right order & at the correct point(s) in the tying cycle? *(see Fig.3.1).* This is all controlled by the knotter's Cam Gear, which both drives and coordinates their various actions.

- 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.3.5)*
- The Twine Disc drive pinion and Bill Hook drive pinion *(Fig.3.4)* 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.3.5)* and this operates the Knife / Stripper Arm.

During each Tying Cycle of a Deering-type Knotter:

- 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 & hold the twine strands and also to expose the next 'notch' in the Disc, ready to receive the 'new' twine strand
  - **Bill Hook** to rotate through 360°, winding the twine strands around its body and also grasping them in its 'jaw' as it turns
    - As it rotates, the Bill Hook needs to pull a little extra twine back through the Twine Disc/Retainer. If the Retainer is set too tightly, it can't do so & the Bill Hook may be damaged
  - **Knife / Stripper Arm** to sweep across the heel of the Bill Hook, stripping the loop & forming the knot and also cutting the twine strands, before returning to its 'at-rest' position.

N.B. The Knife Arms of certain Deering-based knotters *(e.g. Hornsby & Albion)* don't sweep across the Bill Hook's heel to remove the twine loop & form the knot. Rather the Knife Arm's motion causes the twine loop to be pulled over the Bill Hook tip because the twine strands run through the twine guide groove in the rear of the Knife Arm *(Fig.3.6)*. Not quite such a positive knot stripping technique, but it works.

Fig.3.6 Twine guide groove on a Deering-type knotter Knife Arm *(arrowed)*

(courtesy Rasspe)

3.2 McCormick Knotters

In certain respects, McCormick-type knotters are similar to the Deering-type. After all, they must perform exactly the same actions, in the same sequence, in order to tie a knot *(see Fig.2.1).* Consequently, McCormick-type knotters also employ components to momentarily hold the twine strands whilst a Bill Hook rotates to form the knot: the twine is then cut by a knife.

However, when compared with a Deering-type knotter, apart from mounting the various knotter components on a cast frame, using a Cam Gear to drive & synchronise them and a Bill Hook to form the knot; everything else looks quite different.

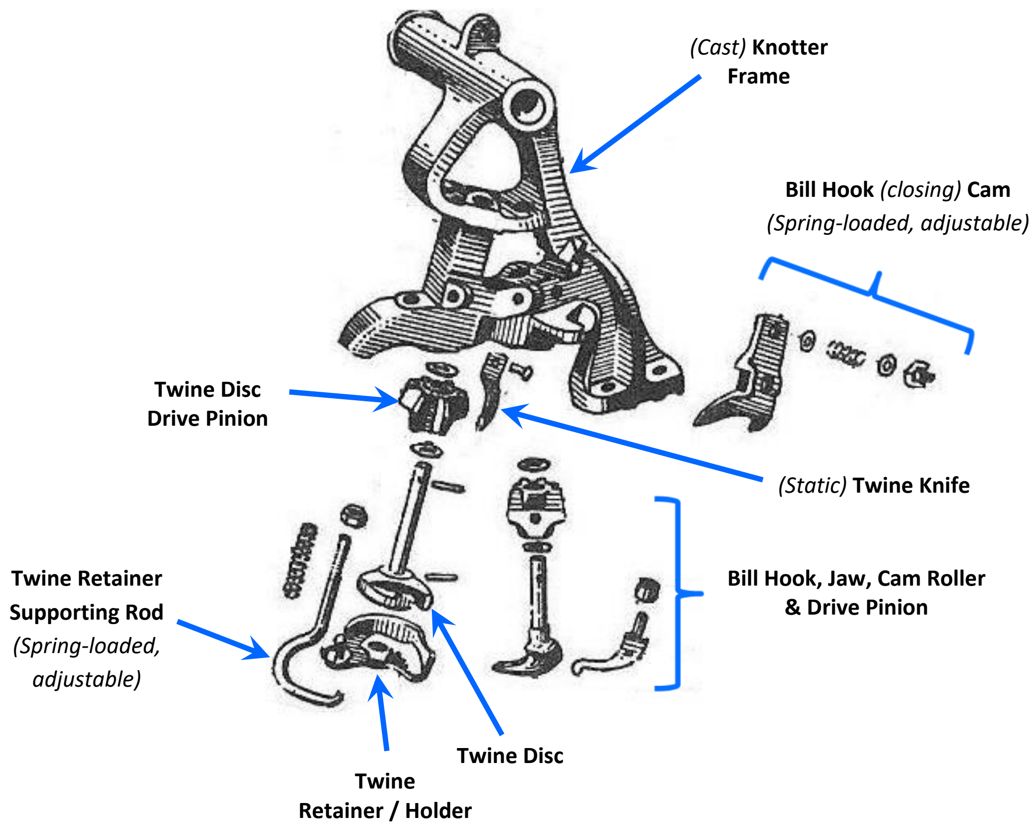


Fig.3.7 McCormick binder knotter – key components

(courtesy International Harvester Company)

McCormick-type Knotters – Characteristic Features *(see also Table 1 and Figs 3.7-3.9)*

- There is no power-operated/moving knife or stripper arm. The twine is cut by a Static Knife, rigidly attached to the Knotter Frame
- The Bill Hook performs exactly the same actions as on a Deering-type knotter, **BUT in this instance,** it is mounted with its jaw / tip pointing at 45 degrees to the direction of crop flow through the machine. In the absence of a stripper/knife arm, the twine loop is pulled off the end of the Bill Hook *(to form the Knot)* by the ejection of the Sheaf /Truss/Bale from the machine.
- Like the Deering knotter, a rotating, slotted Twine Disc operates in conjunction with a spring-loaded Twine Retainer to hold the twine strands while the Knot is being formed. **But here all similarity ends**

- The McCormick-type knotter Twine Disc:
  - Is relatively thick & has a slightly conical upper surface, with two slots running across it, one on either side of its central drive shaft *(Figs 3.7, 3.8 & 3.9(a))*
  - Is orientated so that its upper surface is parallel to the Needle's direction of travel. So, during twine delivery, the Needle passes directly over the top of the Twine Disc and places the free-end of the twine *(the 2nd strand)* into one of the Twine Disc's slots *(Fig.3.9(b))*
- An almost circular plate-type Twine Retainer is pressed against the underside of the Twine Disc by a spring-loaded, cranked rod *(Figs 3.7 & 3.8)*. A vertical rim extends around approx. ⅔ of the Retainer's edge and partly encloses the edge of the twine disc *(Fig.3.9(a))*

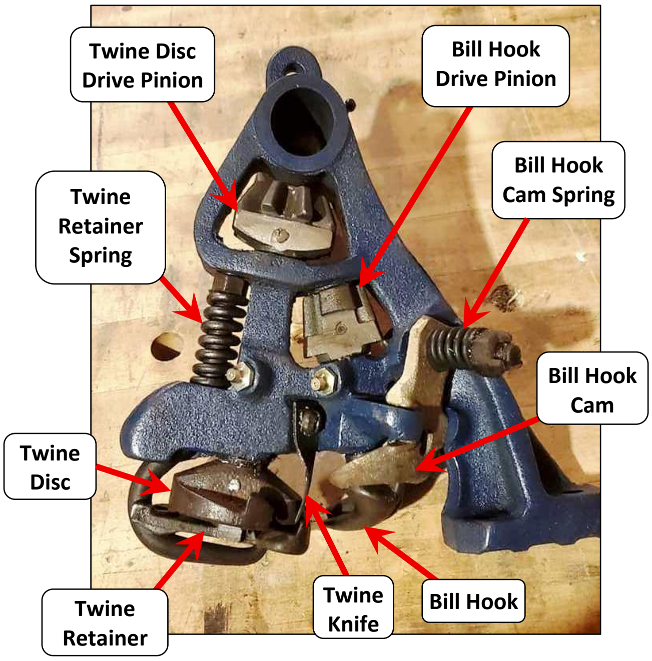


Fig.3.8 McCormick binder knotter

(courtesy B.W. Macknair & Son)

  - As the Twine Disc rotates during the tying cycle, the single twine strand delivered by the Needle is drawn in and held between the Twine Disc and the Retainer *(disc)*
  - The far side *(approx. ⅓)* of the Twine Retainer *(disc)* is cut-away *(Figs 3.7, 3.8 & 5.12)*. Consequently, as the Twine Disc rotates, upon reaching the cut-away section of the Retainer, any twine held by it is released
- Unlike a Deering-type knotter, the McCormick-type knotter only cuts one twine strand during each tying cycle. The end of the other *(1st)* twine strand is automatically released by the Twine Retainer as the Knot is removed from the Bill Hook. This, of course, coincides with the 1st twine strand reaching the cut-away section of the Twine Retainer. The practical consequences of this are that:
  - The form of Knot made by a McCormick-type knotter is different to that produced by a Deering-type knotter *(see Tables 1 & 2)*
  - Unlike the Deering-type knotter, a McCormick-type knotter does not produce twine offcuts
- Cleverly, the Twine Disc only rotates through a ½ turn during each tying cycle, so the upper part of the twine delivered by the Needle remains held, ready for the next tying cycle
- Less cleverly, during its part-rotation, the Twine Disc also has to draw the lower part of this *(Needle-delivered 2nd)* twine over the *(static)* twine knife *(Fig.3.8)*, to cut the twine free of the Retainer and enable the Knot to be formed
  - This approach works fine when everything is in good condition and the twine knife is kept sharp. However, as & when wear develops in the Knotter Drive Gears, Twine Disc timing can suffer *(become retarded)* and cause issues. Unlike a Deering-type knotter, the Twine Disc timing of a McCormick knotter cannot be adjusted.

Steps in the McCormick Knotter's Tying Cycle

1) The **Twine Disc & Retainer** holds the *(fixed)* end of the twine *(the 1st strand)* during sheaf/truss/bale 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** & the **Twine Bridge** and around the forming sheaf/truss/bale *(Fig.3.9(a))*

2) When the Knotter(s) are tripped, the **Needle** draws the free-end of the twine around the sheaf/truss and places it *(alongside the 1st strand of twine)*, over the **Twine Bridge** & **Bill Hook** and into the slot on the upper surface of the **Twine Disc** *(Fig.3.9(b))*

N.B. Unlike a Deering knotter, only a single *(the **Needle**)* twine strand is placed in the Twine Disc Slot. The other *(1st)* twine strand is already held by the **Twine Disc & Retainer** *(Fig.3.9(a))*

3) The **Twine Disc** begins to rotate *(through ½ a turn)* and grips the *(2nd)* twine strand *(delivered by the **Needle**)* between the **Disc** & the **Twine Retainer** *(Fig.3.9(c))*

   At the same time the **Bill Hook** begins to rotate *(through one turn)*, lifting both strands of twine over the tip of the **Twine Bridge.** It then winds them around its body, forming a loop *(Fig.3.9(c))*

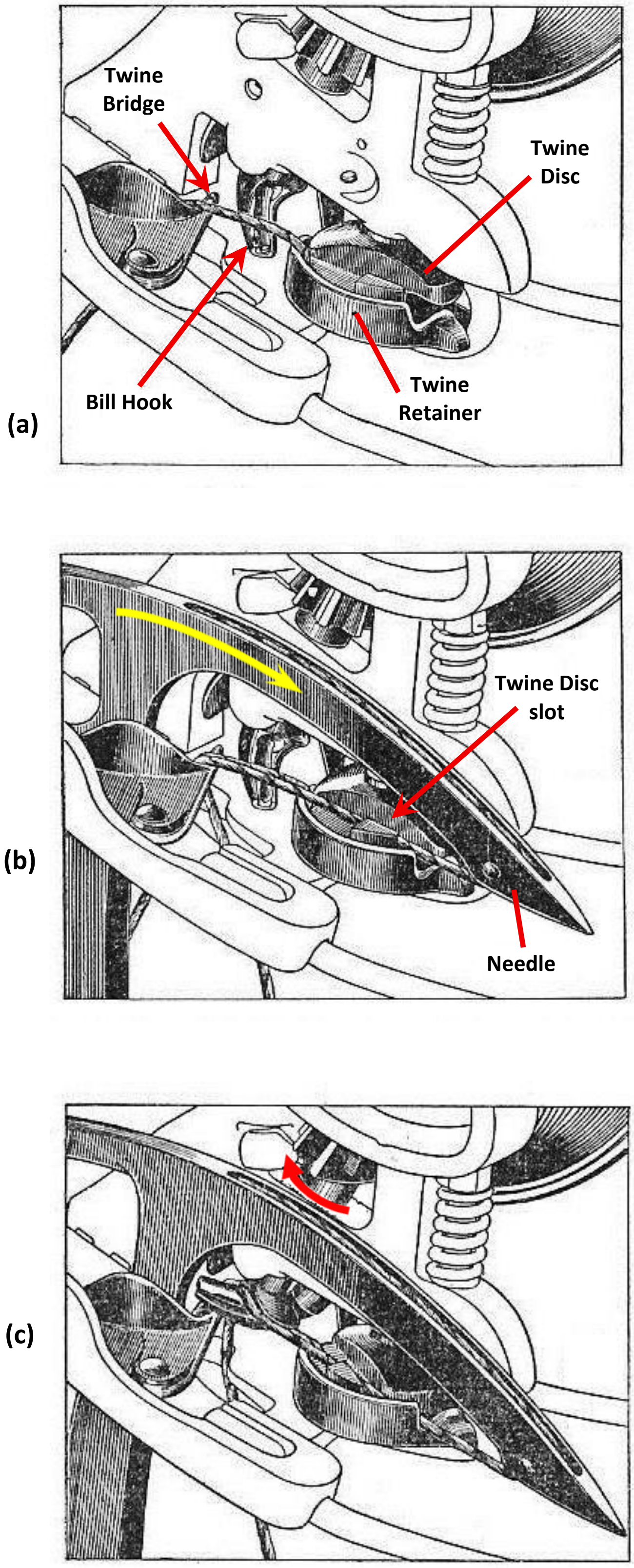
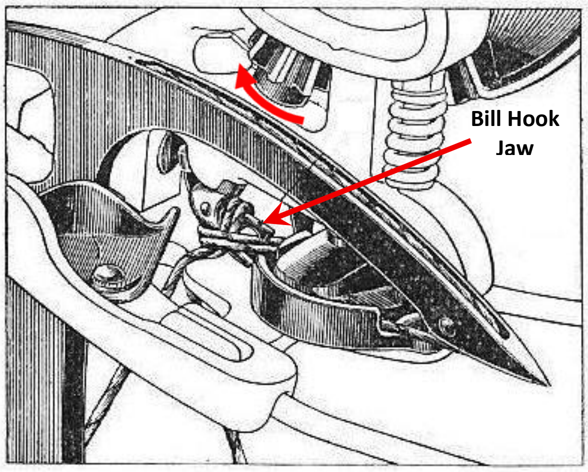


Fig.3.9 McCormick-type knotter operation

Steps in the McCormick Knotter's Tying Cycle *(continued)*

4) As the **Bill Hook** rotates, its **Jaw** opens & grasps both strands of twine held by the **Twine Disc & Retainer** *(Fig 3.9(d))*

(d)



5) The **Twine Disc** continues to rotate *(through ½ a turn)* and draws the 2nd strand of twine over the **Static Twine Knife** mounted on the **Knotter Frame.** This cuts the 2nd strand between the **Bill Hook** and the **Twine Disc & Retainer** *(Fig.3.9(e))*

   At the same time the *(previously held)* 1st strand of twine reaches a cut-away section in the **Twine Retainer** and is released

   The **Discharge Arms** now begin to eject the sheaf/truss, which pulls on both twine strands, causing them to slide along the curved slot in the **Breast Plate**. This helps to pull the twine loop off the end of the **Bill Hook** *(Fig 3.9(e))*

   However, the **Bill Hook Jaw** holds onto the twine ends sufficiently so they are pulled through the *(twine)* loop, completing the Knot.

(e)

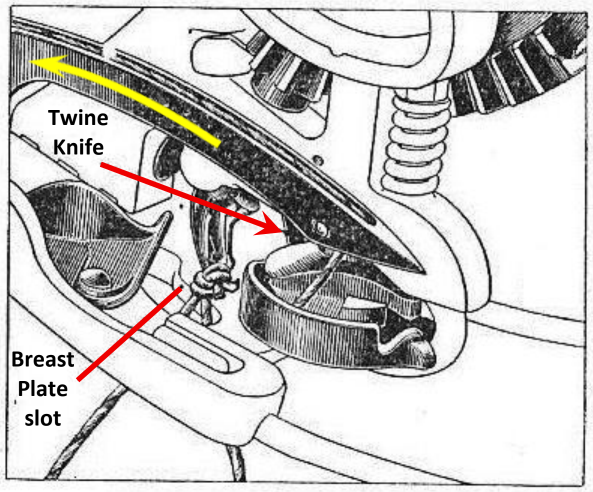
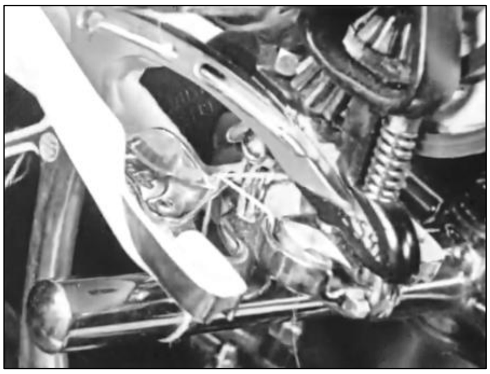


Fig.3.9 McCormick-type knotter operation *(continued)*

6) The retracting **Needle** now lays a new strand of twine, already held by the **Twine Disc & Retainer**, over the *(now empty)* **Bill Hook** and **Twine Bridge**, ready to bind around the next package of crop.



(courtesy Shutterstock)

Click on the adjacent image or scan the QR code for video of McCormick Knotter operation

What Should a McCormick-type Knot Look Like?

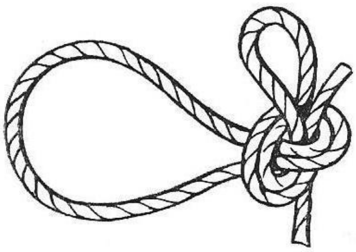
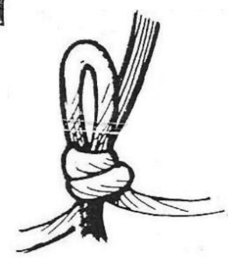
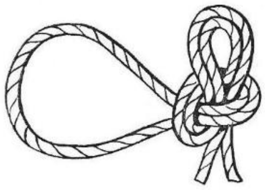
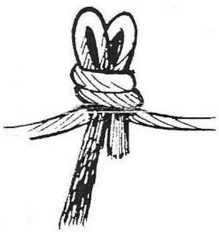
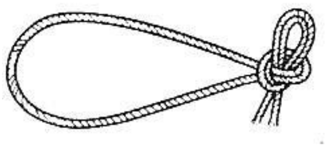
Simple Answer: It depends on the make/brand of *(McCormick-type)* Knotter which made the knot.

That's not a very helpful answer, but unfortunately opinion and documentary evidence differs regarding what is the correct form of knot that a McCormick-type knotter should produce *(Table 2).*

There is no question that the McCormick knot should be a 'loop' knot, but should it have one or two loops? Should both the twine ends be free or should one be tucked back into the knot? Does it really matter? In reality, the exact form of knot produced by the McCormick-type knotter depends on the relative positions & orientations of the Twine Retainer, Bill Hook and Twine Knife.

Possibly it's due to confusion between McCormick binders and McCormick International balers, whose knotter designs differ *(see Sections 5.4 & 5.5)*. Nonetheless, some machines must have produced knots of the 'Option (a)' type, but the balance of evidence suggests that 'Option (b)' is the more likely 'correct' type. Perhaps you can enlighten us?

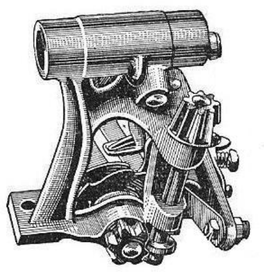
Table 2 Alternative types of *(correct)* Knot produced by a McCormick-type knotter

Option (a)	**Option (b)**
 	   
Overhand loop knot with a single loop: • One tail end protrudes from the knot • The other tail end is tucked into the knot • One tail end is longer than the other	**Overhand loop knot with a double loop**: • Both tail ends protrude from the knot • One tail end is longer than the other
Produced by: • McCormick binders *(possibly)* • Lanz binders *(possibly)*	**Produced by:** • McCormick binders *(probably)* • McCormick International balers • Claas trussers & balers • Lanz binders *(possibly)* • Lanz trussers & balers *(probably)* • Welger balers

3.3 Deering or McCormick-type Knotters – Which Are Best?

A difficult question to answer. All alternative designs of any piece of machinery have their own pros & cons but, ultimately, which generic type of knotter is likely to be more reliable in-service over the long term? Table 3 attempts to present an objective summary.

Table 3 Principal knotter types – Advantages and disadvantages

Knotter Type	**Deering** 	**McCormick** 
Disadvantages	• Slightly more moving parts to wear *(moving knife/stripper arm)* • Produces short twine offcuts *(may/may not be regarded as an issue)*	• Passive twine cutting mechanism *(static knife)* - Performance dependent on good *(knotter)* setup & maintenance • Less positive method of Knot removal from Bill Hook • More susceptible to wear-induced component timing variations • Limited scope for knotter component adjustment *(e.g. Twine Disc timing)* – Must instead repair or replace components
Advantages	• Positive-action twine cutting mechanism *(power-operated, moving Knife)* • More positive method of Knot removal from Bill Hook *(moving Stripper/Knife Arm)* • Greater scope for knotter component adjustment *(e.g. Twine Disc timing)*	• Slightly fewer moving parts to wear • Doesn't produce twine offcuts

Both Deering and McCormick-type knotters are inherently reliable designs which work well when properly set-up & maintained. However, wear will develop over time. After all, most Binders and Trussers currently used in thatching straw production would be regarded as museum pieces.

The method of operation of a McCormick-type knotter makes it more dependent on the correct timing & synchronisation of its various components. So, when wear develops in the Knotter's drive gears & pinions, the resulting free-play & backlash causes timing issues, leading to unreliable tying performance. Unfortunately, McCormick-type knotters also offer limited scope for adjustment of component timing; component replacement *(or repair)* being the only possible solutions: and replacement components availability is now very limited *(see Sections 5.4 & 6)*.

By comparison, the method of operation of a Deering-type *(moving knife arm)* knotter is inherently more positive and so they are more able to accommodate in-service wear with without loss of performance. Additionally, they also incorporate more scope for component adjustment to compensate for wear. They are therefore likely to be more reliable in the long run.

4 Main Knotter Problems / Performance Issues

This Section provides an overview of the main problems likely to affect any type of knotter / tying mechanism, whether on a Binder, Trusser or Baler. Specific types & brands of knotter are considered, together with what can be adjusted to correct problems, in Section 5.

Have You Really got a Tying Problem?

A little reassurance for neurotic machine operators. A missed/dropped knot every 300 – 500 tying cycles isn't poor knotter performance: **it's to be expected!** Similarly, one or two mis-tied sheaves or trusses, particularly at the start of the season, isn't a justification for machine adjustment. However, if you get three mis-ties in a row, then action should probably be taken.

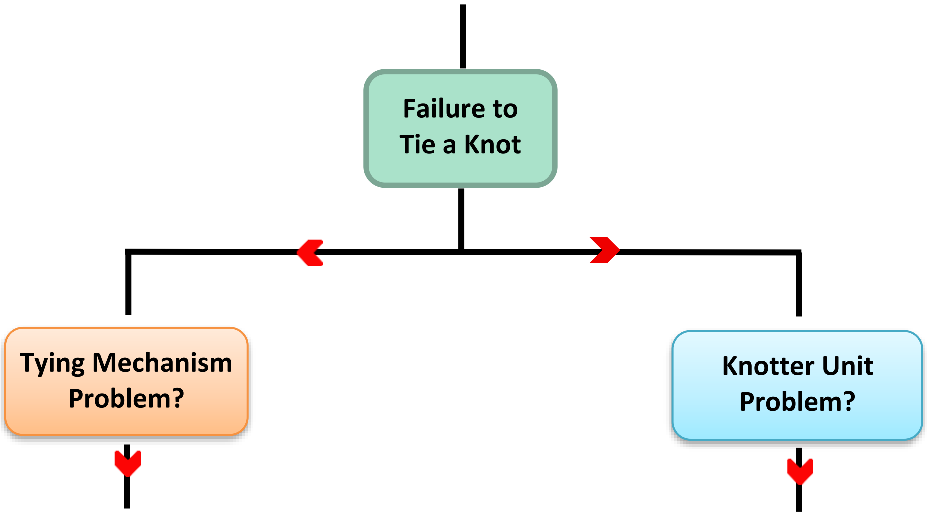
Intermittent faults which occur sporadically are the worst to try & correct, due to the lack of repeatable evidence. In these, and indeed in most other circumstances, working through the machine, looking carefully at the tying mechanism and getting the various settings correct from the start, is likely to offer the best chance of success.

The Key Question – Is the Knotter the Real Cause of the Problem?

- **ALWAYS** pause & ask yourself this question before reaching for the spanners to adjust the knotters. You may *(inadvertently)* do more harm than good
  - Does the real cause of the problem lie elsewhere?
- Just because the Binder/Trusser/Baler isn't tying properly **doesn't necessarily mean there's a fault with the knotters**
  - It could be a problem with some other part of the tying mechanism *(Fig.4.1)*
  - Have you actually got a 'Twine (mis) Tying' problem **<u>or</u>** is it a 'Twine Breakage' problem?
- If there's a Tying Problem, **the 1st place to look should be Needle operation & Twine placement**
- **ALWAYS look carefully and think before jumping to conclusions**
- **Is it a problem with just one Knotter or all of them?** *(if you have more than one)*
  - **If it's just one Knotter**, focus on that unit, its Needle **and** the twine supply *(and twine tension)* to it
  - **If all of the Knotters are misbehaving,** what things are common to them all?
    - **Knotter Trip and/or Drive Mechanism?**
    - **Needle timing or travel?**
    - **Twine supply** *(twine tension and/or twine quality)***?**

The Golden Rule

- If you do make an adjustment:
  - **Only ever adjust one thing at a time**
  - **If the adjustment doesn't correct the fault, put it back to its original setting BEFORE adjusting anything else!**



- **Accumulation of Debris**
- **Twine Quality issues**
- *(Incorrect)* **Twine Tension**
- **Needle operation** *(incorrect twine placement)*
- **Needle - Knotter component timing**
- **Twine Finger operation** *(Balers only)*

- **Twine Disc/Retainer operation**
- **Bill Hook operation**
- **Twine Knife operation**
- **Stripper Arm operation**

Fig.4.1 Principal causes of binder, trusser or baler tying problems

4.1 Tying Mechanism Problems

These are potential causes of tying problems where the Knotter Unit isn't at fault, but rather there's any issue with some other element of the tying mechanism. It may not even be a mechanical issue *(i.e. those on the left-hand branch in Fig.4.1)*.

In these instances, it's important that you **DON'T immediately adjust the Knotter!** First check the twine supply and make sure that the Needle is placing the twine in the correct location.

4.1.1 Debris Accumulation

Crop or other debris is bound to accumulate occasionally during operation of any Binder, Trusser or Baler: the only question is whether or not it accumulates sufficiently to affect the operation of the machine's tying mechanism. Debris could be loose pieces of straw, fragments/wisps of twine, twine offcuts *(from Deering-type knotters)* or even a stray grain stuck under the Bill Hook's Jaw.

As such it can restrict the flow of twine to the Knotter, cause Twine Tension to vary, obstruct twine delivery/placement into the Knotter or affect the correct operation of the Twine Disc/Retainer or the Bill Hook's Jaw. If they occur, such faults will typically be intermittent and are often blamed, mistakenly, on the incorrect adjustment of the Knotter Unit.

The operator's first response should be to thoroughly inspect the machine, particularly the twine supply system and the Knotters, and remove any debris. A battery-powered Leaf Blower can be an effective tool for this purpose. Following cleaning, the Twine Supply and Twine Tension setting should be checked *(at the Needle tip)* before recommencing work *(see Fig.4.4)*.

4.1.2 Twine Quality and Twine Tension

The supply of twine at a consistent & correct pre-tension is very important and is frequently overlooked. It has more influence on tying mechanism operation than many operators appreciate. All too often it's the last thing which gets checked when a problem occurs, when in fact it should be one of the first.

Twine Quality

Poor quality twine is both a waste of your money and your *(in-field)* time. It is likely to be of varying thickness and/or prone to shedding fragments/debris. Either of these characteristics will cause the machine's Twine Tension setting *(i.e. the pre-tension in the twine supply to the Needle)* to vary, irrespective of whether you use sisal or synthetic *(polypropylene)* twine. This in turn will cause poor/erratic knotter performance. Variable twine thickness can also affect the ability of the Twine Retainer and/or the Bill Hook Jaw to hold the twine with the correct force *(see Fig.4.4).* All too often this results in mis-guided adjustment of the Knotter, when in fact it probably was not to blame.

Table 4 shows the range of sisal & synthetic twine grades commonly used in Binders, Trussers & Balers *(those which use tying mechanisms)*. In essence, as the 'package' produced by the machine gets heavier *(i.e. larger and/or more dense)*, the twine used must be stronger and so, is usually thicker.

Table 4 Twine materials and grades commonly used in agricultural machinery

Twine material	**Application**		**Twine Grade**
Sisal	Binders		'No. 0'
	Trussers & Low-density Balers		'No. 1'
	Conventional *(small, square)* Balers		'No. 2'
Polypropylene	Conventional *(small, square)* Balers	Straw	'12,000' (ft) – 'Medium'
		Hay	'10,000' (ft) – 'Hay'
	Howard Bigbalers		'8,600' (ft)
	High-density *(large, square)* Balers		'7,200' (ft)

Twine Tension

So, twine *(pre-)* tension is important. It is also very easy to check and also adjust the twine tension setting. So why not do this a bit more often?

Fig.4.2 shows the twine supply path to the Knotter Unit on a typical Binder: the arrangement on most Trussers and Balers is very similar. Twine passes from the Twine Box, through the Twine Tensioner and a series of Twine Guides, through the Needle and around the forming sheaf, to the Knotter Unit.

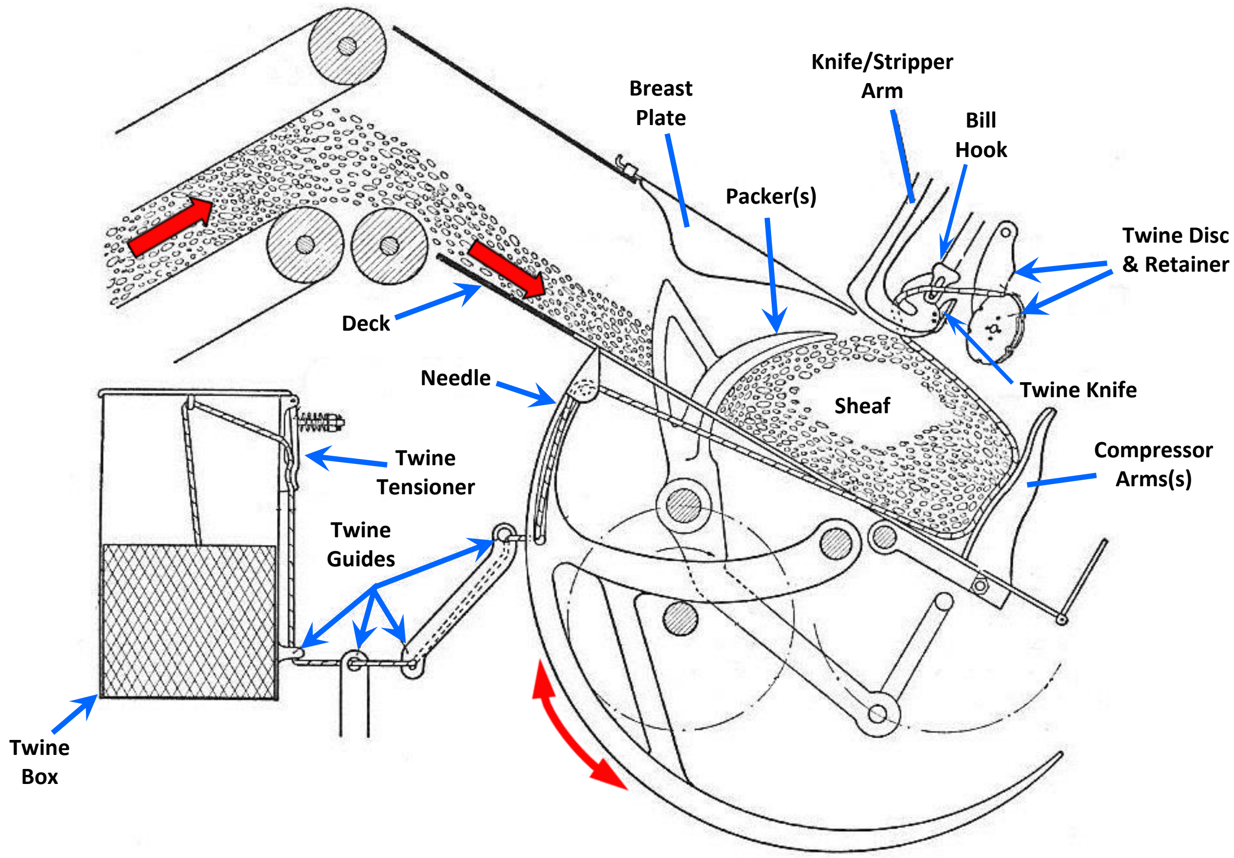


Fig.4.2 Twine supply path to the knotter unit on a Deering-type binder

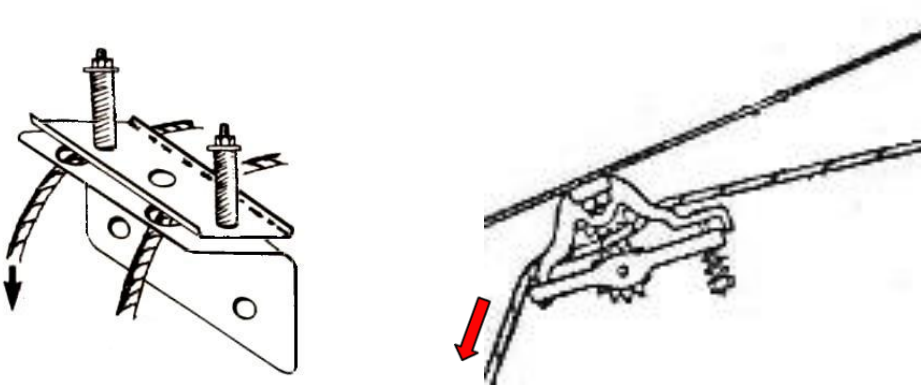


Fig.4.3 Alternative designs of twine tensioner - Spring-loaded plate-type *(left)* and spring-loaded intermeshing *(free-turning)* gear-type *(right)*

As the sheaf/truss/bale forms, more twine is drawn through the *(stationary)* Needle. When the tying mechanism is 'tripped', the Needle moves up quickly, taking more twine with it and delivers this to the Knotter Unit *(see Sections 3.1 & 3.2).* So, the rate of twine supply is fairly slow at first, but when the Needle moves it suddenly increases quite dramatically.

The twine *(supply)* tensioning system has to apply sufficient pre-tension to the twine to control its behaviour, both during sheaf/truss/bale formation and then also during the tying cycle. However, if excessive tension is applied, the twine could break or pull out of the Twine Disc/Retainer.

Most binders, trussers & balers use *(adjustable)* spring-loaded plate-type Twine Tensioners *(Fig.4.3 (left))*, although the intermeshing *(free-turning)* gear-type *(Fig.4.3 (right))*, is also found. In either case the twine passes between the plates or meshing gears and increasing or reducing the spring pressure on them increases/reduces the twine tension.

Some machines *(e.g. Massey Harris & Sunshine binders, many conventional balers & Howard (Mk2) Bigbalers)* incorporate additional tensioning devices to help control the rapid flow of twine & prevent 'twine looping' immediately following outward travel of the Needle. However, an equal number of machines seem to function happily without such additions.

Although the Twine Tensioner is normally sited near the Twine Box, it is important to check/measure the twine tension as it is pulled through the Needle's 'eye' *(Fig.4.4).* Passage though the Twine Guides and the Needle itself all add to the twine tension value which Knotter experiences; and this is what matters during work!

What Should the Twine Tension Setting Be?

Fig.4.4 shows the recommended twine tension range for binders, measured by pulling the twine through the Needle's 'eye' with a spring balance. Perhaps surprisingly, very similar settings are recommended both for Trussers and Conventional Balers. Even the Howard Bigbaler, which uses stronger/thicker twine to make a much larger/heavier package, recommends a twine tension of only 15 lb (~7 kg). Ultimately, the Knotters all operate in a similar way and this is what they need.

Twine Tension settings can be adversely affected by accumulations of crop debris, variable-quality twine and, **importantly,** by wear grooves in the Twine Guides and Needle eye(s). Similarly, wear grooves and/or roughness in the Twine Tensioner itself will cause unwanted twine tension variations. In all cases, inspect the twine path, seek out any signs of wear and repair/rebuild the components.

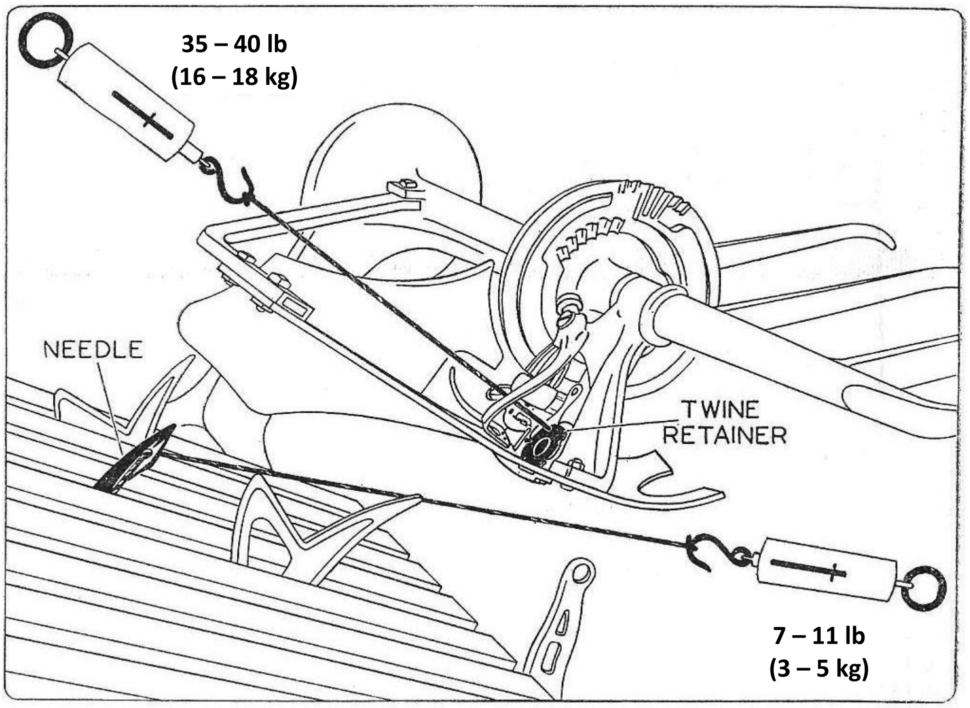


Fig.4.4 Recommended twine *(pre-)* tension when measured at the Needle's 'eye' *(bottom)*

N.B. Top-mentioned value(s) concern the Twine Retainer's clamping pressure setting

4.1.3 Needle Operation and Twine Delivery/Placement

The Needle is a critical component which must interact precisely with the Knotter Unit but, rather like Twine Tension, all too often it isn't immediately considered when a tying problem arises.

Needle Operation – Key Points

- **Needle setting & operation** should be the first thing to check if you have a tying problem
- **Is the Twine Delivery and Placement correct?**
  - If not, the Knotter can't produce a knot!
- If either Needle alignment, travel **or** timing are incorrect, the Knotter won't function properly, no matter how much you may try to adjust the Knotter

Where Should the Needle Place the Twine in the Knotter Unit?

- **Deering-type Knotters:**

  Into the Knife Arm twine groove, over the Bill Hook Jaw & into the waiting *(partially open)* 'notch' on the edge of the Twine Disc *(see Fig.3.1(a))*

- **McCormick-type Knotters:**

  Over the Twine Bridge and the Bill Hook Jaw & into the 'slot' on the upper surface of the Twine Disc *(see Fig.3.9(b))*

In either case that's quite a precise positional requirement for quite a large, rapidly moving object. Also, not only must the Needle deliver the twine in the correct position relative to the Knotter Frame and the waiting Twine Disc & Retainer, it must do so at exactly the right time so that the twine is caught & held by the Twine Disc & Retainer as it begins to rotate. As with so many things, **Timing is Everything!**

Needle Lateral Position

With few if any exceptions, the side of the Needle should rub lightly on the side of the Knotter Frame as it passes through/beside it *(Fig.4.5)*. Light contact with the *(fixed/stationary)* Knotter Frame improves the Needle's lateral stability and accuracy of twine placement during the tying cycle.

Binder and Trusser Needles are made of malleable iron which *(after gentle heating)* may be bent slightly *(with care)* to correct alignment issues: they can also become bent accidentally in-service.

However, Baler Needles are usually made from cast iron or cast aluminium and cannot be bent to correct faults. Accordingly, their mountings usually incorporate means for lateral & vertical *(position)* adjustment.

Remember, just because the Needle's lateral position is incorrect, before you attempt to adjust it, first make sure that it actually is the cause of the problem. Has the Knotter Frame moved on the Knotter Shaft? Has the Needle Shaft or the Needle Mounting Frame *(Needle Yoke)* moved sideways?

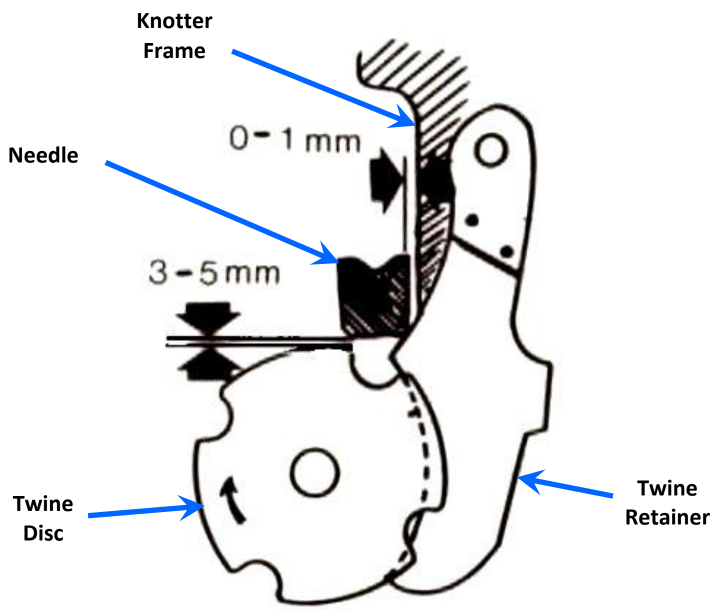


Fig.4.5 Deering-type *(New Holland)* Knotter - Recommended positioning of Needle in relation to Knotter Unit

- Side of Needle should rub lightly against the Knotter Frame with minimal clearance
- Underside of Needle should clear Twine Disc by $^{1}/_{8}$" - $^{5}/_{16}$" (3 - 5 mm)

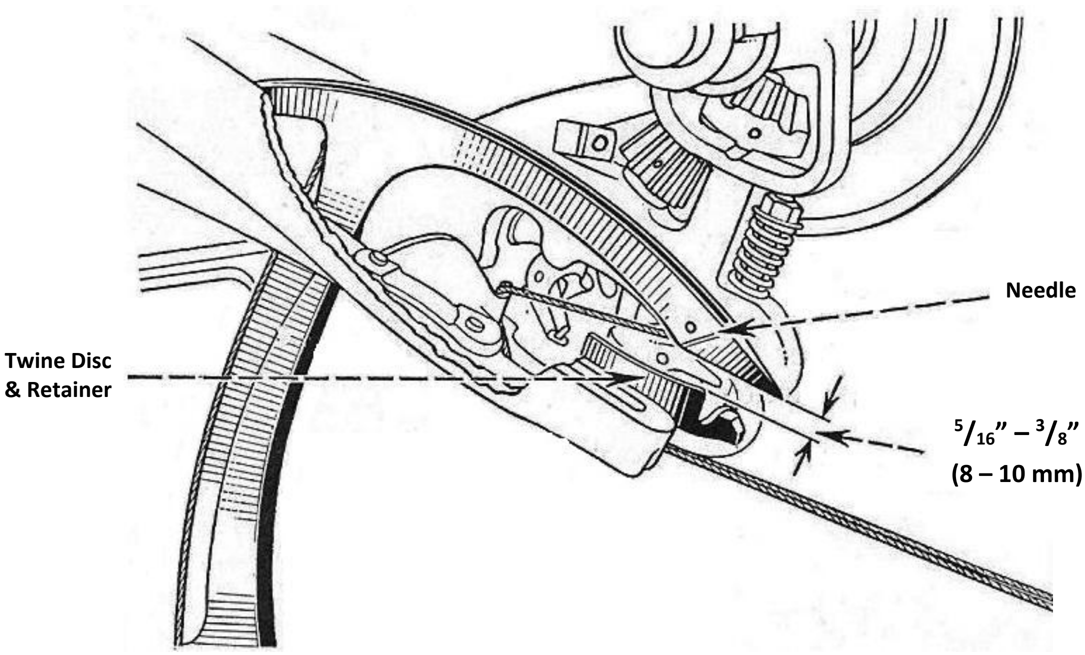


Fig.4.6 McCormick binder knotter - Recommended vertical position of Needle relative to Knotter Unit

- Underside of Needle should clear the upper surface of Twine Disc by $^{5}/_{16}$" – $^{3}/_{8}$" (8 - 10 mm) when positioned as shown

(courtesy IHC)

Needle Vertical Position

This setting is a bit more specific to particular machine / knotter designs so, if in doubt, always follow the recommendations given in the Operator's Manual – assuming you have one and it provides some *(unfortunately many Binder & Trusser manuals don't).*

For everything to work properly the:

- Underside of the Needle must pass close to the Twine Disc, but must not touch it
- Twine strand running below the Needle *(Fig.4.6)* must be drawn down sufficiently so that it is laid in the waiting notch or slot in the Twine Disc.

The Needle moves through/beside the Knotter Frame in an arc. As it progresses the twine is drawn through either a slot or around a roller in the Needle's tip *(the 'eye') (Fig.4.7 (top)).*

Although the Needle's tip passes close to the Twine Disc, this isn't close enough to deliver the twine into the Twine Disc.

Rather the Needle's tip has to pass beyond the Twine Disc *(Fig.4.7 (middle))* so that the twine strand is effectively pulled/lowered down into the slot/notch *(Fig.4.7 (bottom))*. To achieve this, both the Needle's vertical position and its travel must be correct *(see 'Needle Travel' below).*

The Needles *(tips)* of Deering-type knotters generally travel much closer to edge of the Twine Disc *(Fig.4.5)*: those of McCormick-type knotters generally maintain a greater clearance *(Fig.4.6)*, but rely on the needle arc of travel to lower twine into Twine Disc slot *(Fig.4.7).*

Baler needles usually incorporate means of vertical adjustment in their mountings, but those of Binders or Trussers rarely do.

Fortunately, Binder & Trusser needles are usually made of malleable cast iron and so their vertical position may be adjusted *(with care)* by bending the Needle upwards/downwards slightly, after gentle heating.

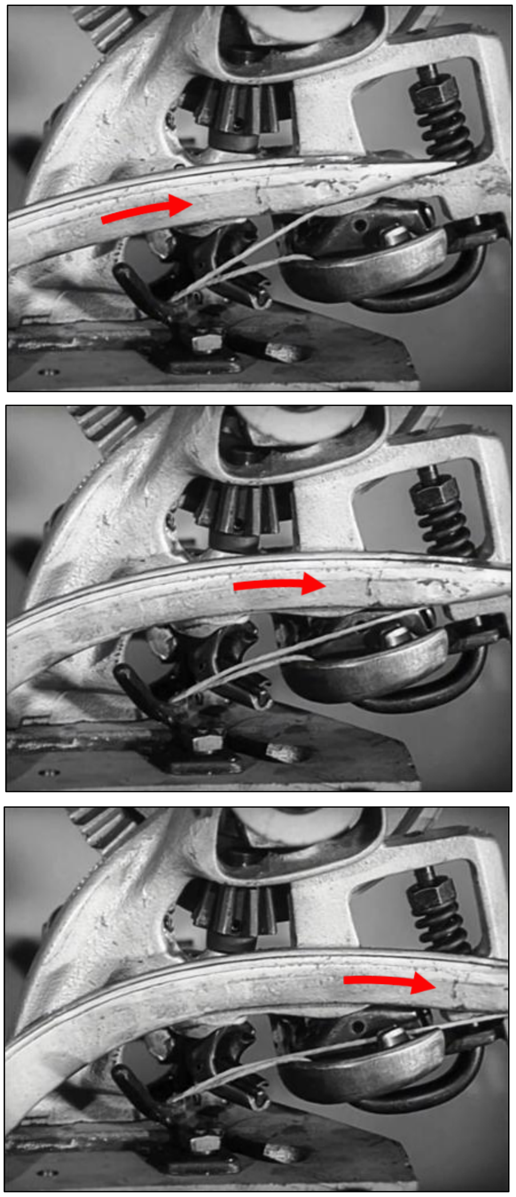


Fig.4.7 Twine delivery by Needle into the Twine Disc slot of a McCormick-type knotter

(courtesy CLAAS GmbH)

Click on the Bill Hook icon or scan the QR code for video of CLAAS Knotter operation

Needle Travel and Timing

Needle Timing: the timing of the needle's operation relative to the other components of the machine *(particularly those of the Knotter Units)* is important and **must be correct** in order to:

- Enable the Knotter Units to capture the twine during the tying cycle
- Permit the twine to be laid in the Knotter during the Needle's return stroke, in readiness for placing around the next sheaf/truss/bale
- Prevent the various components from colliding with each other.

The Needle is normally operated via a linkage driven by Knotter *(drive)* Shaft so, unless the drive mechanism is damaged, worn or out-of-adjustment, Needle Timing should be OK. However, the Knotter and the Needle drive mechanisms will wear over time and the resulting free-play / backlash in the system will eventually cause trouble. It will probably develop gradually over time, but it will eventually arrive. Similarly, wear and/or incorrect adjustment of the Needle's Trip Mechanism can also cause timing issues.

The Needle's operating linkage and trip mechanism can usually be adjusted to correct poor setup or to compensate for system wear *(to an extent)* but, ultimately, the best solution is to try and remove the wear/free-play. This may only be within the Needle's drive mechanism, **BUT** often wear and/or excessive clearance / 'end-float' between the Knotters and their drive *(Cam)* gears will also make a contribution *(see Section 4.2.5).*

Wear in drive chains can be easily addressed by their renewal. Drive gears & sprockets are more challenging; usually due to lack of new, replacement parts. Minimising gearset end-float is a first step, but building-up with Nickel-Bronze weld & re-profiling may be the only option for badly-worn sprocket or gears.

Needle Travel: the extent to which the Needle's tip passes through the Knotter Unit during the tying cycle is also of critical importance, to ensure the twine is placed correctly in the Knotter Unit *(Fig.4.7)*. However:

- The Needle's physical travel is affected by wear in, and/or incorrect setup of, its drive mechanism, **but:**
- Twine Placement may still not be correct, even though the Needle is travelling through the correct distance

In the latter case, always check the Needle's eye for wear. The passage of twine will almost certainly wear a slot into the eye over time, effectively enlargening it. So, even though the Needle travels to the correct point beyond the Twine Disc, the twine won't necessarily be taken as far as it should be.

Some Needles feature rollers within their 'eyes': if worn these should be replaced. Wear slots in 'solid' needles may be filled by brazing or, as a temporary fix, with 'liquid metal' type epoxy resin filler. It's a quick, temporary fix and may get you through to the end of the season.

4.1.4 Twine Finger Operation

Twine *(or 'Tucker')* Fingers tend only to be found on Balers, but they play an important role in helping the Knotter Units to perform reliably. However, they are usually hidden below the Knotters and sometimes get forgotten about.

On Balers, the physical dimensions of the bale chamber & other constraints mean that the Knotters can't be located & orientated in as ideal a position as they can on a Binder or Trusser.

This makes it more difficult for the Needle to deliver the twine correctly into the Knotter Unit, so that everything works properly. The Twine Finger's job is to help the Needle get the twine to the right place(s) so the Knot is tied correctly.

Each Knotter Unit has a Twine Finger, usually a 'half-moon'-shaped piece of steel plate which can be rotated through ~90 degrees by a linkage connected to a cam on the Knotter Shaft *(Fig.4.8)*.

Fig.4.8 Conventional baler twine finger *(arrowed)* in open position

During the tying cycle the Twine Finger rotates *(closes)* & its tip catches the twine strand from the underside the Needle and pulls it back against the side of Bill Hook *(Fig.4.9)*.

This ensures that when the Bill Hook rotates, the twine strands wrap properly around it, and its Jaw can grab them to form the Knot.

The Twine Finger must then return to its 'open' position, so that it doesn't obstruct the *(sideways)* movement of the Knife/Stripper Arm *(on Deering-type knotters).*

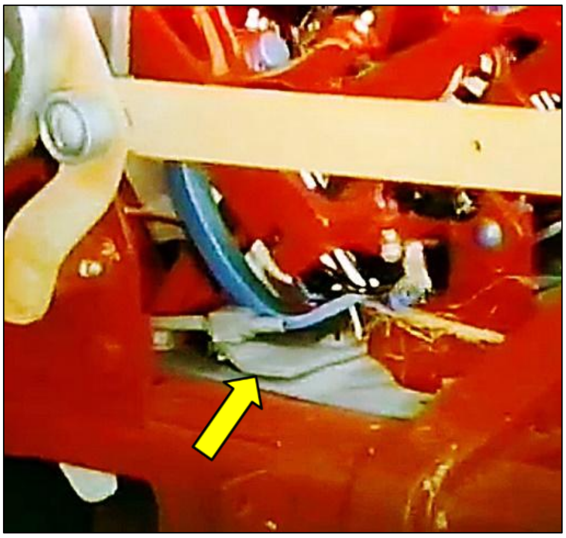


Fig.4.9 Conventional baler twine finger *(arrowed)* in closed position

(courtesy New Holland)

It is important that Twine Fingers are properly adjusted in terms of their:

- Position & clearance relative to the Needle's underside
- Open, 'at-rest' position
- Extent of travel / rotation.

Precise settings differ according to machine make & design, but correct Twine Finger operation is important and can cause tying problems which would otherwise be blamed on the Knotters!

4.2 Knotter Unit Problems

This Section considers operational problems which are likely to affect Knotter Units and the corresponding Cam *(Drive)* Gears *(i.e. those listed on the right-hand branch in Fig.4.1 & shown in Fig.4.10).* These problems can be grouped into four key areas, namely operation of the Twine Disc & Retainer, Bill Hook, Twine Knife, and the Stripper Arm *(if fitted).*

4.2.1 Twine Disc and Twine Retainer Operation

The Twine Disc & Retainer configurations used on the principal knotter designs *(i.e. Deering-type & McCormick-type)* are described in Sections 3.1 & 3.2. Their function is the same: to grasp the *(2nd)* strand of twine delivered by the Needle and to hold it firmly *(together with the initial/1st strand)* while the Bill Hook forms the Knot. Twine Disc/ Retainer problems fall into one of two categories:

Incorrect Twine Disc Timing

Disc 'notch' or 'slot' is not in the correct position to receive the twine delivered by the Needle, so no knot is formed. This can also cause twine *(knife)* cutting issues on McCormick-type knotters. Wear-induced backlash / free-travel will develop in the drive gears/mechanism over time.

- **Deering-type:** The Twine Disc 'notch' should be **almost completely open** *(beside the Retainer)*, **BUT it should be starting to enter the Retainer** *(Fig.4.11)*

  A very precise setting. Means of adjustment is usually provided
- **McCormick:** Twine Disc 'slot' should be parallel to the side of the Needle & Knotter Frame

  Means of adjustment is rarely provided. Delayed timing *(due to drive gear wear)* can cause twine cutting & knot formation issues.

Incorrect Twine Retainer *(clamping)* Pressure

An important and very sensitive adjustment – Only ever adjust ⅙ - ¼ turn at a time!

- **If Too Low:** The twine may be pulled from the Knotters *(Twine Disc/Retainer)* during sheaf/truss/bale formation *(Table 5 – Fault 2)*

  If a Knot is tied *(by a Deering-type knotter)*, its 'tail-ends' will be long & one may be looped back into the knot *(Table 5 – Fault 7)*

  N.B. Excessive Twine Tension *(or a twine supply restriction)* can cause similar symptoms!
- **If Too High:** The Bill Hook won't be able to 'borrow' additional twine from the Retainer when it rotates to form the Knot. This can overload & damage the Bill Hook & other components *(e.g. Knotter Frame or drive components)*

  Alternatively, the twine may break between the Retainer & the Bill Hook, preventing a Knot being formed *(Table 5 – Faults 2 or 3)*

  If a Knot is tied *(by a Deering-type knotter)*, its 'tail-ends' will be short and may pull through the Knot *(Table 5 – Fault 6)*

Operator's Manuals rarely suggest values for Twine Retainer Pressure but, for a Binder, it is suggested that a force of at least 35—40 lb should be required to pull the twine from the Retainer *(see Fig.4.4).* For Balers, particularly Bigbalers, this value should no doubt be slightly higher.

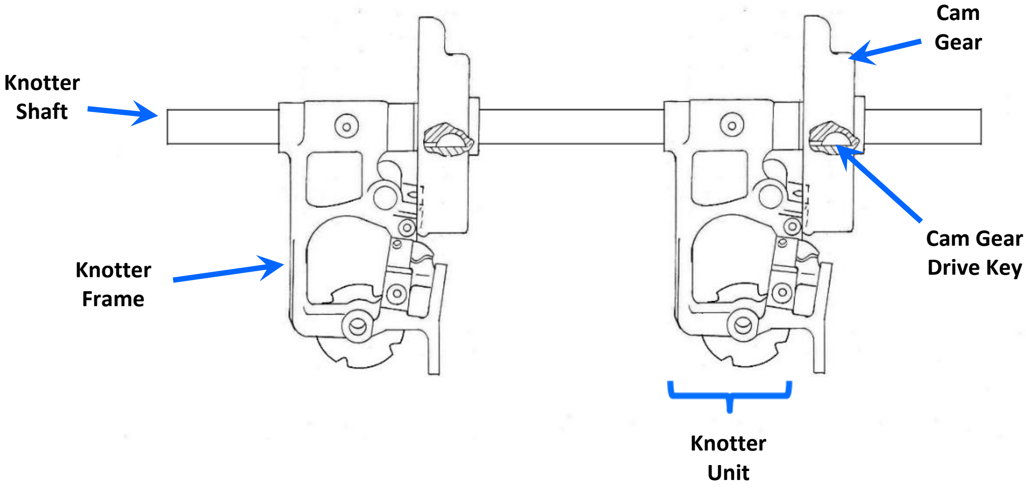


Fig.4.10 Likely arrangement of knotter components on a Trusser or Conventional Baler

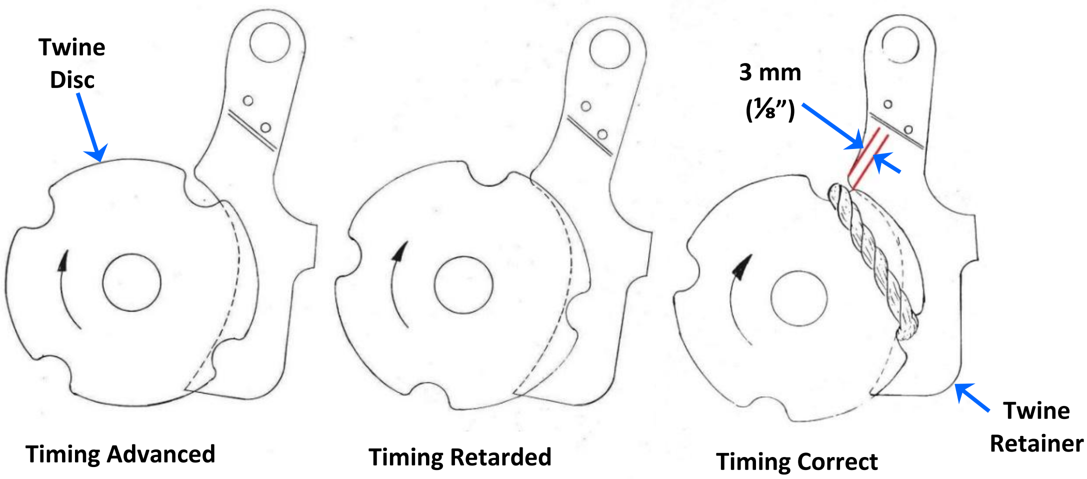


Fig.4.11 Twine Disc timing for a Deering-type knotter – Timing is correct if *(after each tying cycle)* the leading edge of the disc notch is 3 mm (⅛") past the front corner of the Twine Retainer *(right)*

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)*

Unexpected Causes

All the previously mentioned problems can be caused by incorrect Knotter setup/adjustment or by wear in the Twine Disc or Retainer or their drive mechanisms, or simply by twine fragments getting caught in hidden places. However, there can also be unexpected causes:

- **Incorrect and/or Variable Twine Disc Timing:** Can result from hidden faults in the Twine Disc driveline. A sheared drive pin or key, or a less-than-tight worm gear on a tapered shaft may transmit drive at times, but not when heavily loaded. This will cause timings variations

- **Damaged/Cracked Knotter Frame:** Hard to imagine and perhaps not immediately visible, but it can happen and will allow the knotter components to move slightly when under load, causing annoying, intermittent malfunctions. Clean the Knotter thoroughly & have a good look!

4.2.2 Bill Hook Condition and Operation

The Bill Hook *(and its moveable Jaw)* is probably one of the most critical components of any twine tying mechanism. In a precisely timed sequence, it must 'Twist, Grab & Hold' the twine strands and then release them in a carefully-controlled manner, to form the Knot. For this reason, if no other, it should be treated with care at all times and adjusted with respect!

Common Biil Hook-related problems include:

Rough / Rusty / Pitted Surface

It is **absolutely essential** that, once a loop of twine has been formed around the Bill Hook, it may be pulled or stripped off smoothly & quickly to form the Knot. Otherwise, the Knotter will perform sporadically or simply won't work *(Table 5 – Fault 4).*

Newer *(Baler)* Bill Hooks are chrome-plated, both to provide a smooth surface finish and for corrosion protection; but even these are not immune to rust damage. Bill Hooks should therefore always be protected against corrosion during winter storage.

- **Slightly rough or rusty surface:** Polish with fine 'wet & dry' paper
- **Very rough/pitted surface:** Renew Bill Hook

Incorrect Timing / Excessive *(rotational)* Free-Travel

The Bill Hook should only ever move *(rotate)* when it's meant to: otherwise, its timing relative to the other knotter components will suffer and, in extreme cases, it may collide with the Stripper Arm and cause serious damage *(e.g. broken Stripper Arm and/or cracked Knotter Frame)*.

The Bill Hook Drive Pinion/Gear incorporates a flat section *(see Fig.3.4)* which normally rests against the *(flat)* side rim of the knotter's Cam Gear *(see Fig.3.5)*. This prevents Bill Hook rotation until the Cam Gear itself rotates *(during the tying cycle)* and the Bill Hook's drive pinion meshes with the Cam Gear drive teeth.

However, wear on the flat section of the Drive Pinion, or excessive Cam Gear end-float, can allow excessive Bill Hook 'backlash' to develop. A little free-rotation is OK, but it should be minimal.

- **Worn Bill Hook Drive Pinion:** Renew pinion or build-up flat section *(with bronze weld)* & file back to original profile
- **Excessive Cam Gear End-float:** Adjust end-float or renew/repair Cam Gear *(see Section 4.2.5)*

Bill Hook Jaw Opening / Closing

As the Bill Hook rotates during the tying cycle, its Jaw must first open over the two twine strands held by the Twine Disc/Retainer *(Fig.4.12)*. It must then close firmly onto the strands and keep hold of them until the Knot has been formed *(Fig.4.13)*.

- **Opens Insufficiently to Grasp Both Twine strands:** A Knot will be tied on only one of the twine strands *(Table 5 – Fault 2)*. Problem caused by wear/damage to the Bill Hook Jaw roller/cam follower or wear on the 'opening' cam track on the Knotter Frame. Address by Bill Hook replacement, building-up the cam track, or simply inserting shim washers under the Bill Hook's drive pinion *(to raise the Bill Hook slightly within the Knotter Frame).*

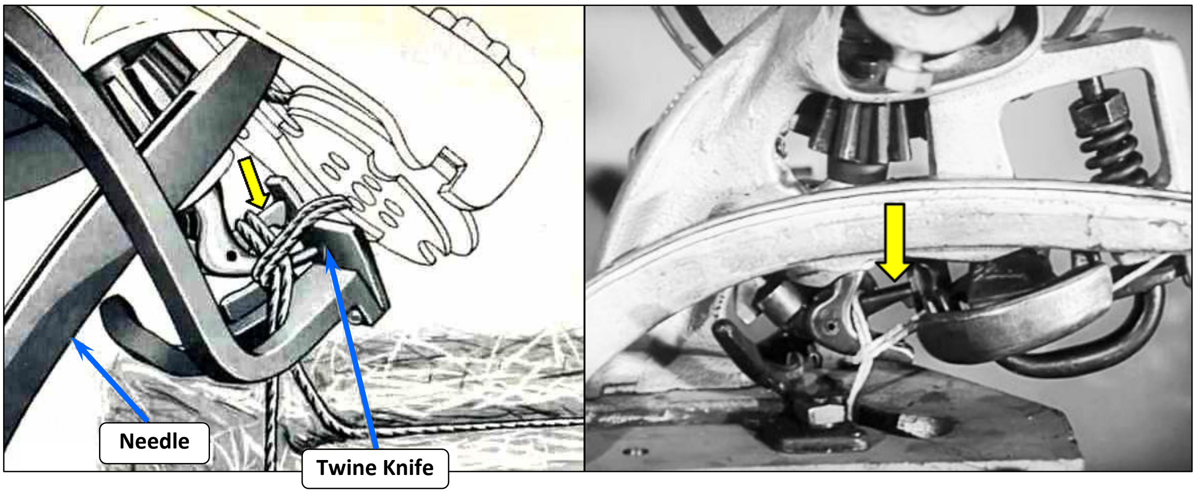


Fig.4.12 Bill Hook Jaw *(arrowed)* opening to grasp the twine strands during the tying cycle: Deering-type knotter *(left)* and McCormick-type knotter *(right)* *(courtesy Deere & Co and CLAAS GmbH)*

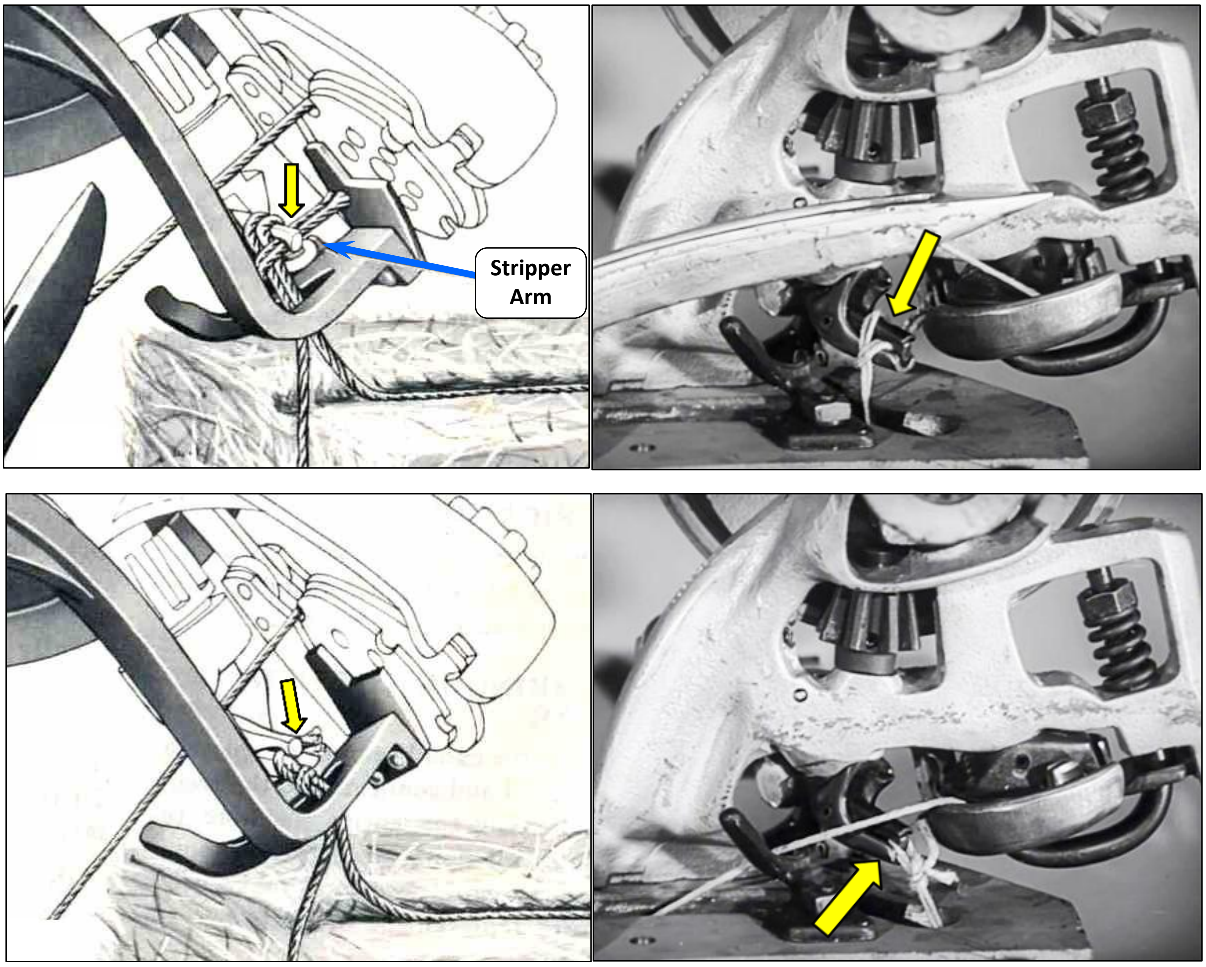


Fig.4.13 Bill Hook Jaw *(arrowed)* closes & grasps the twine strands *(top)* and keeps hold of the twine ends/loops as the Knot is stripped/removed from the Bill Hook body: Deering-type knotter *(left)* and McCormick-type knotter *(right)* *(courtesy Deere & Co and CLAAS GmbH)*

Bill Hook Jaw Opening / Closing *(continued)*

- **Bill Hook Jaw doesn't close sufficiently to Hold the Twine Strands, despite adequate 'Clamping' Pressure setting:**

  The Jaw doesn't hold onto the twine tail-ends and pull them sufficiently through the 'loop' to form the Knot *(Fig.4.13)*. If a Knot is made, it will be loose & short-tailed and may well pull apart *(Table 5 – Faults 5 or 6)*.

Caused by:

- Worn or damaged Bill Hook Jaw roller/cam follower
- Worn Bill Hook Jaw and/or Body
- Worn Bill Hook 'closing' cam track
- 'Tip' of Bill Hook Jaw preventing Bill Hook from closing sufficiently to hold the twine *(thickness)* being used

Component replacement or rebuilding are the main remedies, but slight grinding of the Bill Hook's groove or the underside of the Jaw's 'tip' can address the last issue.

Incorrect Bill Hook *(clamping)* Pressure

The *(adjustable)* spring-applied pressure which determines how firmly the Bill Hook's Jaw tries to keep hold of the twine strands towards the end of the tying cycle *(Fig.4.13).*

Another important & very sensitive adjustment – Easy enough to adjust **BUT only ever adjust ⅙ - ¼ turn at a time <u>and</u>** return it to the original setting if the adjustment doesn't cure the problem!

- **If Too Low:** The twine tail-ends won't be held firmly enough to pull them sufficiently through the 'loop' to form the Knot. If a Knot is made, it will be loose & short-tailed and may well pull apart *(Table 5 – Faults 5 or 6)*
- **If Too High:** The completed Knot won't be stripped/pulled off the Bill Hook at the end of the tying cycle. A knot is formed, but it hangs on the Bill Hook and the twine band will break as the sheaf/truss/bale is discharged *(Table 5 – Fault 4).*

4.2.3 Twine Knife Operation

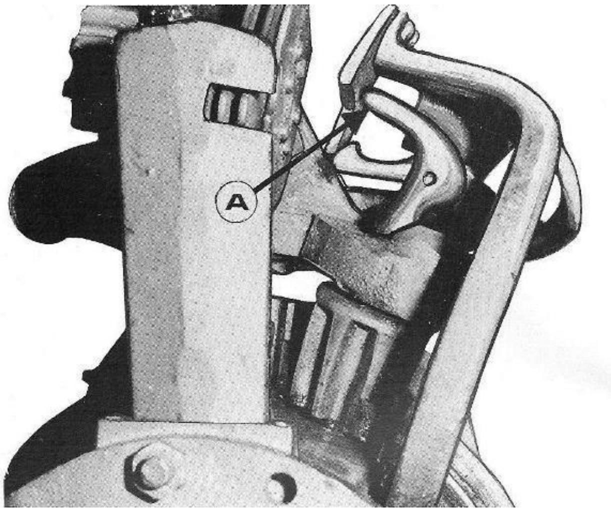
As explained in Sections 3.1 & 3.2, the Twine Knife may be either moving / power-operated *(Deering-type knotters)* or fixed / static *(McCormick-type knotters)*. In either case it has to perform the same function: to cut the twine strand(s) towards the end of the tying cycle. So, what can go wrong?

Blunt Knife

A fairly obvious problem which can be easily addressed, either by sharpening or replacing the Knife. Tell-tale signs include frayed twine ends *(Table 5 – Fault 10)*, **BUT a blunt knife can also cause other tying problems, particularly with fixed/static knife** *(McCormick-type)* **knotters.**

N.B. Always check that the Twine Knife is actually sharp in the localised part of the blade which cuts the twine strands. You might be surprised!

(continued)



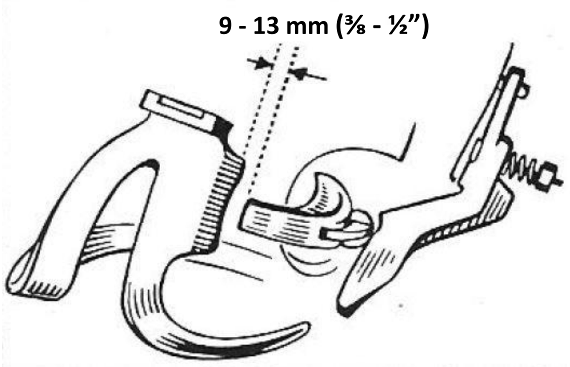


Fig.4.14 The Knife/Stripper Arm should not contact the Bill Hook ***(A)*** during the tying cycle **EXCEPT** to rub across the Bill Hook's heel

(courtesy New Holland)

Fig.4.15 Typical *(correct)* Stripper Arm travel past the Bill Hook's tip

(courtesy Rasspe)

Incorrect Knife Position or Travel *(see also Section 4.2.4)*

The likely problems & the remedies depend on the knotter and knife type:

- **Fixed Knife:** Can work loose and/or become bent. Ensure that it's in the right position and is fixed firmly to the Knotter Frame
- **Moving Knife**
  - **Bent Knife Arm:** The Twine Knife is usually attached to the end of a pivoting, cam-driven Knife/Stripper Arm made of malleable cast iron *(see Figs 3.3)*. It can be bent *(slightly)* to adjust its position and/or travel **BUT,** it can also become bent in-service. This can affect knife-twine strand contact and/or allow the Bill Hook Tip to contact the Knife as it passes, and stress the Knotter Frame *(Fig.4.14 & Table 5 – Fault 8).*

    Bent Knife Arms can be bent *(levered)* back to the correct shape, but considerable force & care is required *(Fig.4.16)* and use of a jig will help to achieve the correct *(critical)* dimensions. There's also a risk that they will bend again! In any case **DO NOT PRE-HEAT THE KNIFE ARM.** If difficult to correct it, component replacement may be preferable.
  - **Worn Cam Roller:** The Knife Arm (cam) Roller *(Fig.3.4)* can wear or seize & develop 'flat spots' or the 'cam lobe' on the Cam Gear can wear. Either will cause insufficient Knife/Stripper Arm travel past the Bill Hook's tip *(Fig.4.15 & Table 5 – Fault 4).*

    Knife Arm Cam Rollers are cheap & easy to replace, if available. Otherwise, worn examples can sometimes be removed & replaced 'upside-down' as a short-term fix, **BUT** removal, building-up *(with bronze weld)* & filing back to the original profile is the long-term fix.

4.2.4 Stripper Arm Operation

The following comments **DON'T apply to McCormick-type knotters!**

All Deering-type knotters *(those with the Bill Hook mounted at 90˚ to the crop flow)* must have some form of mechanism to remove the Knot from the Bill Hook. All feature a cam-operated, moving knife, usually mounted on a pivoting Knife Arm. **However,** the Knife Arm may / may not also include a 'Stripper Arm'; an additional 'lump' on the Knife Arm which sweeps across the heel of the Bill Hook as the arm moves, to strip-off the twine loop & form the Knot *(Figs 4.13, 4.16 & 4.18)*.

Those Deering-type knotters which don't feature a Stripper Arm *(e.g. Hornsby & Albion machines)* rely on the twine being pulled off the Bill Hook by the movement of the Knife Arm. The twine strands pass from the Sheaf/Truss to the Knotter via the Twine Guide Groove in the Knife Arm: so, when the Knife Arm moves sideways to cut the twine, the twine strands are pulled.

'Stripper Arm' problems usually show up as a failure to remove the Knot from the Bill Hook at the end of the tying cycle. A knot is formed, but it hangs on the Bill Hook and the twine band breaks as the sheaf/truss/bale is discharged *(Table 5 – Fault 4).*

The possible reasons for this, the underlying causes and likely remedies are as follows:

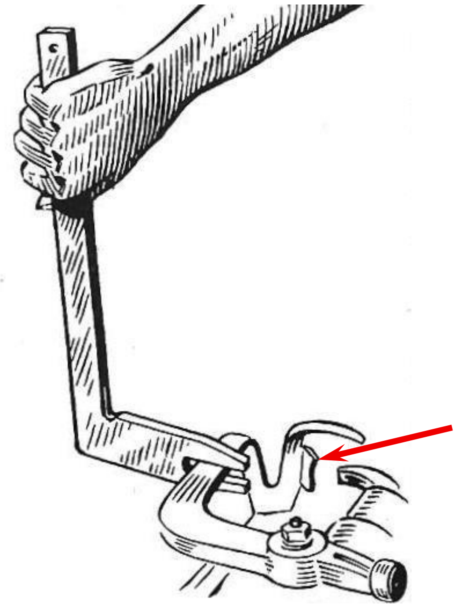


Fig.4.16 Adjusting a Deering-type Knife Arm – Integral Stripper Arm *(arrowed)*

(courtesy Rasspe)

Fig.4.17 Twine Guide Groove on a Deering-type knotter Knife Arm *(arrowed)*

- All edges in circled area must be rounded & smooth

(courtesy Rasspe)

- **Insufficient Stripper Arm Travel past Bill Hook Tip** *(Fig.4.15)*
  - **Bent Knife Arm:** – Straighten/adjust *(Fig.4.16)* or replace
  - **Worn Knife Arm Cam Roller:** - Replace or repair Cam Roller *(see Section 4.2.3)*
  - **Worn Cam Track *(on Cam Gear)*:** - Repair or replace Cam Gear *(see Section 4.2.3)*

- **Excessive Clearance between Stripper Arm and Bill Hook's Heel** *(Fig.4.18)*
  - Stripper Arm should rub 'lightly' across the Bill Hook's heel:
    - **To Reduce Clearance:** - Hit the back of the *(malleable)* Stripper Arm with a decent-sized hammer to bend the arm & obtain the correct clearance. **Don't pre-heat the Knife Arm**
    - **To Increase Clearance:** - Bend the Arm up slightly with a suitable pry bar or lever *(Fig.4.16)*
  - Bill Hook should have no vertical movement: - Insert shim washers under the Bill Hook Drive Pinion to eliminate any movement, so it doesn't lift up as the Stripper Arm passes.

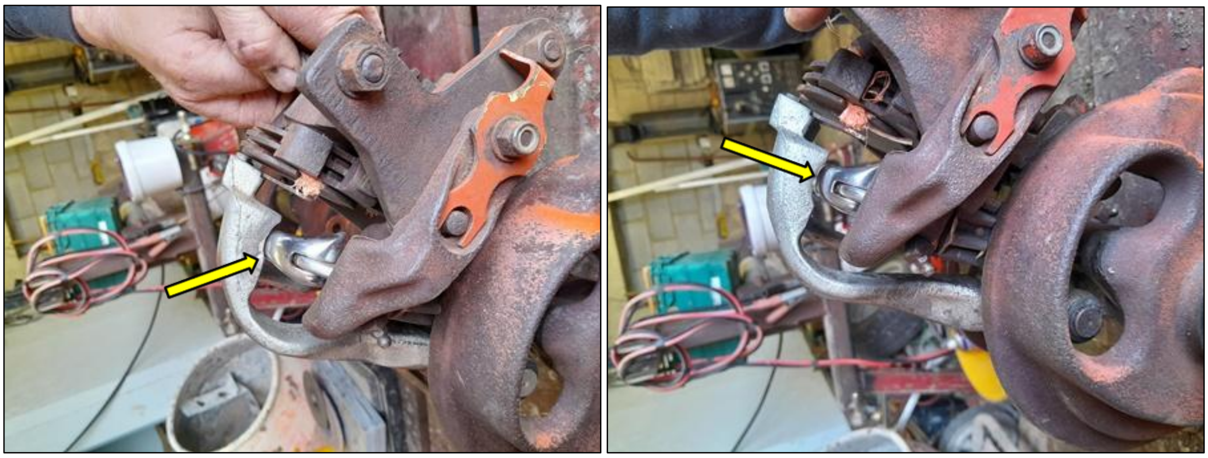


Fig.4.18 The Stripper Arm should rub lightly across the Bill Hook's heel *(left - arrowed)*
- Excessive Stripper Arm – Bill Hook clearance *(right - arrowed)*

4.2.5 Knotter Unit to Cam Gear End-Float

Remember, as far as Knotters are concerned, **TIMING IS EVERYTHING!**

As explained back in Section 3, all the various actions of any type of Knotter Unit are precisely co-ordinated by the Cam Gear *(see Fig.3.5).* Driven from the Knotter *(drive)* Shaft, the Cam Gear drives and triggers the movements of all the components fitted to the Knotter Frame *(see Fig.4.10).*

That's all well & good when it's new, but over time wear is inevitable, both on the Cam Gear's drive teeth and also on the Knotter's *(Bill Hook & Twine Disc)* Drive Pinions. As wear develops, knotter component timing will suffer, things will no longer be where they should be when they're meant to be and knotter reliability will reduce.

The trouble is that, because it develops gradually over time, it's not always easy to recognise the underlying fault. In extreme cases, drive teeth can 'jump', causing incorrect knotter component position(s) during the tying cycle, potentially causing collisions & severe knotter component/frame damage. **This is definitely worth avoiding at all costs.**

So, what can be done?

If the parts are available *(and the wear is bad!)*, the Drive Pinions and/or the Cam Gears can be replaced. The former are fairly cheap; the latter much less so, but it's all cheaper than a broken Knotter Unit! If replacement parts aren't available, then it's either a case of locating good second-hand spares *(which may also be worn)* or trying to rebuild your own, worn parts. Time to start bronze welding and get the files & die-grinder out of the cupboard.

However, before that stage is reached, things can be improved a great deal by minimising the 'end-float' clearance between the Cam Gear(s) and the Knotter Unit(s). 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 *(Fig.4.19)*.

N.B. **BEWARE** of shimming the Cam Gear too tightly against the Knotter Unit Pinions and the Knotter Frame. **It must be able to turn freely without binding.** Otherwise, the rate of wear will accelerate and/or components may be stressed and break!

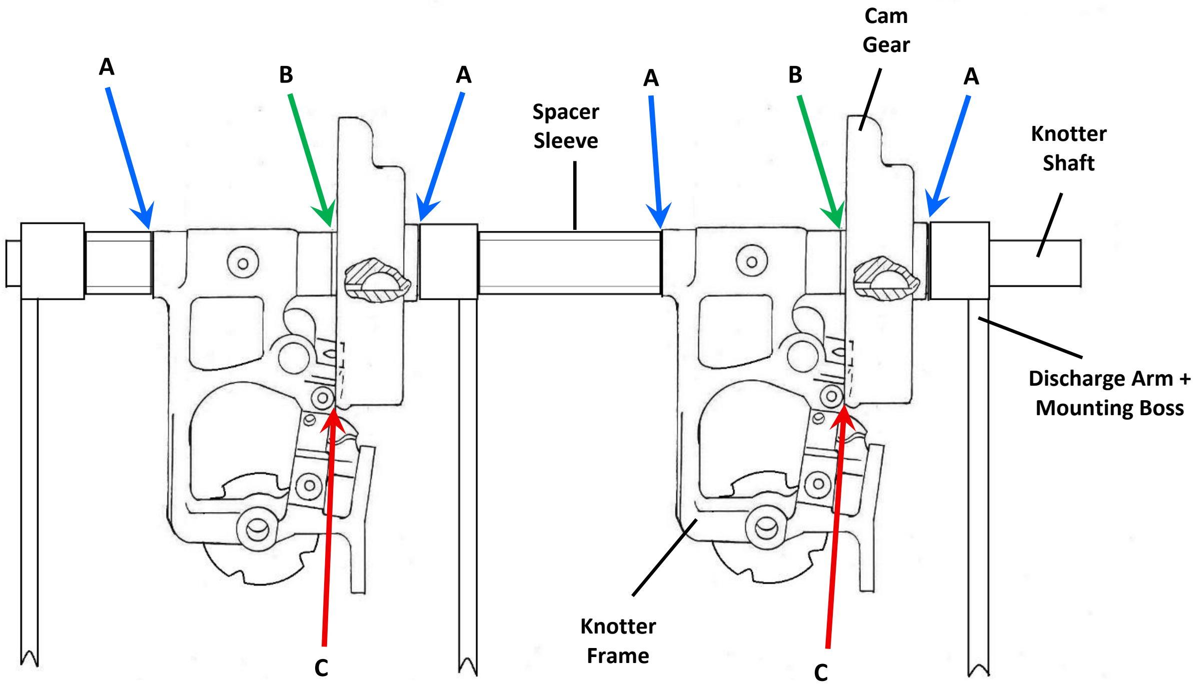


Fig.4.19 Knotter Unit – Cam Gear end float adjustment – Progressively add shims at Points 'A' and ***(very gradually)*** remove shims at Points 'B' until it is possible to rotate each knotter frame freely against the Cam Gear face with minimal clearance at Points 'C' *(less than 0.4 mm (0.015"))*

- **Don't overdo the adjustment! – The Cam Gear MUST NOT bind on the Knotter Frame or Gears**

N.B. On Conventional Balers, the adjacent Knotter Units & Cam Gears may almost butt-up against each other *(Fig.4.20)*.

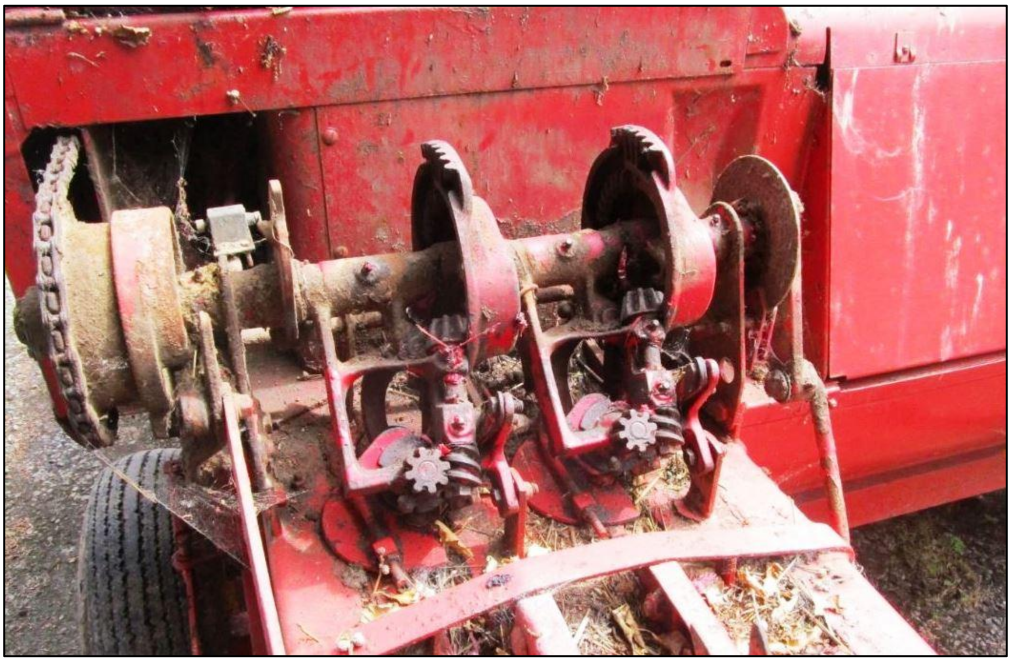


Fig.4.20 Pair of Deering-type knotters installed on a 1960s New Holland conventional baler

4.3 Diagnosing Knotter Problems

It's much better to try and set things up properly in the first place, to avoid a problem, rather than having to try and diagnose & identify the source of the problem in the tying mechanism after it has raised its ugly head in the field *(when the pressure is usually on)*.

However, that almost suggests that, if you follow the system setup recommendations in this Guide, you'll never experience a knotter problem and everything will work just fine. Unfortunately, that would be wishful thinking.

So, sooner or later you will experience a knotter or tying mechanism problem and end-up with a mis-tied knot or broken piece of twine. This can be useful to help identify the root cause of the problem **BUT,** it requires some careful observation and a bit of detective work *(see below)*.

Diagnosing Knotter Problems – Things to Remember

Look, Think & Look Again

- **Careful examination** of a mis-tied knot or broken piece of twine **and also** noting the location where you found it, can help to identify the cause of tying mechanism problems
- **Table 5 shows the symptom(s) of ten common tying mechanism faults BUT,** accurate knotter / tying mechanism fault diagnosis from twine appearance is not easy because:
  - **There are a number of possible causes** of any particular tying fault
  - **Different knotter types** *(Deering or McCormick)* produce different-looking knots *(see Table 1)*: the appearance *(& the occurrence)* of certain mis-ties may also differ between them
- **NEVER, EVER be tempted to 'take a closer look'** while the machine is under power / in-motion, to try & identify a problem, because:
  - **You won't see anything -** The mechanisms operate too quickly
  - **You'll risk serious bodily injury -** Don't become an accident statistic!

SAFETY WARNING

Keep a Look Out for:

- **Sharp Edges**
  - Sometimes the cause of the fault can be this simple!
  - **ALWAYS** check for sharps edges *(and snagging points)* on components near where the twine may pass, whether during sheaf/truss/bale formation, the tying cycle or 'package' discharge
- **Accumulation(s) of Debris**
  - Can alter the Twine Tension or prevent the Knotter components from working properly
  - **ALWAYS** check for this **BEFORE** heading elsewhere

When You Think You've Found the Problem:

- **Only ever adjust one thing at a time**
- If the adjustment doesn't correct the fault, **put it back to its original setting BEFORE adjusting anything else!**

Table 5 Symptoms of tying mechanism problems and possible causes

(Click on section no. for further info.)

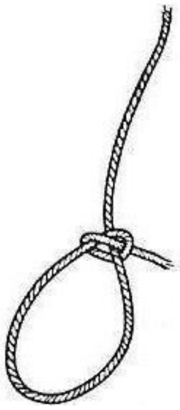
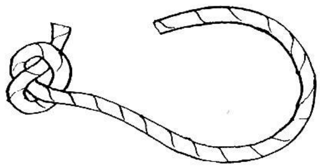
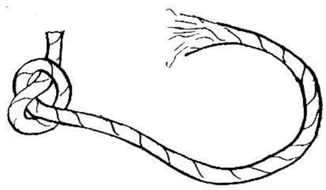
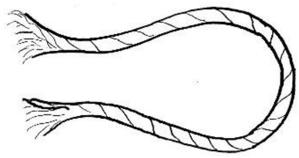
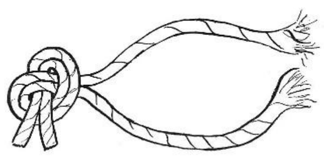
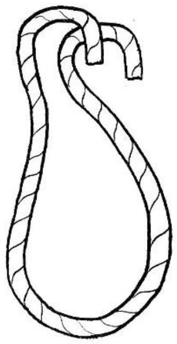
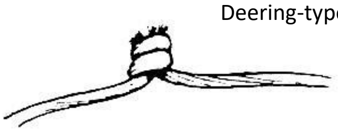
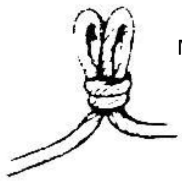
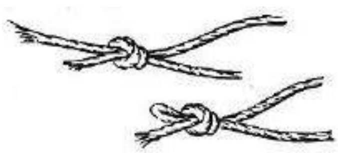
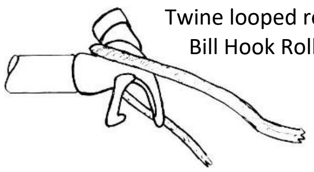
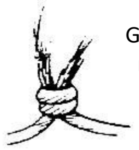
Fault No	Appearance	Problem & Possible Cause(s)	For Remedy see Section No.
1		**Incorrect Twine Delivery to Twine Disc & Retainer:** • Needle timing too late relative to Twine Disc • Twine Disc timing incorrect relative to Needle • Needle Lateral or Vertical position *(relative to Knotter Frame or Twine Disc)* incorrect • Needle travel insufficient • Needle 'eye' worn • Crop debris obstructing Needle eye or Twine Disc 'notch' / 'slot' • Twine Finger setting incorrect *(Balers only)* • Excessive Twine Tension	4.1.3 4.2.1 4.1.3 4.1.1 4.1.4 4.1.2
2	 Single Knot on Needle end of Twine 	**If end of Twine is Cut, the Twine has pulled out of Twine Disc/Retainer:** • Twine Retainer *(clamping)* pressure is too Low • Excessive Twine Tension *(if Knot found on Bill Hook)* **If end of Twine is Frayed / Broken:** • Twine Retainer *(clamping)* pressure too High • Excessive Twine Tension *(if Knot found on Bill Hook)* **Or, in either Case:** • Bill Hook Jaw not opening sufficiently to grasp both Twine Strands	4.2.1 4.1.2 4.2.1 4.1.2 4.2.2
3	 Both ends of Twine broken	• Twine Retainer *(clamping)* pressure too High – Possibly to compensate for worn *(Retainer)* component(s) • Poor Twine quality	4.2.1 4.1.2
4	 Correct Knot found on Bill Hook Twine Band broken	**Knot remaining on Bill Hook:** • Bill Hook Jaw *(clamping)* pressure too High – Possibly to compensate for worn *(Bill Hook)* component(s) • Rusty, rough or pitted Bill Hook surface • Insufficient / incorrect Stripper Arm Travel • Excessive clearance between Stripper Arm & Bill-Hook Heel • Excessive Bill Hook vertical travel in Knotter Frame • Binder/Trusser Trip Spring set to make too loose a sheaf/truss	4.2.2 4.2.3 4.2.4 -

Table 5 Symptoms of tying mechanism problems and possible causes *(continued)*
(Click on section no. for further info.)

Fault No	Appearance	Problem & Possible Cause(s)	For Remedy see Section No.
5	 No Knot tied - Twine ends bent Discharged untied	**Twine ends not held & pulled through Loop by Bill Hook:** • Bill Hook Jaw *(clamping)* pressure too Low • Bill Hook Jaw and/or Body worn • Bill Hook Jaw 'tip' worn **or** preventing sufficient closure of Jaw • Bill Hook Roller/Cam Follower or 'closing' cam track worn • Debris in Bill Hook 'groove' preventing Jaw from closing fully • Bill Hook timing retarded due to drive gear wear and/or excessive Cam Gear end-float	4.2.2 4.2.5
6	Deering-type  **Short or No Tail-ends**  McCormick-type	• Bill Hook Jaw *(clamping)* pressure too Low • Bill Hook Jaw and/or Body worn • Bill Hook Jaw 'tip' worn **or** preventing sufficient closure of Jaw • Bill Hook Roller/Cam Follower or 'closing' cam track worn • Debris in Bill Hook 'groove' preventing Jaw from closing fully • Twine Retainer *(clamping)* pressure too High	4.2.2 4.2.1
7	 One Tail-end longer or looped into Knot	**N.B. Deering-type Knotters only** • Twine Retainer *(clamping)* pressure too Low • Blunt Twine Knife • Twine Disc timing incorrect • Excessive Twine Tension	4.2.1 4.2.3 4.2.1 4.1.2
8	 Twine broken below Knot	• Knife/Stripper Arm contacting Bill Hook during tying cycle • Rough edges on Knife/Stripper Arm or elsewhere	4.2.3 4.2.4
9	 Twine looped round Bill Hook Roller	**Needle Twine not caught by Twine Disc:** • Needle position incorrect • Twine Disc timing incorrect • Insufficient Twine Tension	4.1.3 4.2.1 4.1.2
10	 Good Knot but ragged ends	• Blunt Twine Knife	4.2.3

5 Knotter Features and Adjustments – By Knotter/Machine Brand

What Do We Know So Far?

- **All** knotters must perform the same sequence of tasks/actions in order to tie a Knot
- Different knotter types and/or brands **will often use different-looking components to perform these tasks, and they may perform them in a slightly different way, BUT** ultimately the operations performed are the same *(see Section 2)*
- There are two distinct designs of knotter: **the 'Deering'** and **the 'McCormick'** *(see Section 3)*
  - Other Binder, Trusser or Baler manufacturers often developed their own versions of these two principal types, sometimes even incorporating elements of both, but the 'Deering' or McCormick' parentage can still be seen in them
- To an extent, the nature & appearance of tying faults which occur, and what can be done to correct them, depends on the make & model of knotter you're dealing with *(see Section 4)*.

With last point in mind, this Section reviews the key features of some common knotter brands found on UK thatching straw harvesting/processing machinery and explores whether & how they may be adjusted to correct knotter faults which may occur in-service.

The following knotter brands & machine types are reviewed:

- Current Deering *(primarily used on Balers & Bigbalers)*
- Deering (IHC) Binder
- Ruston & Hornsby Binder (& Trusser)
- McCormick Binder
- McCormick International baler
- Massey Harris *(and Sunshine)* Binder (& Trusser)
- Albion Binder (& Trusser)

Before diving into the detail, a couple of general observations:

- **Scope for Knotter Adjustment?**

  Remember that many Binder or Trusser knotter designs date from the early 20th Century or even the late 1800s. Generally, later *(post-1940)* designs offer a greater range of adjustments to suit particular operating conditions, to correct tying problems and to compensate for system wear.

- **Are Binder & Trusser Knotters the Same?**

  Frequently Not! Although a given Binder & Trusser manufacturer will generally use a particular type of knotter *(i.e. Deering or McCormick)*, the exact design and even the means by which key adjustments can be made, will often be different. Although they will operate in the same general way, Trusser Knotters are usually of a more robust build: so, their components parts are often not interchangeable with those of a Binder from the same manufacturer.

5.1 Current Deering (Conventional and Bigbaler) Knotters

Background

This is the design of Deering-type knotter used on Conventional Balers today: however, it has been produced in this exact form by numerous manufacturers since the mid-1950s. Over that period this knotter *(or stronger versions of the basic design)* has been used on:

- **Conventional Balers** produced by New Holland, John Deere, Bamford, Deutz-Fahr, Jones/Allis-Chalmers, McCormick International *(later models)* and numerous others
- **Howard Bigbalers** *(see separate technical guide – Section 8)*
- **Large Square** *('Hesston'-type)* **Balers** produced by Hesston, Massey Ferguson and New Holland.

The German 'Rasspe' company *(now part of the Schumacher Group)* was & remains one of the main manufacturers of Deering-type knotters. Genuine and spurious 'aftermarket' replacement parts are readily available at reasonable cost.

Key Features *(see Figs 5.1-5.3 and also Section 3.1 & Tables 1 & 6)*

- **Bill Hook:** Mounted at 90° to direction of crop flow. Rotates through 360° during the tying cycle. Opening 'Jaw' closed by *(adjustable)* spring-loaded 'closing' cam
- **Twine Knife:** Moving, mounted on end of pivoting, cam-operated arm
- **Stripper:** Incorporated into bottom of Knife Arm. Sweeps across Bill Hook's heel to remove the twine loop & form the Knot
- **Twine Disc:** Multiple (2 or 3) plate disc with four twine notches on its outer edge. Mounted with its face / edge at 90° to the underside of the Needle. Driven by a pinion, shaft, worm & gear from the Cam Gear. Rotates through ¼ turn (90°) during each tying cycle
- **Twine Retainer:** Double or triple-plate 'comb'-type which is pressed into the side of the Twine Disc by one or more *(adjustable)* leaf springs *(Figs 5.2 & 5.3)*
- **Characteristics:**
  - Produces short twine offcuts
  - When installed on Balers, usually operates in conjunction with a Twine Finger to ensure effective twine transfer from the Needle to the Bill Hook & Twine Disc *(see Section 4.1.4).*

These knotters are regarded as robust and extremely reliable. Produced in a range of *(normal, medium & heavy-duty)* variants to suit the intended application, they are the most commonly used type of knotter on modern machinery.

Spare Parts Availability

New, replacement spare parts are readily available for current Deering-type knotters from a number of sources *(see Section 6)*. Due to 'carry-over' of some older-design parts on to certain newer machines, such availability extends to certain parts for machines manufactured in the 1950s and 1960s.

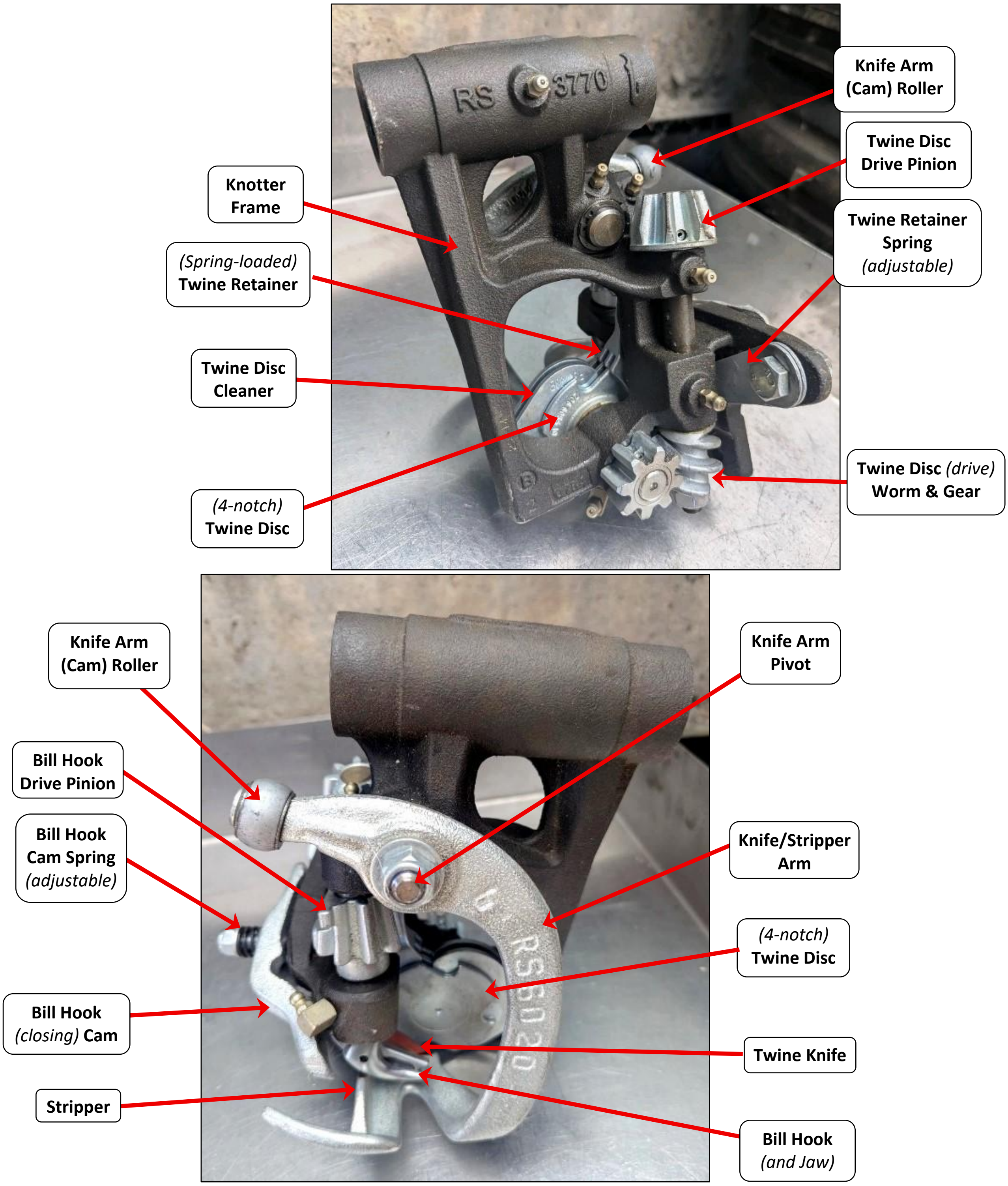


Fig.5.1 Current Deering knotter – Key components - Viewed from above *(top)* and underneath *(bottom)*

Fig.5.2 ‘Comb’-type Twine Retainer which meshes with the *(multi-plate)* Twine Disc

Table 6 Current Deering *(baler)* knotters – Range of available adjustments

Knotter Characteristic	Adjustment Possible?	Means of Adjustment	See Fig. No.
Twine Disc Timing	Yes	• Loosen worm gear on Twine Disc drive shaft, rotate Twine Disc to correct position & re-tighten gear • Also minimise Cam Gear end-float • Replace Twine Disc Drive Pinion if badly worn	4.11 4.19
Twine Retainer *(clamping)* Pressure	Yes	• Loosen or tighten spring retaining bolt or nut • **Very sensitive – Only ever adjust ⅙ - ¼ turn at a time**	5.1 5.3
Bill Hook Timing	No	• Minimise Cam Gear end-float • Renew Bill Hook Drive Pinion and/or Knotter Cam Gear if gear teeth are badly worn	4.11
Bill Hook Jaw *(clamping)* Pressure	Yes	• Loosen or tighten Bill Hook *(closing)* Cam Spring nut • **Very sensitive – Only ever adjust ⅙ - ¼ turn at a time**	5.1
Twine Knife	Yes	• If blunt, remove Knife Arm & sharpen or replace knife • If mis-aligned, bend Knife Arm to correct shape	- 4.16
Knife / Stripper Arm Travel	Yes	• If insufficient, bend Knife Arm or renew Cam Roller • Renew Knotter Cam Gear if cam track is badly worn	4.15
Stripper Arm - Bill Hook clearance	Yes	• Stripper Arm should rub lightly across Bill Hook's heel • **To Reduce Clearance:** Hit back of 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**	4.18

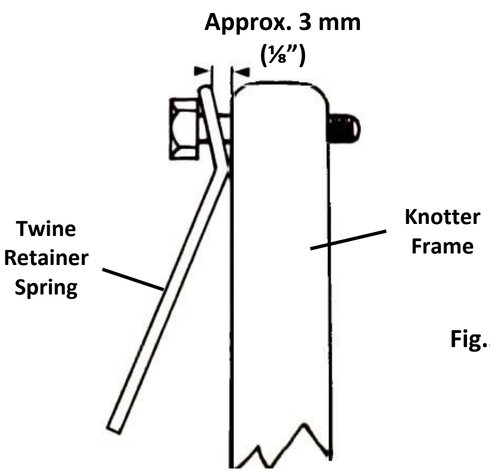


Fig.5.3 Recommended *(initial)* setting for the Twine Retainer *(clamping pressure)* spring on a New Holland conventional baler

5.2 Deering (IHC) Binder Knotters

Yes, 'Deering' and 'McCormick' are completely different Knotter designs **BUT,** they were produced by the same company – the International Harvester Company (IHC). This was formed in 1902 by the merger of the Deering Harvester Co. and the McCormick Harvesting Machine Co. *(and three other, smaller firms)*.

After the merger, IHC continued to manufacture & market harvesting machinery under the entirely separate 'Deering' and 'McCormick' brands. The machine designs differed in some respects *(e.g. knotters)* but in other respects they were identical. So, whilst a Deering Binder used a different knotter design and a shaft & gear-driven reel *(chain-driven on a McCormick)*, in most other respects the machines were remarkably similar. So 'badge-engineering' isn't a modern phenomenon!

Returning to Deering Binder Knotters, as you might expect, their design features and operating characteristics are very similar to current *(modern)* Deering-type knotters *(see Section 5.1)*, **BUT** certain components are perhaps not quite as strongly built, no doubt reflecting the slightly lesser operational demands on a Binder, compared to a Baler.

Key Features *(see Figs 5.4 & 5.5 and also Section 3.1 & Tables 1 & 7)*

- **Bill Hook:** Mounted at 90° to direction of crop flow. Rotates through 360° during the tying cycle. Opening 'Jaw' closed by *(adjustable)* spring-loaded 'closing' cam
- **Twine Knife:** Moving, 'L'-shaped blade, rivetted to end of pivoting, cam-operated arm
- **Stripper:** Incorporated into bottom of Knife Arm. Sweeps across Bill Hook's heel to remove the twine loop & form the Knot
- **Twine Disc:** Twin-plate disc with six twine notches on its outer edge. Mounted with its face / edge at 90° to the underside of the Needle. Driven by a pinion, shaft, worm & gear from the Cam Gear. Rotates through ⅙ turn (60°) during each tying cycle
- **Twine Retainer:** Single plate, pressed between the *(two)* plates of the Twine Disc by a single or double *(adjustable)* leaf spring.
- **Characteristics:**
  - Method of operation is identical to that of 'current' Deering-type knotters *(see Sections 3.1 & 5.1)*
  - Produces short twine offcuts
  - Setup / adjustment requirements are identical to current Deering-type knotters
  - Certain adjustments, whilst possible, are not quite so 'user friendly' *(e.g. Twine Disc timing)*.

Deering (binder) knotters gained a reputation for robust construction and reliable performance, resulting in their widespread use on other machine brands. This popularity has endured to the present day, outliving the original manufacturing company.

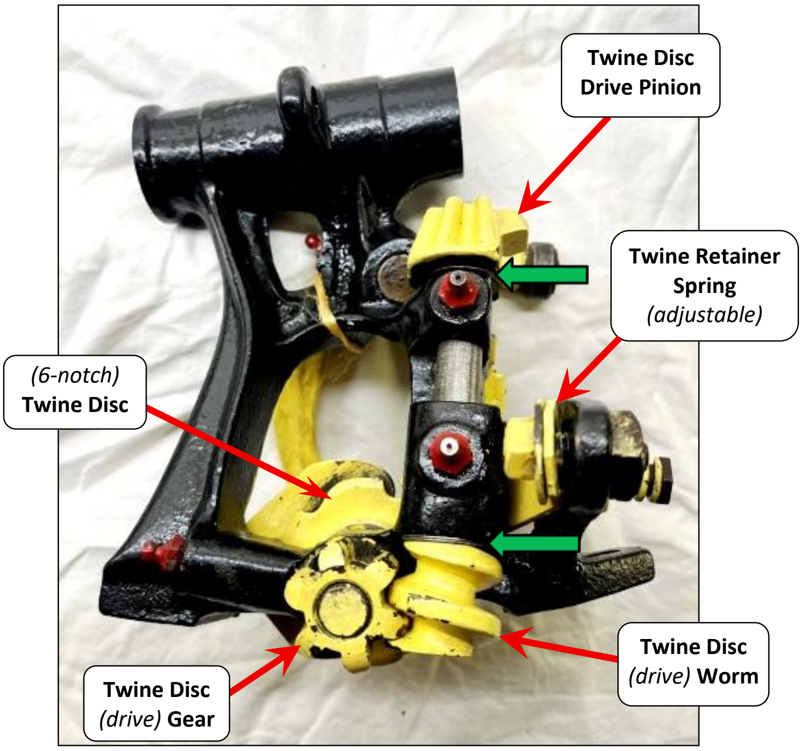
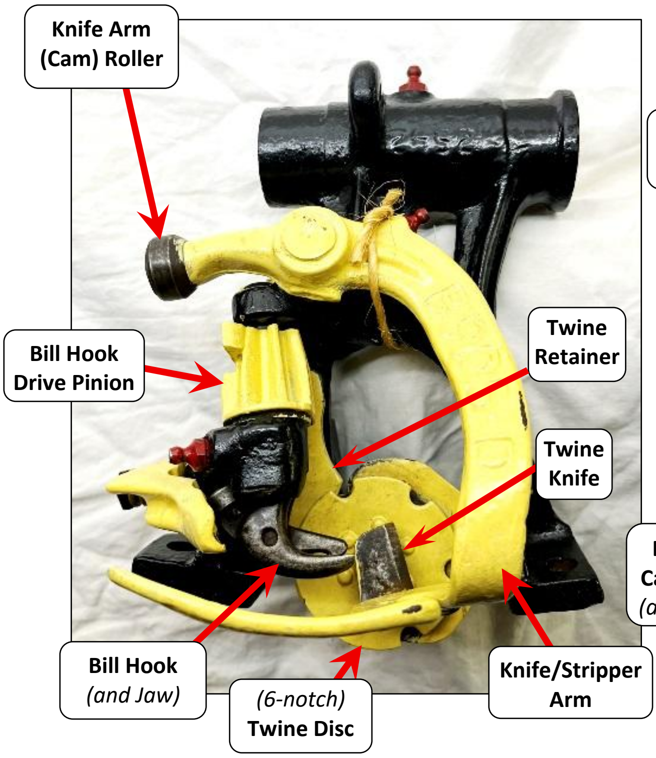


Fig.5.4 Deering binder knotter – Key components - Viewed from above

Method of Twine Disc Timing adjustment:

- **Coarse adjustment:** Remove Twine Disc drive gear, rotate & refit securing pin in an alternative hole
- **Fine adjustment:** Relocate / exchange shim washers on Twine Disc Worm Shaft *(at Green arrows)*



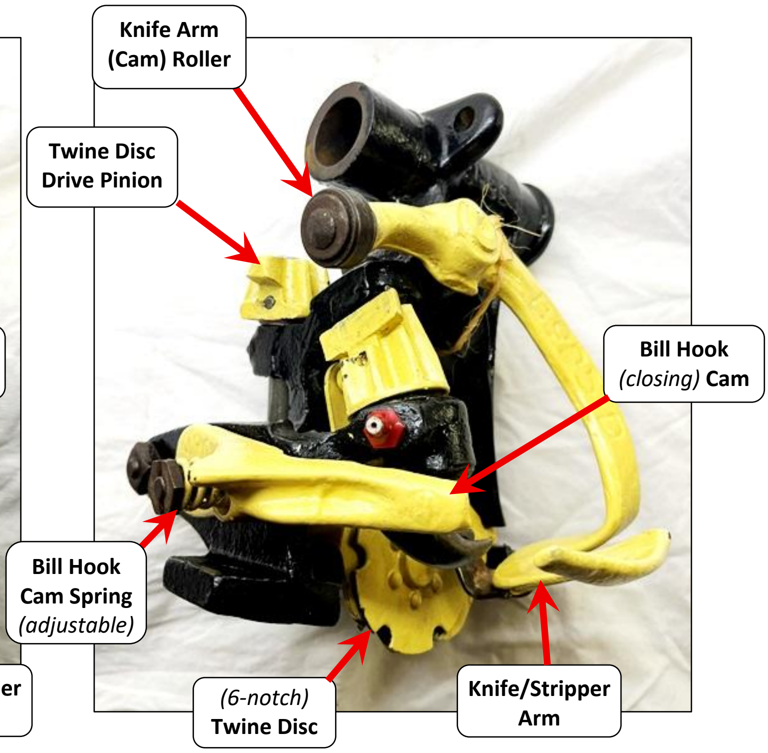


Fig.5.5 Deering binder knotter – Key components - Viewed from underneath *(left)* and the *(Cam Gear)* side *(right)*

(courtesy G. Kirk)

Table 7 Deering binder knotters – Range of available adjustments

Knotter Characteristic	Adjustment Possible?	Means of Adjustment	See Fig. No.
Twine Disc Timing	Yes, but not convenient	• **Coarse adjustment:** Remove gear from Twine Disc shaft, rotate & refit securing pin in an alternative hole • **Fine adjustment:** Relocate shim washers on Twine Disc Worm Shaft *(above worm gear / below drive pinion)* • Also minimise Cam Gear end-float • Replace Twine Disc Drive Pinion if badly worn	5.4 5.4 4.11 4.19
Twine Retainer *(clamping)* Pressure	Yes	• Loosen or tighten spring retaining bolt & nut • **Very sensitive – Only ever adjust ⅙ - ¼ turn at a time**	5.1 5.3
Bill Hook Timing	No	• Minimise Cam Gear end-float • Renew Bill Hook Drive Pinion and/or Knotter Cam Gear if gear teeth are badly worn	4.11 5.5
Bill Hook Jaw *(clamping)* Pressure	Yes	• Loosen or tighten Bill Hook *(closing)* Cam Spring nut • **Very sensitive – Only ever adjust ⅙ - ¼ turn at a time**	5.5
Twine Knife	Yes	• If blunt, remove Knife Arm & sharpen or replace knife • If mis-aligned, bend Knife Arm to correct shape	- 4.16
Knife / Stripper Arm Travel	Yes	• If insufficient, bend Knife Arm or renew Cam Roller • Renew Knotter Cam Gear if cam track is badly worn	4.15
Stripper Arm - Bill Hook clearance	Yes	• Stripper Arm should rub lightly across Bill Hook's heel • **To Reduce Clearance:** Hit back of 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 heat & bend the Arm**	4.18

Spare Parts Availability

Most manufacturers ceased production of *(grain)* Binders in the 1950s. If a manufacturer's Binder knotters were subsequently used on other machines *(e.g. Pick-up Balers)* then production of new & replacement parts continued. The Deering Binder Knotter was very reliable but, for some reason, IHC elected to use a heavily modified version of the McCormick knotter on their pick-up balers. Consequently, production of Deering *(binder)* knotter spare parts diminished and eventually ceased.

Numerous other baler manufacturers utilised the Deering knotter design *(see Table 1)* and, in some instances, certain spares parts intended for those applications **may** fit a Deering binder knotter. Limited supplies of spares may be available from the United States *(see Section 6)*. However, in many cases, 'parts repair' rather than 'parts replacement' will be the most likely available option.

5.3 Ruston and Hornsby (Binder and Trusser) Knotters

The knotters of Ruston & Hornsby (R&H) Binders and Trussers operate on the Deering principle, but they incorporate certain unique features. Indeed, given that Richard Hornsby & Sons *(of Grantham, Lincs)* began building self-tying binders in the 1880s, it could perhaps be asked whether Hornsby machines used Deering-type knotters, or if Deering machines actually used Hornsby-type knotters?

The appearance & operating principles of a Hornsby knotter are largely identical to a Deering knotter, with just a few, minor design differences. The biggest problem is that most R&H equipment is now over 100 years old and new, replacement parts are unavailable. This is not good news for any tying mechanism.

Ruston & Hornsby Binder and Trusser Knotters – Are They the Same?

In a word, **No!** R&H were one of the few Binder manufacturers who also made Trussers *(others being Albion & Massey-Harris)*. R&H Binder and Trusser knotters were both of Deering-type design, but the Trusser knotters were much more heavily built, incorporated thicker/stronger components and used slightly different methods for adjustment of key knotter settings *(see below & Table 8).*

Key Features *(see Figs 5.6–5.9 and also Tables 1 & 8)*

- **Bill Hook:** Mounted at 90° to direction of crop flow. Rotates through 360° during the tying cycle. Opening 'Jaw' closed by *(adjustable)* spring-loaded 'closing' cam
- **Twine Knife:** Moving, 'L'-shaped blade, rivetted to end of pivoting, cam-operated arm
- **Stripper:** **Not present.** The twine loop is removed from the Bill Hook by the sideways movement of the Knife Arm pulling on the twine strands, which run through the Twine Guide Groove on the rear of the Knife Arm *(see Figs 4.17 & 5.6 (left))*. There is no physical contact between the Knife Arm & Bill Hook
- **Twine Disc:** __Binder__**:** A single-plate disc with six twine notches on its outer edge *(Fig.5.6)*. Mounted with its face / edge at 90° to the underside of the Needle. Driven by a pinion, shaft, worm & gear from the Cam Gear. Rotates through ⅙ turn (60°) during each tying cycle

  __Trusser__**:** A much thicker single-plate disc, also with six twine notches on its outer edge *(Fig.5.7)*. Mounted as in the Binder knotter *(above)*. Also driven by a pinion, shaft, worm & gear from the Cam Gear and rotates through ⅙ turn (60°) during each tying cycle
- **Twine Retainer:** Slotted, pivoting 'shoe'-type, pressed over the Twine Disc's edge by an *(adjustable)* leaf spring. A larger/wider component is used on the Trusser
- **Characteristics:**
  - Method of operation is almost identical to that of 'current' Deering-type knotters *(see Sections 3.1 & 5.1)*, **except** for the precise method of twine removal from the Bill Hook *(see above)*
  - Produces short twine offcuts
  - Setup / adjustment requirements are identical to current Deering-type
  - Certain adjustments *(e.g. Twine Disc timing)* are only possible in discrete steps. Adjustment method differs between Binders & Trussers.

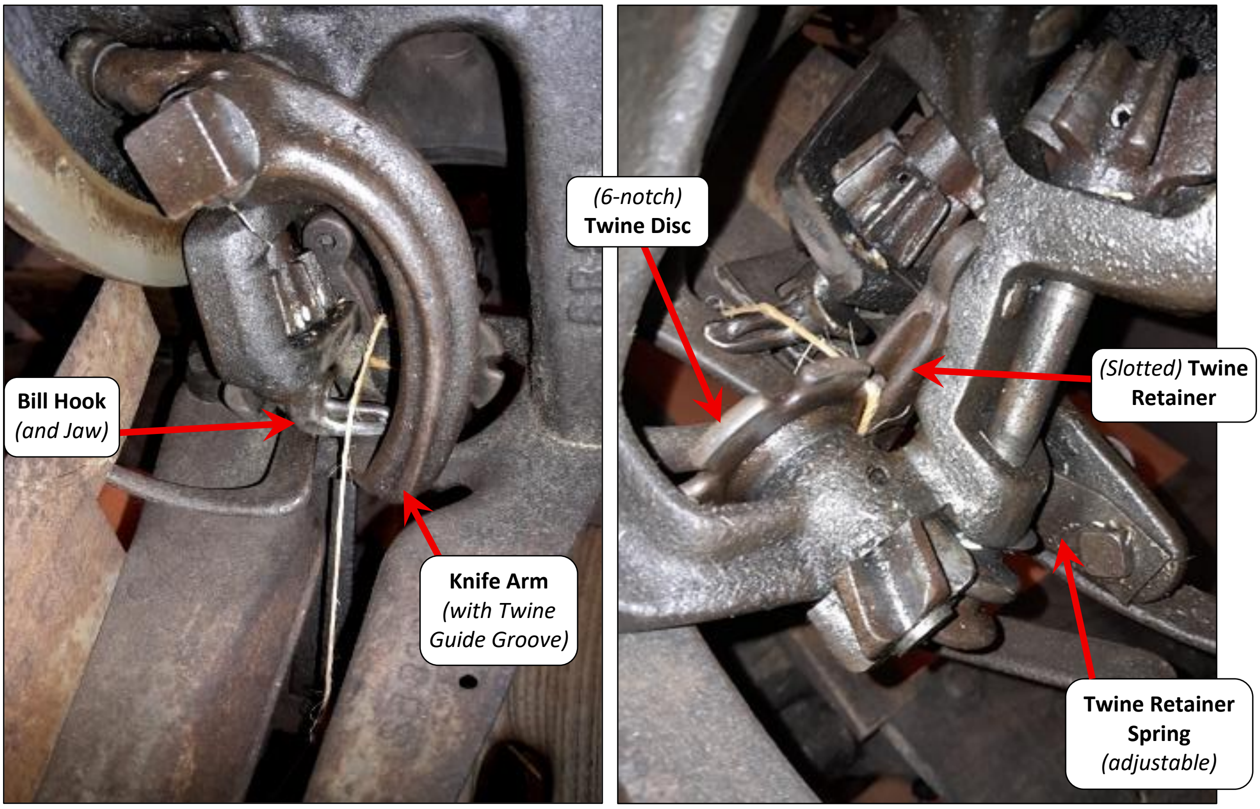


Fig.5.6 Hornsby binder knotter – Key components – **Note** slotted 'shoe'-type Twine Retainer which presses over the edge of the *(6-notch)* Twine Disc

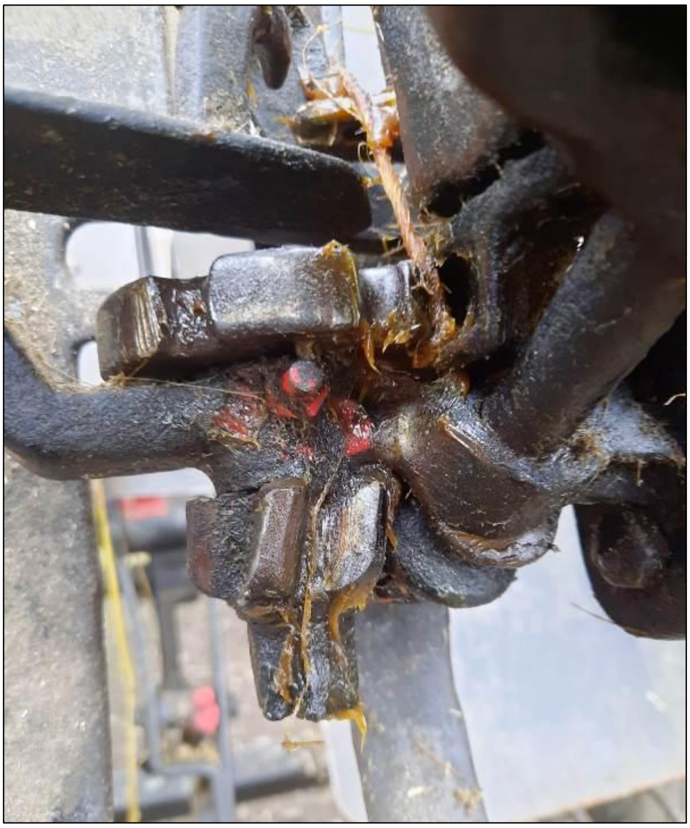


Fig.5.7 Ruston & Hornsby trusser knotter – Twine Disc and Retainer *(greased for winter storage)*

Note: *(6-notch)* Twine Disc is considerably thicker than the Binder's Twine Disc

(courtesy P. Wheeler)

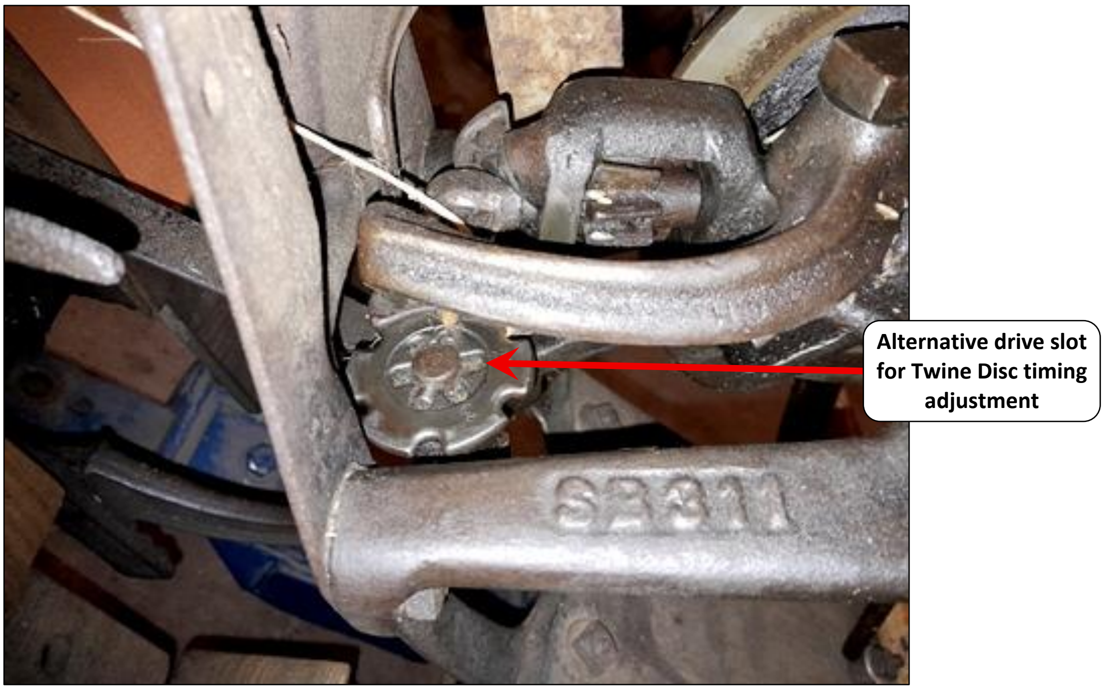


Fig.5.8 Hornsby binder knotter – Twine Disc timing is adjusted by removing Twine Disc and placing the drive pin in one of the *(three)* alternative drive slots *(arrowed)*

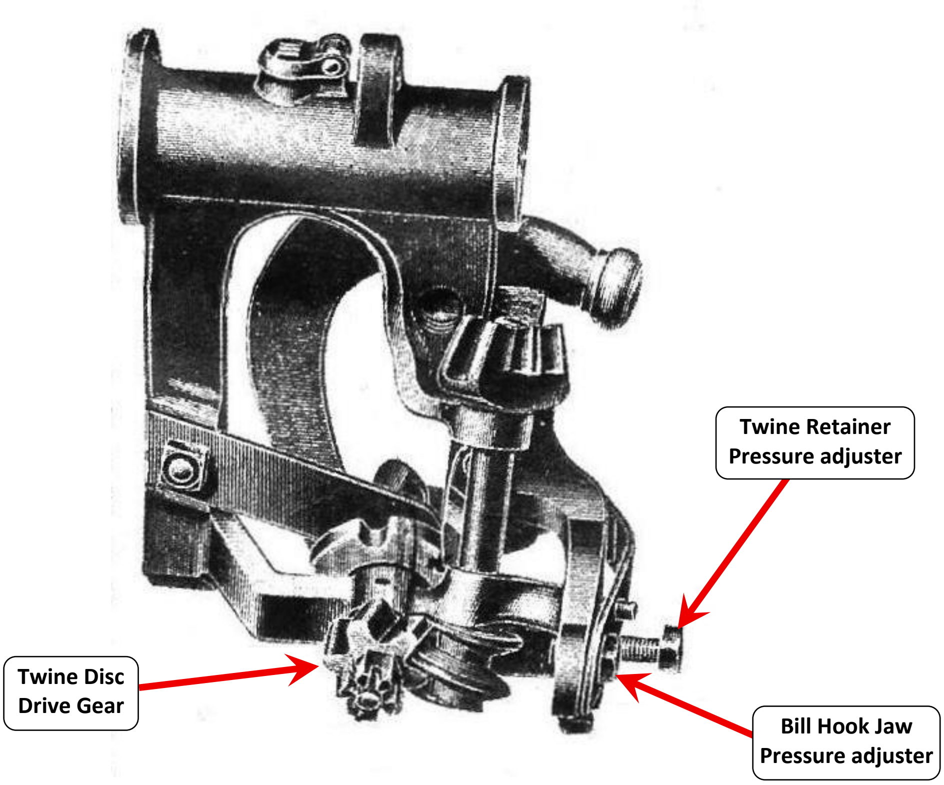


Fig.5.9 Ruston & Hornsby trusser knotter – Key adjustments

- **Twine Retainer pressure or Bill Hook Jaw pressure:** Loosen or tighten the appropriate set screw
- **Twine Disc Timing:** Remove the Twine Disc drive gear *(arrowed)* & replace on the shaft in one of the three alternative positions *(keyways)* provided

Table 8 Ruston & Hornsby (binder & trusser) knotters – Range of available adjustments

<table>
<tr><th>Knotter Characteristic</th><th colspan="2">Adjustment Possible?</th><th>Means of Adjustment</th><th>See Fig. No.</th></tr>
<tr><td rowspan="2">Twine Disc Timing</td><td rowspan="2">Yes, but only in steps</td><td>Binder</td><td>• Only adjustable between one of three positions
• Remove Twine Disc from shaft & reposition drive pin in one of the (3) available slots
• Also minimise Cam Gear end-float
• Rebuild Twine Disc Drive Pinion if badly worn</td><td>5.8
4.11
4.19
5.6</td></tr>
<tr><td>Trusser</td><td>• Only adjustable between one of three positions
• Remove Twine Disc from shaft & reposition Drive Gear in one of the (3) available positions
• Also minimise Cam Gear end-float
• Rebuild Twine Disc Drive Pinion if badly worn</td><td>5.9
4.11
4.19</td></tr>
<tr><td>Twine Retainer (clamping) Pressure</td><td colspan="2">Yes</td><td>• Loosen or tighten spring retaining bolt or set screw
• Very sensitive – Only ever adjust ⅙ - ¼ turn at a time</td><td>5.6
5.9</td></tr>
<tr><td>Bill Hook Timing</td><td colspan="2">No</td><td>• Minimise Cam Gear end-float
• Rebuild Bill Hook Drive Pinion and/or Knotter Cam Gear if gear teeth are badly worn</td><td>4.11
5.6
5.9</td></tr>
<tr><td>Bill Hook Jaw (clamping) Pressure</td><td colspan="2">Yes</td><td>• Loosen or tighten Bill Hook (closing) Cam Spring set screw
• Very sensitive – Only ever adjust ⅙ - ¼ turn at a time</td><td>5.9</td></tr>
<tr><td>Twine Knife</td><td colspan="2">Yes</td><td>• If blunt, remove Knife Arm & sharpen knife
• If mis-aligned, bend Knife Arm to correct shape</td><td>-
4.16</td></tr>
<tr><td>Knife Arm Travel</td><td colspan="2">Yes</td><td>• If insufficient, bend Knife Arm or rebuild Cam Roller
• Don't heat & bend the Arm
• Rebuild Knotter Cam Gear if cam track is badly worn</td><td>4.15</td></tr>
<tr><td>Stripper Arm - Bill Hook clearance</td><td colspan="2">Not Applicable</td><td>-</td><td>-</td></tr>
</table>

Spare Parts Availability

The manufacture / sale of Ruston & Hornsby Trussers *(by Ransomes of Ipswich)* continued into the early 1950s, but production of the Hornsby Binder ceased at some point earlier; possibly before the Second World War. Consequently, today, any remaining Dealer-held stocks of spare parts have long since been exhausted, and the only available source of parts for these machines is from scrap machines. These are either becoming increasingly rare or, given the passage of time and the likelihood of having been consigned to a dark corner of the farmyard, are unlikely to be in particularly good condition. Today R&H Trussers remain very popular amongst thatching straw growers, but Hornsby Binders are much less common.

5.4 McCormick (IHC) Binder Knotters

As explained in Section 5.2, both McCormick and Deering were competing brand names of the International Harvester Company (IHC). Both brands made successful Binders which were very similar to each other but, as you'd expect, one used the Deering-type *(moving knife)* knotter, whereas the other used the McCormick-type *(static knife)* knotter.

McCormick binders were very popular and many are still in use today. The characteristic features and operation of McCormick knotters are described in detail in Section 3.2, whereas this section reviews those features and the ways in which the knotter may be adjusted in-service.

Unfortunately, this is a shortfall of this design. Unlike all other knotters, the Twine Disc timing of a McCormick knotter cannot be adjusted. As end-float and wear develops between the Twine Disc drive gears *(Cam Gear & Twine Disc Drive Pinion)*, the Twine Disc timing will become retarded.

Whilst this may not unduly affect twine placement into the Disc *(see Fig.3.9(b))*, it will affect knotter performance because the Twine Disc also has to draw the twine over the *(static)* Twine Knife, to cut the twine free of the Retainer and enable the Knot to be formed. If the Twine Disc is retarded, this process won't be completed correctly and tying problems occur. In the absence of any means of timing adjustment, all that can be done is to minimise Knotter Unit - Cam Gear end-float *(Fig.5.13)* and, in extreme cases replace the drive gears or *(more likely)* rebuild their teeth to address wear.

Key Features *(see Figs 5.10-5.13 and also Section 3.2 & Tables 1 & 9)*

- **Bill Hook:** Mounted at 45° to direction of crop flow. Rotates through 360° during the tying cycle. Opening 'Jaw' closed by *(adjustable)* spring-loaded 'closing' cam
- **Twine Knife:** Static, slightly curved blade, fixed rigidly *(bolted)* to the Knotter Frame
- **Stripper:** **Not present.** The twine loop is pulled from the *(angled)* Bill Hook as the sheaf/truss is ejected by the Discharge Arms *(see Fig.3.9(e))*. A curved slot in the Breast Plate aids twine removal from the Bill Hook
- **Twine Disc:** A single, thick disc with a slightly conical upper surface & with two deep slots running across it, one on either side of a central drive shaft. Mounted with its upper surface parallel to the Needle's underside. Driven directly from the Cam Gear by a pinion. Rotates through ½ turn (180°) during each tying cycle and draws the twine strand over the *(static)* Twine Knife to cut it
- **Twine Retainer:** A part-circular, thick disc with a raised rim extending around approx. ⅔ of its outer edge *(Fig.5.12)*. Pressed up against the underside of the Twine Disc by a cranked rod & *(adjustable)* coil spring *(Fig.5.11)*
- **Characteristics:**
  - Method of operation is completely different to that of Deering-type knotters *(see Sections 3.1 & 3.2)*
  - Slightly fewer moving parts than a Deering-type knotter
  - Produces knots of a different shape/appearance
  - Does not produce twine offcuts
  - Twine Retainer and Bill Hook clamping pressures can be adjusted
  - **Certain adjustments** *(e.g. Twine Disc timing)* **are not possible**.

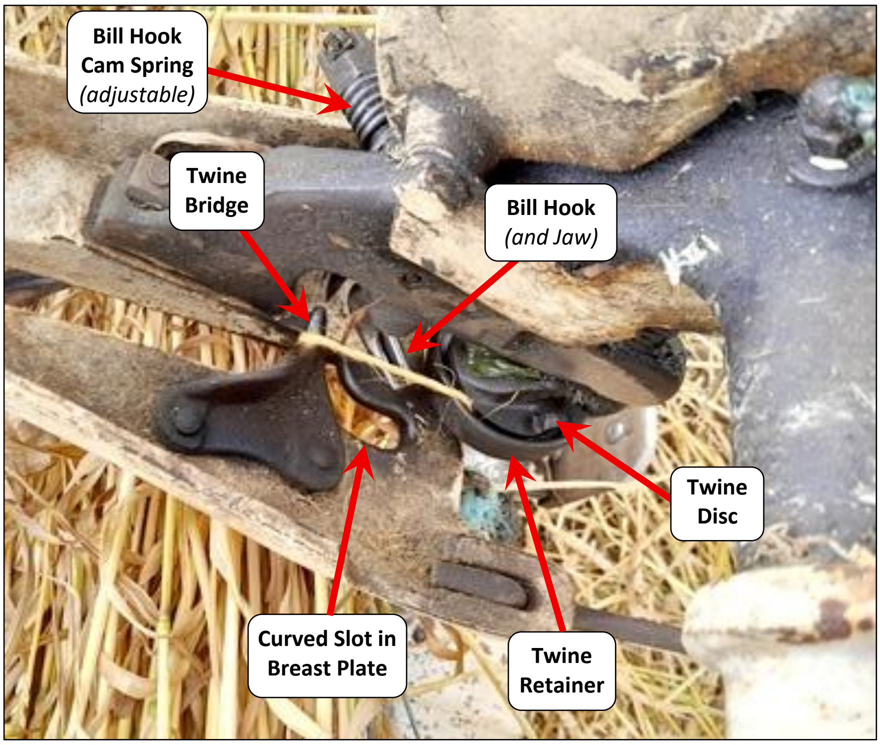


Fig.5.10 McCormick binder knotter

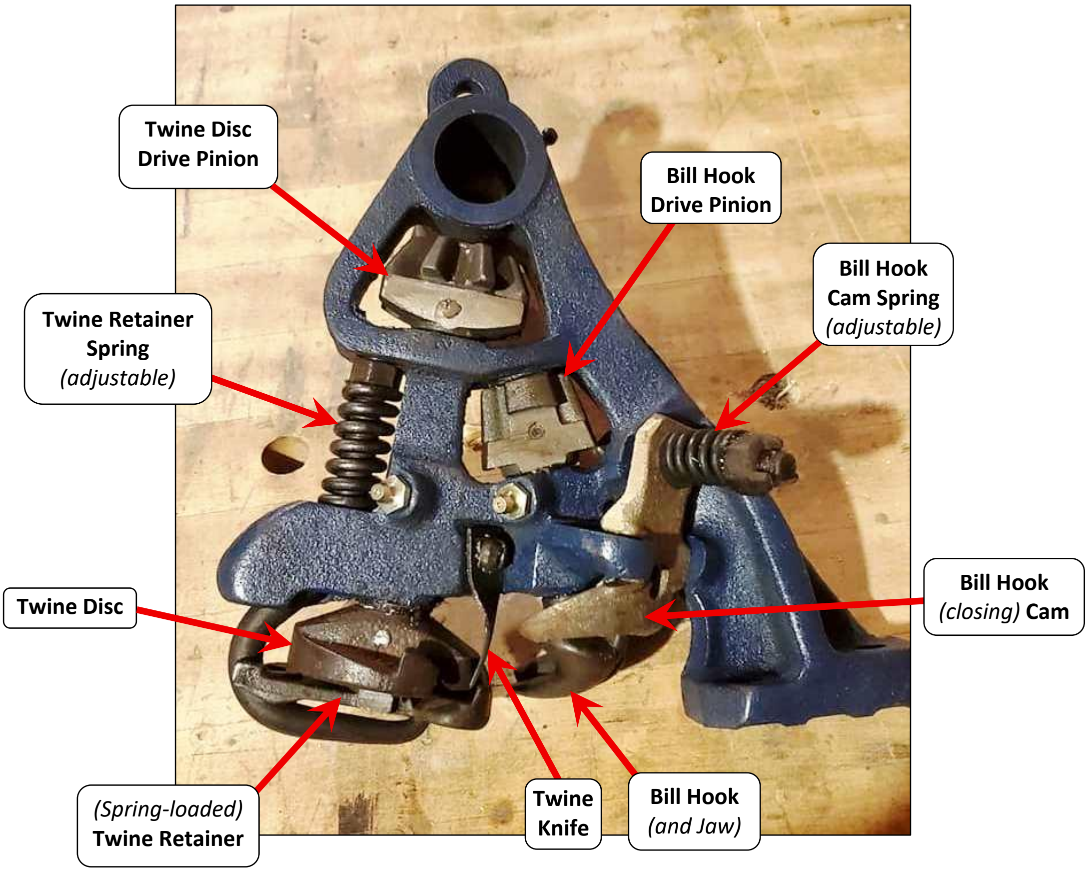


Fig.5.11 McCormick binder knotter – Viewed from side which fits against the Cam Gear

(courtesy B.W. Macknair & Son)

Table 9 McCormick binder knotters – Range of available adjustments

Knotter Characteristic	Adjustment Possible?	Means of Adjustment	See Fig. No.
Twine Disc Timing	No	• Minimise Cam Gear end-float • Rebuild or renew Twine Disc Drive Pinion and/or Knotter Cam Gear if gear teeth are badly worn	4.11 5.14 5.11
Twine Retainer ***(clamping)*** **Pressure**	Yes	• Loosen or tighten spring retaining nut • **Very sensitive – Only ever adjust ⅙ - ¼ turn at a time**	5.11
Bill Hook Timing	No	• Minimise Cam Gear end-float • Rebuild or renew Bill Hook Drive Pinion and/or Knotter Cam Gear if gear teeth are badly worn	4.11 5.14 5.11
Bill Hook Jaw ***(clamping)*** **Pressure**	Yes	• Loosen or tighten Bill Hook *(closing)* Cam Spring nut • **Very sensitive – Only ever adjust ⅙ - ¼ turn at a time**	5.10 5.11
Twine Knife	Yes	• If blunt, remove Knife & sharpen or replace • If mis-aligned, bend Knife to correct shape • Renew Knife if badly worn	5.11
Knife Arm Travel	Not Applicable	-	-
Stripper Arm - Bill Hook clearance	Not Applicable	-	-

Fig.5.12 McCormick binder knotter Twine Retainer *(new, replacement part)*

(courtesy B.W. Macknair & Son)

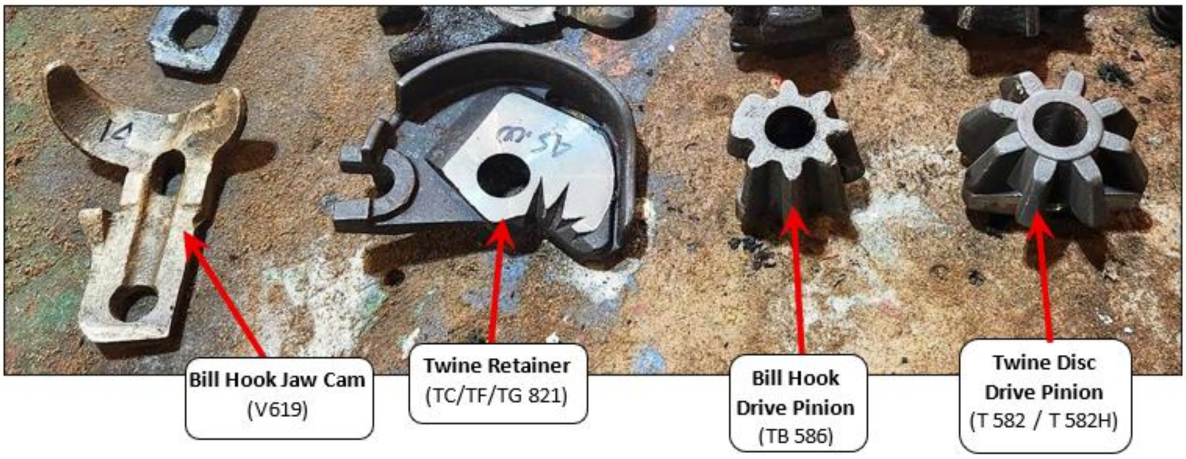


Fig.5.13 Selection of McCormick binder knotter parts available from a U.S. supplier

(courtesy B.W. Macknair & Son)

Spare Parts Availability

Unfortunately, it's not very good. McCormick *(grain)* Binders were imported from the United States in their 1,000s during the 1920s-40s. Thereafter French-built machines were imported well into the mid-1950s. Today McCormick Binders remain very popular amongst UK thatching straw growers.

Despite significant penetration of the UK Binder market and the reliable performance of the McCormick knotter *(if well-maintained)*, unlike some other manufacturers, IHC somewhat surprisingly chose not to transfer either its *(successful)* Deering or its McCormick-type knotters to its subsequent, range of Conventional Balers. Consequently, the McCormick Binder Knotter & its associated spare parts didn't remain in production beyond the 1960s.

Dealer-held stocks of spare parts probably remained available into the 1970s, but these have now been exhausted, leaving scrap machines as the only available UK source of spare parts. **However,** supplies of certain McCormick knotter parts are still available from the U.S. *(Figs 5.12 & 5.13)*. See Section 6 for more information.

Other Users of McCormick-type Knotters

McCormick-type knotters were also used on Trussers manufactured by J & F. Howard *(of Bedford)*. Whilst robust machines, some of which are still operational, their production ceased in the early 1930s. Consequently, spare parts are no longer available and machine repair/rebuilding or modification are the only options available to ensure their continued operation.

Minimising McCormick Knotter Unit – Cam Gear End-Float

As previously mentioned, because of the inability to adjust the Twine Disc *(or Bill Hook)* timing of a McCormick knotter, it is vital to minimise the end-float between the Knotter Unit and its adjacent Cam Gear. The general principles to follow are much as outlined in Section 4.2.5 *(and Fig.4.19)*, with shim washers being used to push the Knotter Unit into closer **(BUT not binding)** contact with the Cam Gear. However, the arrangement of the McCormick Binder's Knotter Shaft is rather unique and so the following End-Float adjustment procedure is reproduced (with kind permission) from the McCormick Binder operator's manual *(Fig.5.14)*.

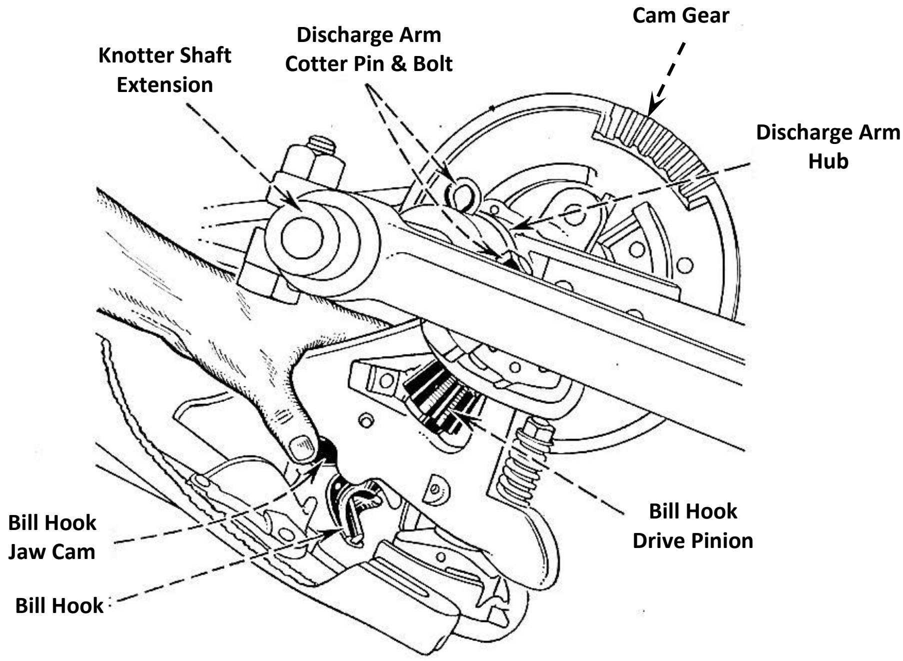


Fig.5.14 McCormick binder knotter – Adjustment of Cam Gear end-float

(courtesy IHC)

The flat faces on the Twine Disc and Bill Hook drive pinions *(Fig.5.11)* should be a snug fit against the flat *(side rim)* surfaces of the Cam Gear, **BUT there should be some slight clearance** to prevent the surfaces binding *(see Fig.4.19).*

If the clearance and/or Bill Hook or Twine Disc rotational free-play is excessive when the Knotter is in the 'at-rest' position, **with reference to Fig.5.14:**

- Loosen the Bolt & remove the Cotter Pin from the Knotter Shaft Extension
- Apply pressure on the Rear Discharge Arm whilst driving the Hub of the Middle Discharge Arm towards the Knotter Unit
    - Do this just enough in order to remove the slack between the Bill Hook & Twine Disc Drive Pinions and the Cam Gear
- To secure the adjustment, the Knotter Shaft Extension must be refitted tight against the Discharge Arm Hub *(and the Cotter Pin replaced and bolt re-tightened)*
    - It may be necessary to insert sheet steel 'shim' washers between the Knotter Shaft Extension and the Discharge Arm Hub in order to obtain proper alignment of the Cotter Pin holes
- Turn the Binder over, to see that a slight clearance is still present between the Knotter Unit & Cam Gear and that the drive components turn freely without binding.

5.5 McCormick International Baler Knotters

UK-manufactured McCormick International conventional balers were very popular in the 1950s – 80s and many are still in use today: some by thatching straw growers for baling of residue from combed wheat reed processing. However, despite being produced by the same manufacturer (International Harvester Co.) as the McCormick Binder, **these knotters are significantly different to those found on a McCormick Binder and they share no common parts.** Rather they incorporate certain features of a Deering-type knotter.

The Baler Knotter does incorporate a static Twine Knife and a Bill Hook orientated at 45˚ to the crop flow, **BUT** uses a Deering-type, multi-plate Twine Disc & Retainer with notches around its outside edge. Later versions of the Knotter progressed to using a power-driven, moving Twine Knife but, eventually, International resorted to fitting conventional, Deering-type knotters to their balers. A move that was generally welcomed by their users.

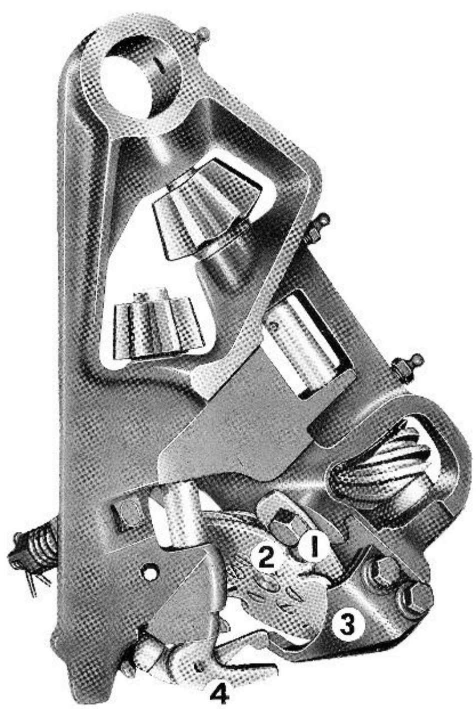


Fig.5.15 McCormick International baler knotter

(1) Twine Retainer
(2) Twine Disc
(3) Twine Knife
(4) Bill Hook

Key Features *(see Fig.5.15)*

- **Bill Hook:** Mounted at 45° to direction of crop flow. Rotates through 360° during the tying cycle. Opening 'Jaw' closed by *(adjustable)* spring-loaded 'closing' cam
- **Twine Knife:** Static, slightly curved blade, fixed rigidly *(bolted)* to the Knotter Frame
- **Stripper:** **Not present.** The twine loop is pulled from the *(angled)* Bill Hook as the bale moves along the bale chamber. A curved slot in a plate on the top of the bale chamber aids twine removal from the Bill Hook
- **Twine Disc:** Twin-plate Deering-type disc with two notches on its outer edge. Mounted with its face / edge at 90° to the underside of the Needle. Driven by a pinion, shaft, worm & gear from the Cam Gear. Rotates through ½ turn (180°) during each tying cycle. Twine Disc rotation draws the twine strand over the *(static)* Twine Knife to cut it
- **Twine Retainer:** Single plate, pressed between the *(two)* plates of the Twine Disc
- **Characteristics:**
  - o Method of operation is a cross between that of a McCormick *(Binder)* knotter and a Deering-type knotter *(see Sections 3.1 & 3.2)*
  - o Slightly fewer moving parts than a Deering-type knotter
  - o Produces 'loop'-type knots of the 'McCormick' form/shape
  - o Does not produce twine offcuts.

5.6 Massey-Harris (Binder and Trusser) Knotters

"And now for something completely different!" Joking apart, the design of the Massey-Harris knotter is unique and, although it performs exactly the same actions as all other twine knotters *(see Fig.2.1)*, the appearance and arrangement its components have only so much in common with either Deering or McCormick-type knotters. However, **by remembering the basic actions which any knotter unit has to perform** *(Section 2)* and recalling the adjustments which need to be made to correct common knotter faults *(Section 4)*, the mystery & confusion which surrounds the Massey-Harris knotter can be solved.

Key Points

- A unique design: it mainly operates on Deering-type knotter principles, but does incorporate some McCormick-type features
- A robust, well-engineered knotter which has been found to be very reliable in-service. However, availability of replacement parts is now an issue
- The 'Sunshine' binder *(also marketed by Massey-Harris)* uses a knotter of almost identical design **BUT** *(rather bizarrely)* **the majority of knotter parts are not interchangeable between Massey-Harris and Sunshine machines**
- Massey-Harris Trussers also use knotters of largely identical design.

Key Features *(see Figs 5.16-5.20 and also Tables 1 & 10)*

- **Bill Hook:** Mounted at 45° to direction of crop flow. Rotates through 360° during the tying cycle. Opening 'Jaw' closed by an *(adjustable, combined)* leaf spring & cam. Unlike other knotters, the Jaw doesn't incorporate a cam roller, but instead a simple *(wear-prone)* cam follower
- **Twine Knife:** Moving blade, rivetted to end of a short, pivoting arm, which is raised & lowered through approx. ½" (12 mm) by a separate track on the Knotter Cam Gear. Cuts both twine strands at end of *(Deering-type)* tying cycle
- **Stripper:** **Not present.** The twine loop is pulled from the *(angled)* Bill Hook as the sheaf/truss is ejected by the Discharge Arms
- **Twine Disc/Ring:** Large diameter gear wheel with seven notches in its upper rim. Inclined to the Knotter Frame so the Needle passes under its outer edge & over its inner edge, to place the twine in the waiting notch. Driven by a pinion, shaft & bevel gear from the Cam Gear. Rotates through $^{1}/_{7}$ turn (51.4°) during each tying cycle. Disc timing simply adjusted by slight repositioning of drive gear
- **Twine Retainer:** Slotted, pivoting 'shoe'-type, pressed down over the Twine Disc's rim edge by an *(adjustable)* leaf spring *(Fig.5.19)*
- **Characteristics:**
    - Method of operation is primarily 'Deering', but there are a few 'McCormick' traits. Use of a Twine 'Ring' is unique
    - Produces Deering-type overhand knots
    - Produces short twine offcuts.

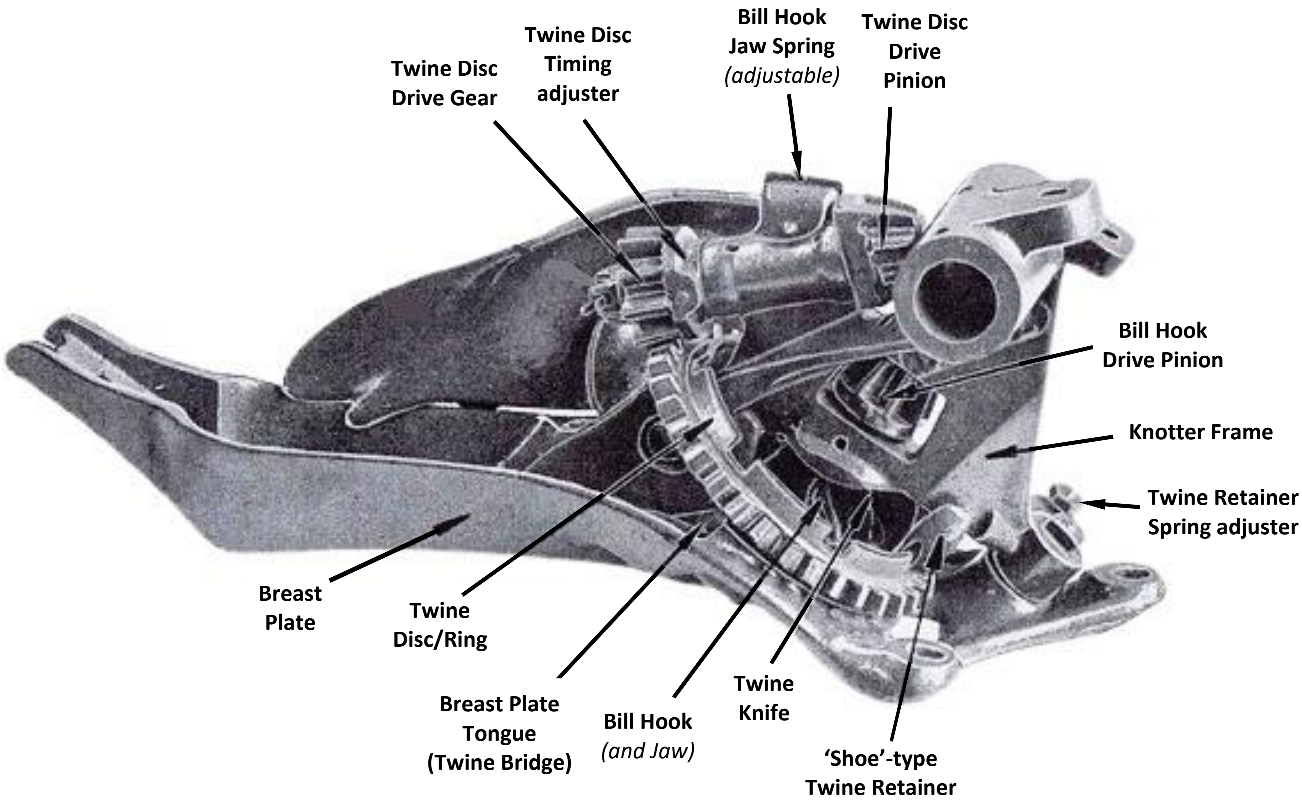


Fig.5.16 Massey-Harris *(Sunshine)* binder knotter – Key components

(courtesy Massey-Harris)

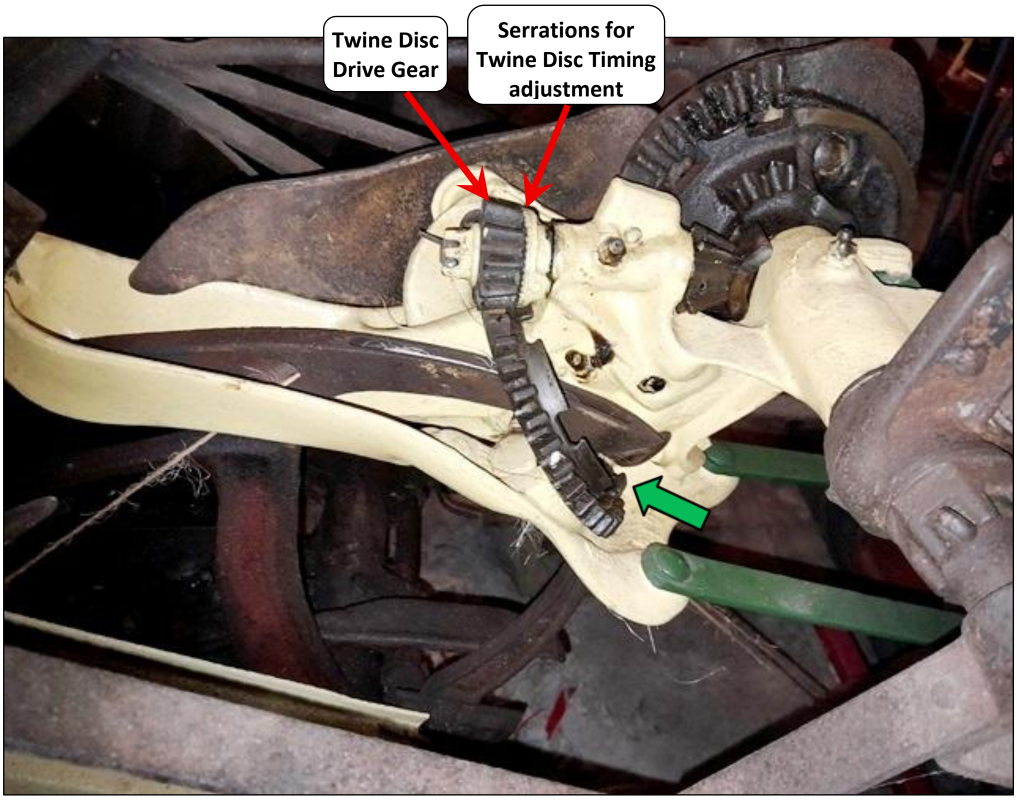


Fig.5.17 Massey-Harris binder knotter in operation – Needle passing through Twine Disc/Ring to place twine into a notch on *(right-hand)* upper surface of the Ring *(Green arrow)*

- Means of Twine Disc Timing adjustment also shown

Table 10 Massey Harris or Sunshine (binder & trusser) knotters – Range of available adjustments

Knotter Characteristic	Adjustment Possible?	Means of Adjustment	See Fig. No.
Twine Disc Timing	Yes	• Loosen Drive Gear on Twine Disc drive shaft, rotate Twine Disc to correct position & re-tighten Gear to mesh in the appropriate serration on the drive shaft hub • Also minimise Cam Gear end-float • Rebuild teeth on Twine Disc Drive Pinion & Gear if badly worn	5.17 4.11 5.16
Twine Retainer *(clamping)* **Pressure**	Yes	• Loosen or tighten leaf spring retaining bolt • **Very sensitive – Only ever adjust ⅙ - ¼ turn at a time**	5.16 5.19
Bill Hook Timing	No	• Minimise Cam Gear end-float • Renew Bill Hook Drive Pinion and/or Knotter Cam Gear if gear teeth are badly worn	4.11 5.16
Bill Hook Jaw *(clamping)* **Pressure**	Yes	• Loosen or tighten Bill Hook *(closing)* Spring retaining nut • **Very sensitive – Only ever adjust ⅙ - ¼ turn at a time** • Bill Hook Jaw Cam Follower is prone to wear, which will cause Jaw opening & closing issues	5.19
Twine Knife	Yes	• If blunt, remove Knife Arm & sharpen or replace knife	5.19
Knife Arm Travel	Slightly	• Only moves *(vertically)* through ½" (12 mm) • If travel insufficient, rebuild Knife Arm cam follower and/or Knotter Cam Gear cam track	5.19
Stripper Arm - Bill Hook clearance	Not Applicable	-	-

Massey-Harris Knotters – Likely Issues In-Service

Whilst a reliable knotter, wear will eventually cause in-service problems. The likely areas are:

- **Bill Hook Jaw Cam Follower:** Unlike other knotters, the Jaw doesn't incorporate a Cam Roller, but instead a simple Cam Follower, which will eventually wear. The Jaw then either won't open or close sufficiently *(see Section 4.2.2).* Rebuilding is possible with careful bronze welding, following gentle pre-heating

- **Twine Disc/Ring or Bill Hook (rotational) Free Travel:** Minimise Cam Gear – Knotter Unit end-float *(see Fig.4.11)*. Rebuild Drive Pinions to original profile *(with bronze weld)*

- **Twine Disc/Ring Notches:** Can wear & become 'hooked' and/or develop sharp edges over time. Rebuild *(with bronze weld)* & restore to original profile.

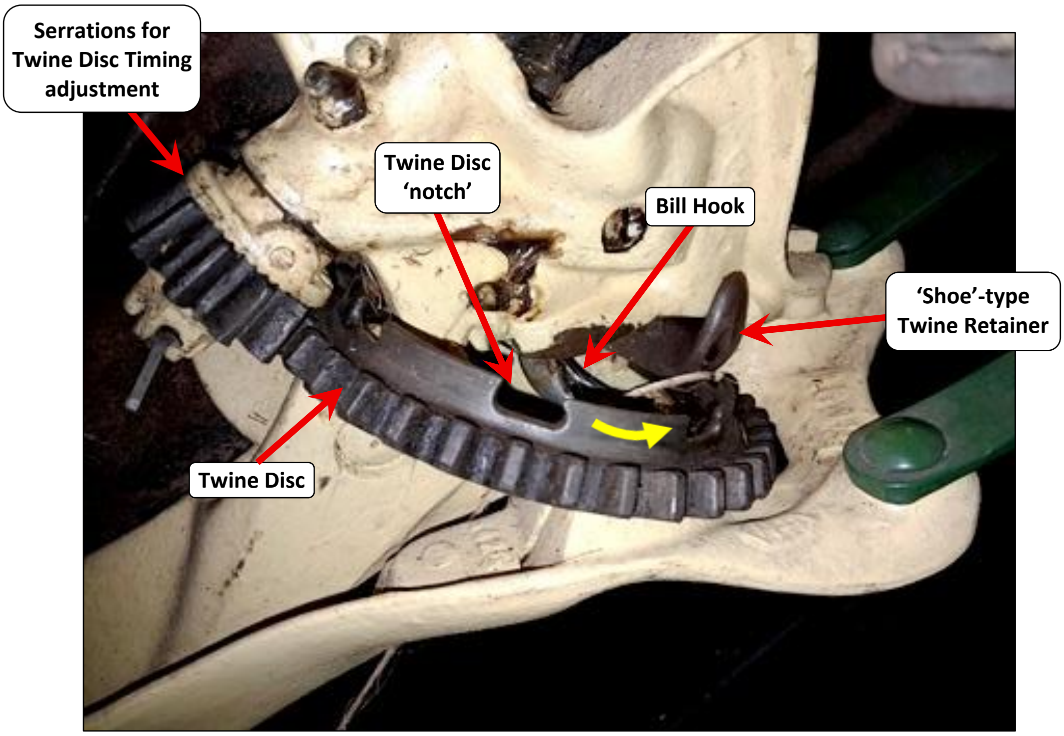


Fig.5.18 Massey-Harris *(Sunshine)* binder knotter – Arrangement of Twine Disc, Twine Retainer & Bill Hook

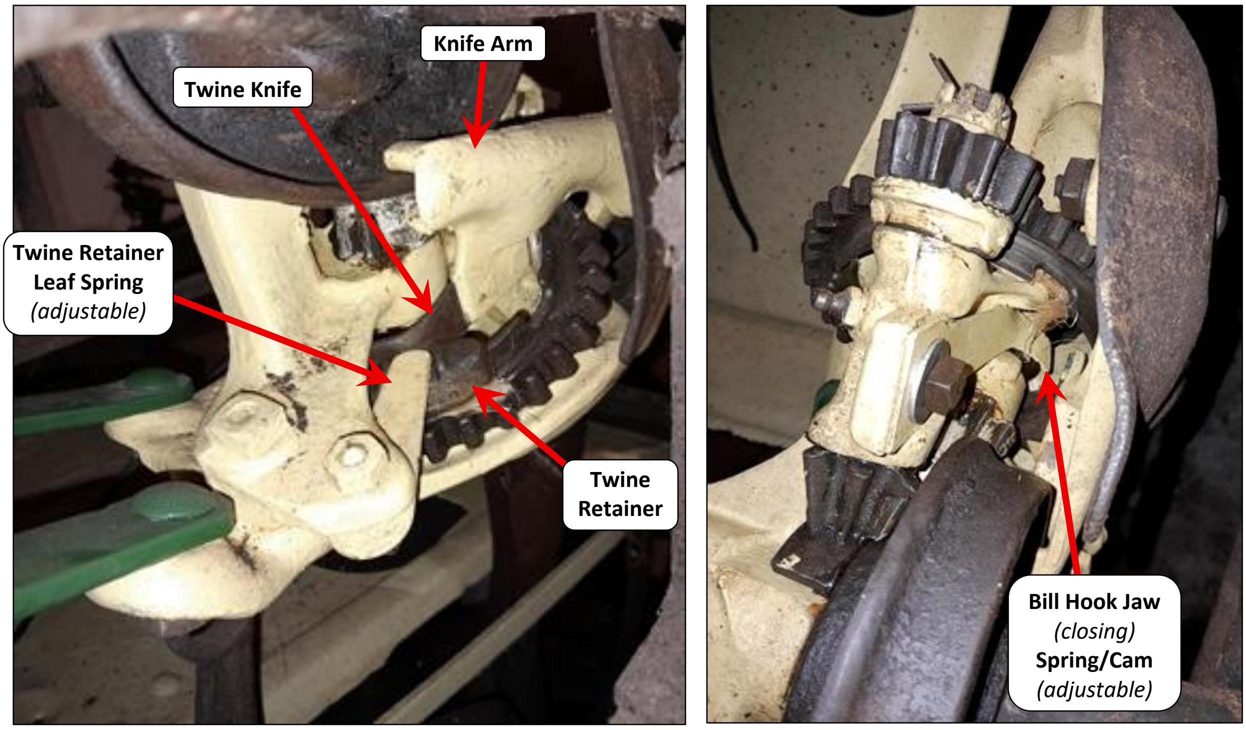


Fig.5.19 Massey-Harris binder knotter – Arrangement of Twine Retainer & Twine Knife *(left)* and Bill Hook closing spring/cam *(right)*

Fig.5.20 Massey-Harris binder knotter in operation – Needle drawing twine over the Twine Bridge and is about to place the strand into the waiting Twine Disc/Ring 'notch'

Spare Parts Availability

Unfortunately, this is very poor. Massey-Harris (M-H) binders & trussers were manufactured in and imported from Canada. Production continued post WW2, primarily under the 'Sunshine' brand-name, but ceased in the mid-late 1950s. This design of knotter was not transferred to subsequent Massey-Harris or *(later)* Massey Ferguson conventional balers.

UK dealer-held stocks of spare parts have long since been exhausted. Whilst M-H Binders & Trussers remain popular amongst UK thatching straw growers, they are now definitely in the 'vintage farm machinery' category.

This leaves the cannibalisation of other *(potentially worn)* machines as the only available UK source of spare parts.

5.7 Albion (Binder and Trusser) Knotters

'Albion' binders and trussers were manufactured by Harrison, McGregor & Co. Ltd of Leigh in Lancashire. Their products were both well-made & popular: production of the Albion 5A binder continued until 1958.

Albion knotters operate on the 'Deering' principle and have much in common with Hornsby Binder knotters *(see Section 5.3)*. However, unlike all other Deering-type knotters, the Twine Disc is not driven *(rotated)* from the Cam Gear by a pinion, shaft, worm & gear. Rather it is indexed by a pawl & ratchet mechanism, operated by the *(moving)* Knife Arm on its return stroke *(Figs 5.21, 5.23 & 5.24)*. A non-return spring prevents backwards rotation of the Twine Disc between tying cycles.

The importance of correct Twine Disc Timing has already been stressed *(see Section 4.2.1)*, particularly in the case of Deering-type knotters. Consequently, the somewhat complex & potentially less positive drive solution chosen by Albion could be argued to be 'brave' design move. Nonetheless, it was found to work well in-service **BUT,** it is rather prone to wear **and** is a 'challenge' to adjust.

Key Features *(see Figs 5.21–5.27 and also Tables 1 & 11)*

- **Bill Hook:** Mounted at 90° to direction of crop flow. Rotates through 360° during the tying cycle. Opening 'Jaw' closed by *(adjustable)* spring-loaded 'closing' cam
- **Twine Knife:** Moving, mounted on end of pivoting, cam-operated arm. Knife arm also rotates the Twine Disc via a pawl & ratchet mechanism
- **Stripper:** **Not quite present.** The twine loop is removed from the Bill Hook by the sideways movement of the Knife Arm, a part of which pulls on the twine strands which run to the Bill Hook *(Figs 5.22, 5.25 & 3.1(d))*. There is no physical contact between the Knife Arm & the Bill Hook during this process
- **Twine Disc:** Single-plate disc with six twine notches on its outer edge *(Fig.5.21)*. Mounted with its face / edge at 90° to the underside of the Needle. Rotated by an *(incremental)* ratchet & pawl mechanism from the Knife Arm *(on its return stroke) (Figs 5.23 & 5.24)*. Non-return spring mounted on Knotter frame prevents backwards rotation of Disc, which rotates through ⅙ turn (60°) during each tying cycle
- **Twine Retainer:** Slotted, pivoting 'shoe'-type, pressed over the Twine Disc's edge by an *(adjustable)* leaf spring
- **Characteristics:**
  - Method of operation is very similar to that of 'current' Deering-type knotters *(see Sections 3.1 & 5.1)*, **except** for the precise method of twine removal from the Bill Hook & Twine Disc drive/rotation *(see above)*
  - Produces short twine offcuts
  - Setup / adjustment requirements are very similar to current Deering-type *(e.g. Rasspe or New Holland)* knotters
  - Certain adjustments *(e.g. Twine Disc timing)* whilst stepless, are not particularly convenient *(Figs 5.26 & 5.27)*.

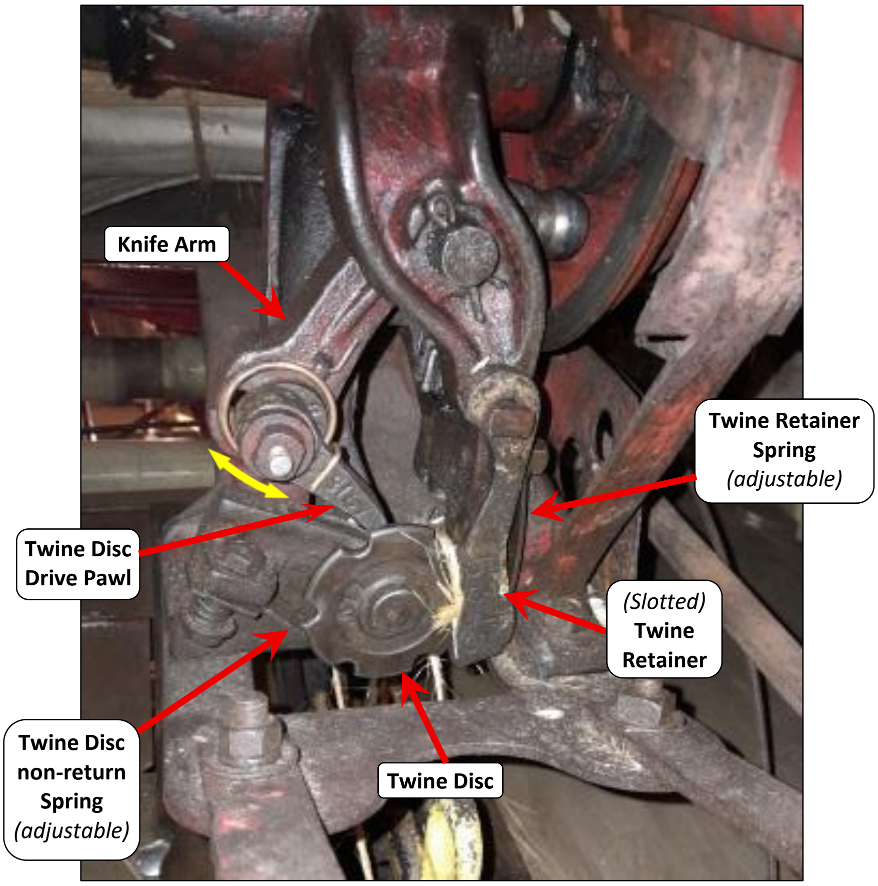


Fig.5.21 Albion binder knotter – Key components
Note: Knife Arm-driven Pawl which rotates the *(6-notch)* Twine Disc

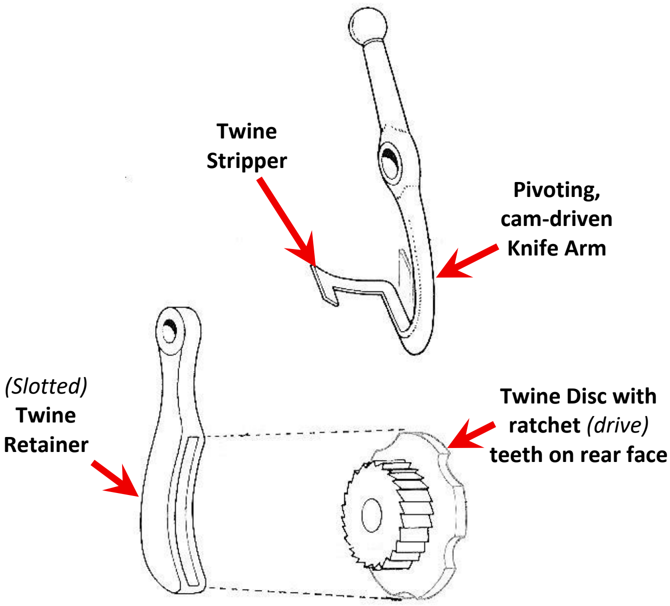


Fig.5.22 Albion binder knotter – Key components

Fig.5.23 Albion binder *(6-notch)* Twine Disc with ratchet drive teeth on rear *(upper)* face

(courtesy G. Kirk)

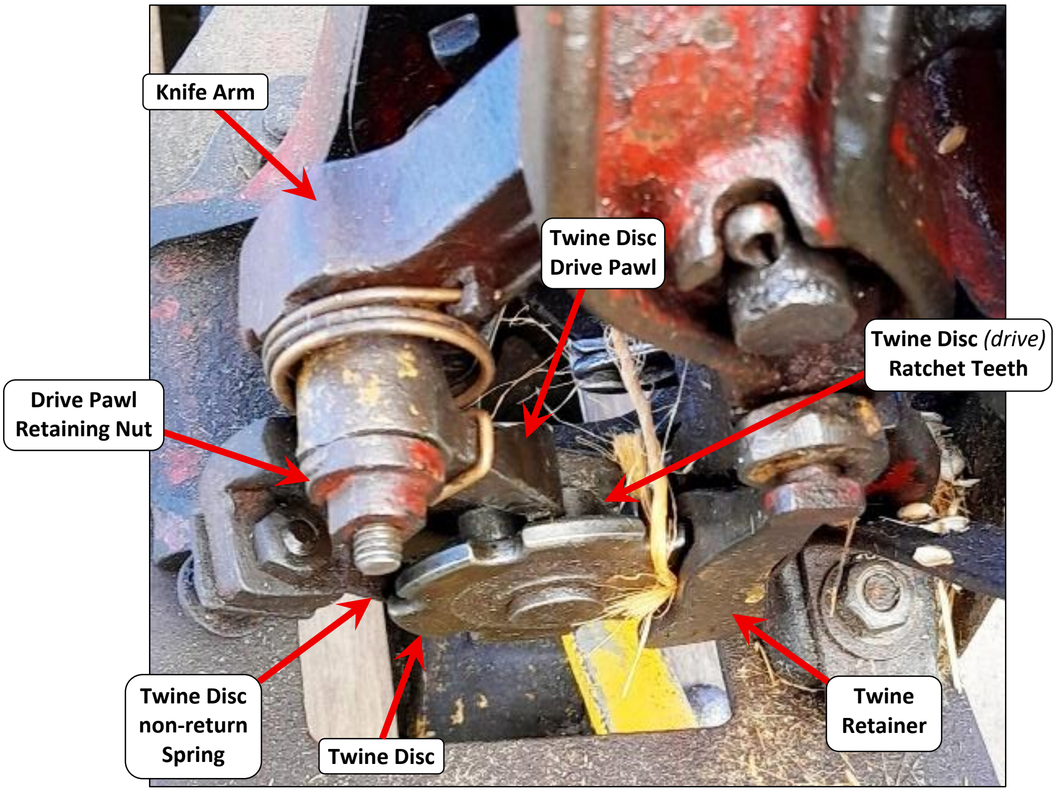


Fig.5.24 Albion binder knotter - Twine Disc drive mechanism – Close-up view

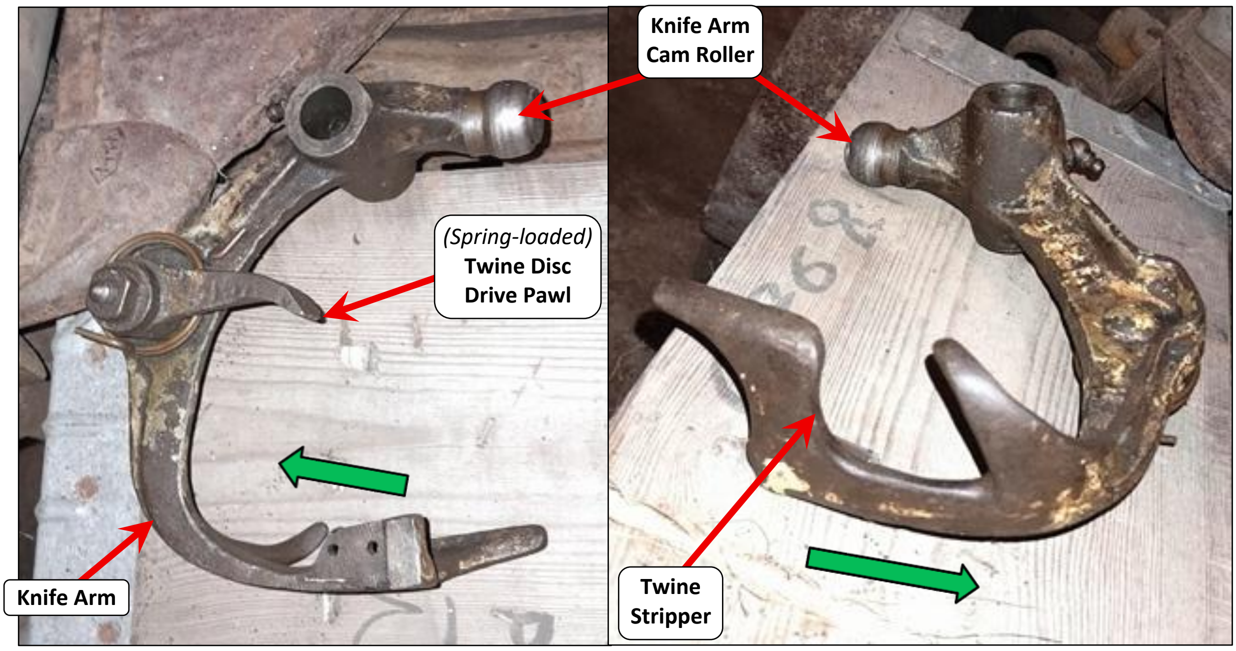


Fig.5.25 Albion binder knotter Knife Arm *(**N.B.** Knife Blade removed)* – Main components – Viewed in normal *(working)* position *(left)* and from the underside *(right)*

- Green arrows show initial direction of travel during the tying cycle

Table 11 Albion (binder & trusser) knotters – Range of available adjustments

Knotter Characteristic	Adjustment Possible?	Means of Adjustment	See Fig. No.
Twine Disc Timing	Yes, but rather fiddly	• Rotate Twine Disc to correct position **and** adjust Non-Return Spring to prevent it turning backwards • Then loosen Twine Disc Pawl retaining nut & rotate eccentric mounting bush until Pawl meshes with Twine Disc Ratchet teeth & re-tighten retaining nut • Rebuild tip of Drive Pawl if badly worn • Ensure Knife Arm Travel is sufficient/correct • Also minimise Cam Gear end-float • Rebuild Twine Disc Drive Pinion if badly worn	5.24 4.11 5.25 5.26 5.25 5.28
Twine Retainer *(clamping)* Pressure	Yes	• Loosen or tighten leaf spring retaining nut • **Very sensitive – Only ever adjust ⅙ - ¼ turn at a time**	5.21
Bill Hook Timing	No	• Minimise Cam Gear end-float • Rebuild Bill Hook Drive Pinion and/or Knotter Cam Gear if gear teeth are badly worn	5.28
Bill Hook Jaw *(clamping)* Pressure	Yes	• Loosen or tighten Bill Hook *(closing)* Cam Spring nut • **Very sensitive – Only ever adjust ⅙ - ¼ turn at a time**	-
Twine Knife	Yes	• If blunt, remove Knife Arm & sharpen or replace knife • If mis-aligned, bend Knife Arm to correct shape	5.25 5.26
Knife / Stripper Arm Travel	Yes	• If insufficient, bend Knife Arm or renew/rebuild Cam Roller • Rebuild Knotter Cam Gear if cam track is badly worn • Insufficient travel will also limit Twine Disc rotation & may cause Timing issues	5.25
Stripper Arm - Bill Hook clearance	Not Applicable	• Stripper should not contact Bill Hook during tying cycle **BUT:** • Ensure twine contact surface(s) are smooth **and** • Knife Arm travel & alignment are correct	5.25

Spare Parts Availability

Unfortunately, this is now somewhere between poor and non-existent. As previously mentioned, production of Albion binders ceased in 1958: it is not known when Albion trusser production stopped. Harrison, McGregor & Co. were acquired by David Brown Tractors Ltd and continued to manufacture agricultural implements, including pick-up balers, into the late 1960s. However, the Balers did not use the Knotter found on Albion Binders & Trussers.

UK dealer-held stocks of spare parts have long since been exhausted. The names of both Albion and David Brown have been consigned to the history books. This leaves the cannibalisation of other *(potentially worn)* Binders and Trussers as the only available source of spare parts.

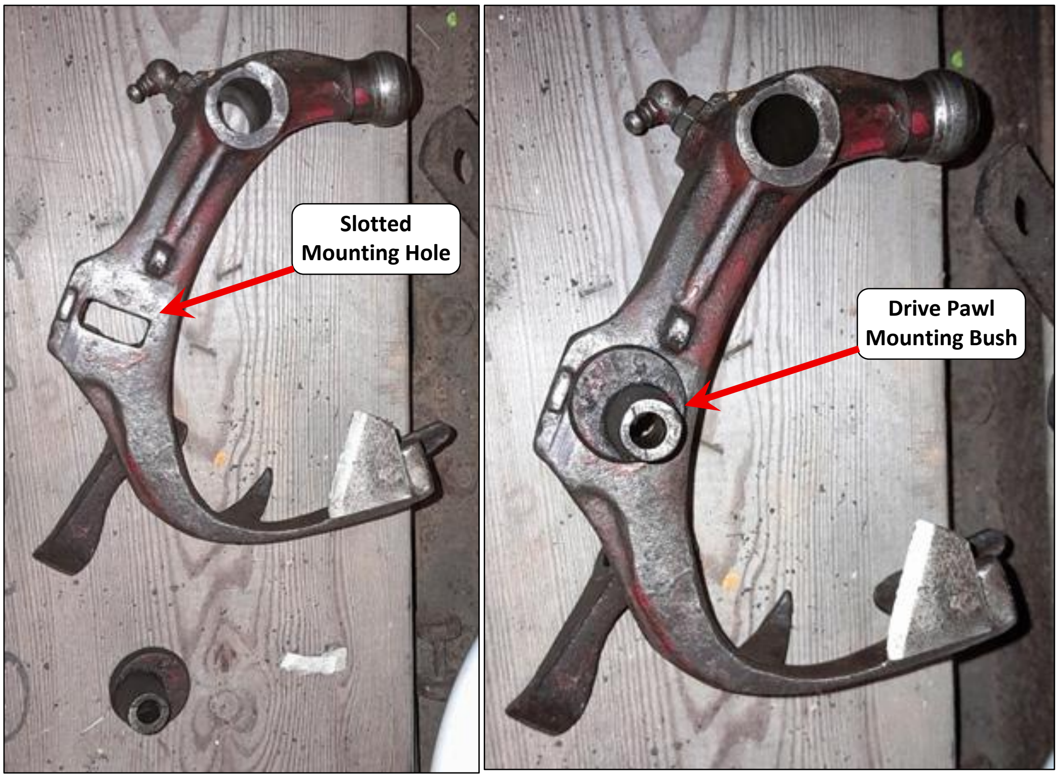


Fig.5.26 Albion binder Knife Arm showing Twine Disc Drive Pawl slotted mounting hole *(left)* and eccentric bush *(right)* for adjustment of Twine Disc Timing

Albion Binder Knotters – Adjusting Twine Disc Timing

The Twine Disc Drive Pawl is bolted to the Knife Arm via a slotted hole *(Fig.5.26 (left))*, so the position of the Drive Pawl *(relative to the Knife Arm)* can be adjusted. This in turn changes the position to which the Twine Disc is rotated on the return stroke of the Knife Arm and, in effect, adjusts the Twine Disc's timing: the desired setting being that shown in Fig.4.11.

As Twine Disc Timing needs to be set quite precisely, the Drive Pawl is mounted on a bush with an eccentric flange, which butts up against a lug on the Knife Arm *(Fig.5.26 (right))*. Rotating the Mounting Bush, after first loosening the Drive Pawl's retaining bolt, permits the Pawl to be positioned & held at any point along the slotted hole *(Fig.5.27)*. The bad news is that, when the Drive Pawl is in place, it's not very easy to rotate the Mounting Bush.

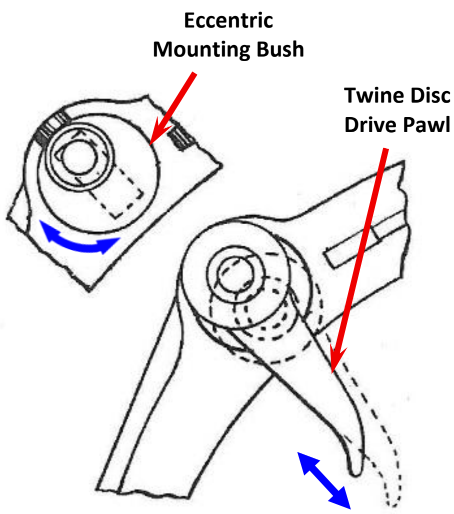


Fig.5.27 Twine Disc Drive Pawl adjustment on Albion binder Knife Arm

The recommended approach *(according to those who have done it)* is to start with the eccentric bush at its 'maximum' position and then rotate it back, reducing the 'reach' of the Drive Pawl, until the desired Twine Disc timing 'position' is obtained. Apparently, attempting the opposite approach is much more difficult. The adjustment procedure in summarised in Table 11. Remember to re-tighten the retaining nut afterwards *(Fig.5.24)*.

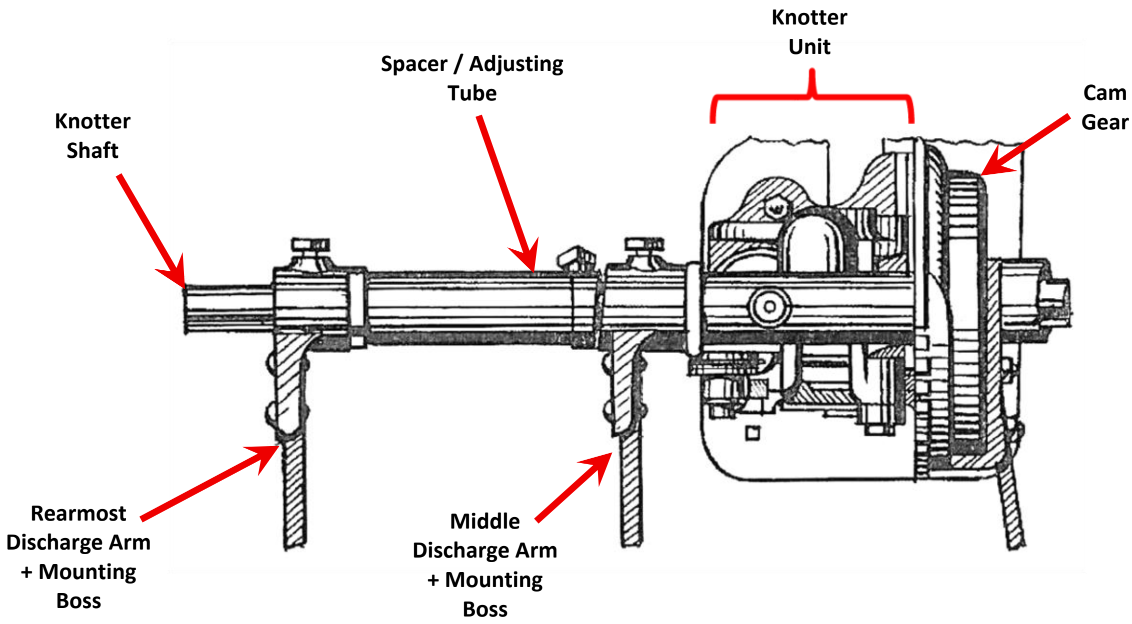


Fig.5.28 Albion binder knotter stack – Adjustment of Cam Gear end-float

Albion Binder Knotters - Adjusting Knotter Unit - Cam Gear End-Float

The Albion Binder Knotter *(and possibly also that of the Albion Trusser)* incorporates a very convenient means of adjusting the Knotter Unit – Cam Gear end-float: it dispenses with the need for insertion/removal of shim washers *(Fig.4.19)* and any associated removal & replacement of components on the Knotter Shaft.

The front end of the Spacer Tube, fitted between the Middle & Rear Discharge Arms, is angled *(Fig.5.28)*. Cam Gear end-float is easily adjusted by the following procedure:

- Slacken the locking screw on the Mounting Boss of the Middle Discharge Arm
- Slacken the locking screw on the Spacer / Adjusting Tube
- Rotate the Adjusting Tube slightly:
  - This pushes the Middle mounting boss & the Knotter Unit along the Knotter Shaft towards the Cam Gear, reducing any end-float present
- Re-tighten the locking screws on the Mounting Boss & the Adjusting Tube
- **REMEMBER don't overdo this adjustment!**
  - The flat faces on the Twine Disc and Bill Hook drive pinions should be a snug fit against the flat *(side rim)* surfaces of the Cam Gear, **BUT there should be some slight clearance** to prevent the surfaces binding *(see Fig.4.19)*
  - The Cam Gear **MUST** be able to rotate freely against the Knotter Unit without any binding or tight spots.

6 Sourcing Spare Parts

The availability of replacement/spare parts for the various types of Binder & Trusser knotters covered by this guide has been reviewed within each of the brand-specific sub-section in Section 5. The following presents a brief summary of the situation and indicates possible known sources of knotter spare parts, where they are available. There are almost certainly other sources of parts but *(perhaps understandably)*, such information may not always be shared too readily between machine owners. In any case, the current situation is understood to be as summarised in Table 12.

Table 12 Binder & trusser knotters – Spare parts availability - Summary

Knotter Brand/Type	Spare Parts Availability	Comments
Current Deering-type ***(Rasspe, New Holland)***	Very Good	• Aftermarket *(spurious & genuine)* replacement parts available via dedicated *(Baler & other)* parts suppliers • Also via CNH & AGCO dealers
Deering Binder	Poor	• Limited new parts availability – Some may perhaps be sourced from U.S.A. • Otherwise, necessary to repair/rebuild existing parts • Dismantling of other machines is the only other source
Ruston & Hornsby ***(Binder & Trusser)***	Very Poor / Non-Existent	• No new parts availability • Necessary to repair/rebuild existing parts • Dismantling of other machines is the only other source
McCormick Binder	Moderate / Poor	• No UK new parts availability • Some new parts availability from U.S.A. • Otherwise, necessary to repair/rebuild existing parts • Dismantling of other machines is the only other source
McCormick International Baler	Good	• Aftermarket *(spurious & genuine(?))* replacement parts available via dedicated *(Baler & other)* parts suppliers & CNH dealers
Massey Harris ***(and Sunshine)*** ***(Binder & Trusser)***	Very Poor / Non-Existent	• No new parts availability *(as far as we can determine)* • Necessary to repair/rebuild existing parts • Dismantling of other machines is the only other source
Albion ***(Binder & Trusser)***	Very Poor / Non-Existent	• No new parts availability • Necessary to repair/rebuild existing parts • Dismantling of other machines is the only other source

(continued)

Known suppliers of replacement parts include the following. **Please note,** this is not intended to be an exhaustive list. **Other parts suppliers are available!**

Kramp UK Ltd

Unit 5
Lancaster Way
Biggleswade
SG18 8YL

Tel: +44 (0)333 051 0111

https://www.kramp.com

(Europe-wide supplier of aftermarket spare parts & accessories for agricultural machinery)

- Can supply Current Deering parts *(i.e. Rasspe, New Holland, MF),* some McCormick Baler parts & knotter parts for most modern, Conventional Balers
- Parts may be selected from the website, but Kramp will only supply via Dealers or account holders. **However,** most local ag. machinery dealers will be able to source Kramp items.

Woodfield's
Station Yard
Bluntisham
Huntingdon
PE28 3PA

Tel: +44 (0)1487 843 331

www.balerparts.co.uk

(Specialist supplier of parts for conventional, large round and large square balers)

- Can supply Current Deering parts *(i.e. Rasspe, New Holland, MF),* McCormick Baler parts & parts for most Conventional Balers produced from the mid-1960s onwards
- Will deal direct, either via website or phone.

B.W. Macknair & Son
3055 US Highway 522 North
Lewistown
Pennsylvania
PA 17044

Tel: +1 717 543 5136

norman@macknair.com

www.macknair.com

(Specialist ag. machinery repairer &supplier of parts for McCormick & Deering (grain) binders)

- Can supply certain (knotter & other) parts for McCormick and Deering *(grain)* Binders
- Will deal direct, either via email, website or phone
- Shipping & other costs must be taken into consideration.

7 Summary

This guide has presented a technical overview of Twine Knotters as used on Binders, Trussers and Conventional Balers; especially concerning knotter setup, adjustment & in-service fault-finding. Areas covered have included:

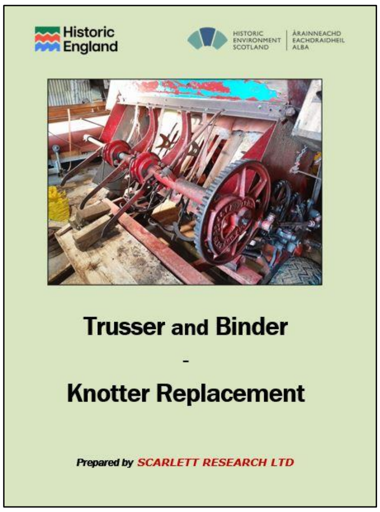
- The basic principles of knotter operation. Particularly that:
    - **All knotters** must perform the same sequence of tasks/actions in order to tie a knot
    - Different knotter types or brands may use different-looking components and/or perform the tasks in slightly different ways, **BUT** ultimately, the operations performed are the same
- The two, principal knotter types used on most Binders, Trussers & Balers; namely **the 'Deering'** & **the 'McCormick'**, which:
    - Are of basically different design
    - Operate in a slightly different way
    - Tie knots of different appearance
- The main problems & performance issues likely to affect any type of Knotter Unit or the *(broader)* Tying Mechanism *(i.e. the Knotter plus the Needle & twine supply system)*
    - What the probable symptoms, causes and potential solutions to these problems might be
- The main knotter brands/types found on thatching straw harvesting machinery: their key features, strengths & weaknesses and the scope for *(and means of)* in-service adjustment(s).
- The likely availability and possible sources of replacement/spare parts for these knotters.

Messages to Take Home

- **The real importance of:**
    - **Twine Placement in the Knotter Unit**: i.e. the operation & adjustment of the Needle(s). This should be one of the first things to check if you have a tying problem
    - **Twine Tension** *(adjustment)* and **Twine Quality**
    - **Knotter Unit component timing** and **Needle – Knotter timing**
- That, to an extent, the nature & appearance of tying faults which occur, and what can be done to correct them, depends on the make & model of knotter you're dealing with
- The limited availability or complete lack of new, replacement parts for many of the knotter brands/types which are still in use today. Over time *(if not already)*:
    - Drive gears, sprockets & chains will wear
    - Slack / free-travel will develop in the tying mechanism
    - Component timing will begin to wander / become variable
- Some knotters incorporate various adjustments which can compensate for wear **to an extent**, **BUT** certain others don't. System adjustments can correct things if the issue isn't too bad **and** it remains constant when in-work: **BUT** if the issue causes random variations, then the underlying problem must be addressed.

Messages to Take Home *(continued)*

- When Knotter / Tying Mechanism wear becomes so bad that adjustment(s) won't restore tying performance:
    - Gear & sprocket teeth can be built-up *(with bronze welding)* & filed back to their original profiles. New, replacement drive chains can usually be obtained
    - **However,** Knotter Unit – Cam Gear end-float **should always be minimised, BUT** not to the point of introducing resistance to the Cam Gear turning against the Knotter Frame or Drive Pinions
- When faced with wear-related problems and absence of replacement parts to correct them, some users have replaced the original knotters on their Trussers and/or Binders with current, Deering-type knotters, as intended for Conventional Balers. This 'upgrade' approach incurs some engineering time, effort & cost, but it will:
    - 'Future-proof' the machine in terms knotter *(replacement)* parts availability
    - Permit more precise adjustment of the Knotter Units *(newer knotter designs have greater scope for adjustment)*
    - Almost certainly lead to more reliable tying performance
- A dedicated Technical Guide in this series provides full details of this *'Knotter Replacement'* process *(see right and Section 8)*



- Both Deering and McCormick-type knotters are reliable designs which work well when properly set-up & maintained. **However:**
    - **McCormick *(static knife)* type:** It's method of operation makes it more dependent on correct component timing: the knotter also has limited scope for adjustment. So, when wear-related free-play develops, component replacement *(or repair)* are the only real ways to restore tying performance; and replacement component availability is now very limited
    - **Deering *(moving knife arm)* type:** Has a more positive method of operation and also offers more scope for component adjustment to compensate for wear. So, despite having more moving parts, Deering-type knotters are more able to accommodate in-service wear without loss of performance. They are therefore likely to be more reliable in the long run.

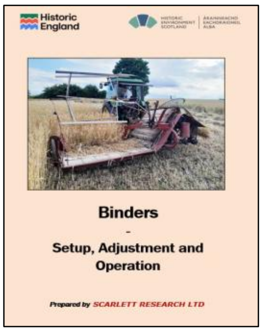
8 Thatching Straw Harvesting Machinery – Technical Guides

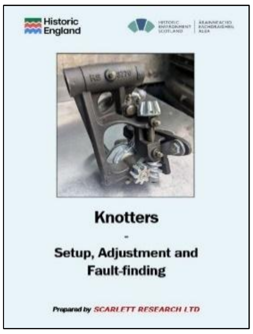
This publication is one of a series of technical guides prepared by Scarlett Research Ltd, on behalf of Historic England and Historic Environment Scotland. These guides are intended to illustrate machine adjustments, modifications & operating techniques which are likely to improve the efficiency & productivity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

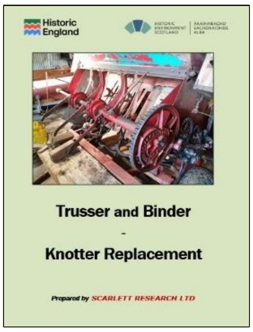
Technical Guides in this series include:

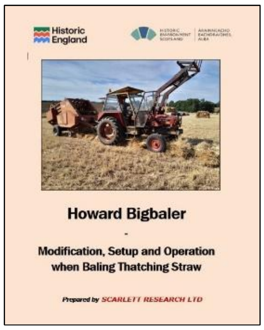
- **Binders – Setup, Adjustment & Operation**
- **Knotters – Setup, Adjustment & Fault-Finding**
- **Trusser and Binder – Knotter Replacement**
- **Howard Bigbaler - Modification, Setup & Operation when Baling Thatching Straw**

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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