

## **Elastic Fencing**

Development of the lightweight, flexible, and quickly applied Lightning spring wire dropper has made an important contribution to modern rural fencing technology. The emphasis on light, elastic and flexible high tensile steel components, attached to ends of adequate strength, is the central theme for this discussion of the efficiency and economy of modern fencing.

Fencing is and always has been one of the most important economic factors in the pastoral industry. The following work is an attempt to explain simply the engineering principles of fencing and we hope that it will encourage interested bodies to embark on the necessary research on animal behaviour relating to fencing.

### **Introduction**

In considering fencing, of basic interest to the grazier is the cost of effective fencing compared with the value of the stock it contains. This proportion varies widely and, while fencing costs are of major concern to all, they become particularly critical in the low-density properties of large areas and usually heavy freight costs. In the light of this it is hardly surprising that there has been increasing interest in suspension fencing and therefore an increasing demand for advice on the design and construction of this type of fence.

To supplement various sources of information on fencing, we constructed and tested several fences using various materials and configurations. The test results and other accumulated data for the basis of our recommendations.

Many people consider fences simply as suspension or conventional on the grounds of intermediate post spacing. We believe that further differentiation is necessary and to explain our approach to the problem, it may help to trace the evolution of strand wire fencing and established definitions.

#### **1. Conventional Fence**

This is characterised by heavy gauge, low strength wires over short spans. These fences were usually equipped with totally inadequate end assemblies and therefore virtually no tension. Their performance was mediocre even over very short spans. The extensive use of barbed wire did assist to stock proof this type.

#### **2. Elastic Fence**

The more recent availability of light gauge high tensile (H.T.) wire has made possible the development of what may be called the " elastic fence ". To utilise the elastic properties of these materials, efficient end (strainer) assemblies have been developed to maintain comparatively high tensions. Subject to satisfactory wire and dropper spacing etc., these tensions ensure stock proof structures over a variety of post spacing. This type we regard as the basis of all modern, economic and efficient strand fencing.

#### **3. Suspension Fence**

The suspension fence is simply a special case of the elastic fence employing very long

intermediate post spacing. In many conditions, this type can provide excellent service at very low cost.

## Type of Wire

### Plain Wire

In discussions on wire strength there has always been considerable misunderstanding and we will attempt to clarify the most important features:

1. The load required to break the wire is called its ultimate or breaking load.
2. Considerably below the breaking load is the elastic limit or yield load; i.e. for loads below the elastic limit, the wire will stretch but will return to its original length when the load is released. On the other hand, for loads in excess of the elastic limit, the wire will remain permanently stretched when the load is released.

When the fence wire is strained to its working tension of, say 140kg. (300lb.), a certain stretch is produced. It is the difference between this initial stretch and the stretch at yield that defines the ability of the fence to survive impact loads, temperature changes, etc.

Changes in strain of wire produce tension force changes that are proportional to the cross-sectional area of the wire. Therefore, shortening of the wires due to settlement of end assemblies, etc, will cause less tension force loss in light wires than in heavy. Similarly, stretching due to impact will cause less tension force increase and therefore will be less likely to overstrain end assemblies if light wires are used.

From 140 kg (300lb.) initial tension to yield point, high tensile wire is capable of greater stretch than standard fencing wire; i.e. 2.5mm (12\12 G) High Tensile 1250lb. wire will absorb more than twice the elastic energy of 4.0mm (8G) and more than four times that of 3.15mm (10G) standard.

Table (a) gives a comparison of the actual values of yield and breaking loads for the materials discussed. It may be seen that despite the considerably lighter gauge of the high tensile material, the yield and breaking load compare very satisfactorily. Note, it is the ability of the high tensile wire to stretch elastically, which gives it the high energy-absorbing ability.

**TABLE (A)**

Type	4.00mm (8G) Std.		3.15mm (10G) Std.		2.5mm (12 1/2G) HT 1250lb	
	Kg	(lb)	kg	(lb)	kg	(lb)
Breaking Load	730	1600	480	1050	570	1250

Yield Load	380	840	250	540	360	800
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If for any reason stronger material is considered necessary, the 2.8mm (11G) High Tensile 1800lb. wire is ideal but is of course more likely to overstrain end assemblies. However, 2.5mm (12 1/2 G) high tensile wire is more than adequate for most needs.

### **Barbed Wire**

As with plain, there is the choice of standard or high tensile. The standard material is in 2.5mm (12 1/2 G) wire with continuous twist and, because it is woven around the barbs, is always a comparatively loose weave. This makes it rather difficult to maintain a tension over long spans because any superimposed load tends to tighten the weave and straighten out the wires. Also, being of soft material, there is very limited available elastic stretch in the wire itself.

The high tensile barbed is in 1.6mm (16G) H.T. wire with reverse twist. In this case the barbs are coiled around the pair of 1.6mm (16G) wires allowing a tight weave which overcomes much of the difficulty experienced with standard barb over long spans.

However, if overloaded, the reverse twists will unwind and so the maximum permissible elastic load is defined not by the tensile yield load of the wire but by the unwinding load; e.g. 1.6mm (16G) H.T. barbed has a breaking load of over 450kg. (1000lb.) but may unwind if taken above 280kg. (600lb.)

It is important to realise that plain wires are free to move through the holes or ties on the posts and so make the entire strain length available to stretch. This, of course is not so with barbed.

It is therefore apparent that while the high tensile material is a more suitable barbed wire for this type of fence, its capacity to sustain impact loads without damage falls far short of that plain H.T.. wire.

### **Plain Versus Barbed Wire**

A fence constructed of all plain high tensile wires provides maximum elasticity but reduced deterrent to stock unless wire and dropper spacing are reduced below that employed with barbed wire. Conversely for the all-barbed fence the situation is reversed. The economics of this comparison will be considered under "costs", but the comparative effectiveness will be poorly defined until suitable research is carried out with stock.

In the meantime it is clear that combinations depending on individual conditions of stock, etc. Also, the use of suitable droppers enables the plain wires to support the more vulnerable barbed.

### **End Assemblies**

Poor end assemblies will seriously reduce the efficiency of a conventional fence but will render elastic and suspension fence practically useless. The entire concept of elastic fencing depends on the maintenance of suitable wire tension and this is quite impossible unless end assemblies are of the highest quality.

Considerable research has been carried out on this subject, both in Australia and overseas, and many configurations have been tested. The most effective was found to be the horizontal stay type as illustrated.

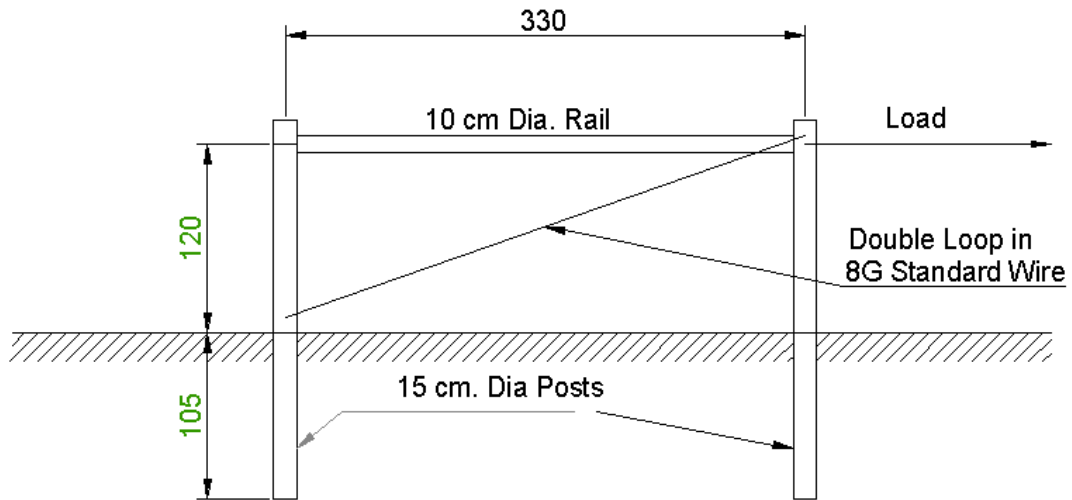


FIG. 1.

Fig 1.

It is strongly advised that the strainer posts be driven into holes bored to size. Oversize holes and ramming almost halve the load carrying capacity. Depth into the ground is also very critical. Reduction from 105cm (3'6") to 75cm (2'6") will also halve the load carrying capacity.

The single span assembly as illustrated in Figure 1., will give satisfactory service provided the ground is firm and posts driven. If, however, these conditions do not exist, it may be necessary to use double assemblies as illustrated in Figure 2.

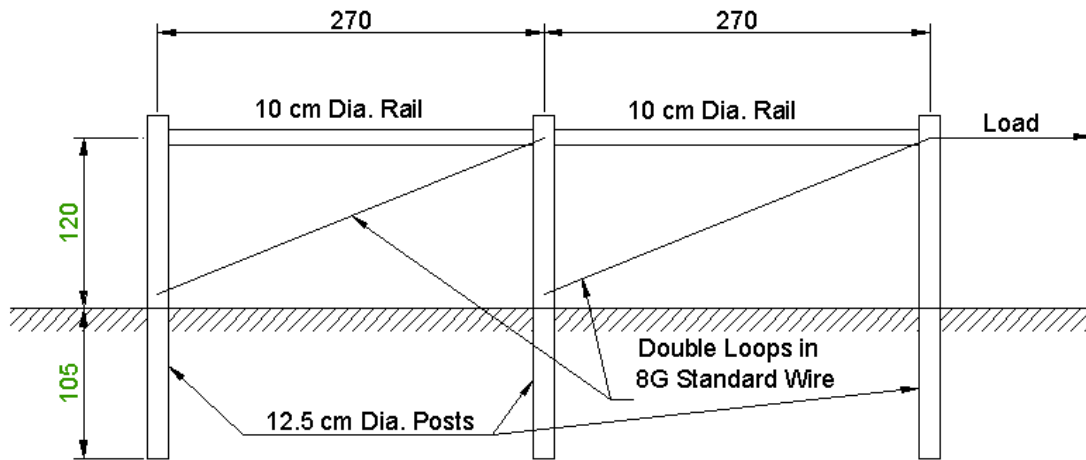


FIG. 2.

This is particularly true of sandy soil or soil subject to much expansion and contraction. Corners also present conditions of loading which make double assemblies desirable.

The importance of overall strength and rigidity of the end and corner strainer assemblies cannot be overstated. It is therefore suggested that if the slightest doubt exists, use double assemblies. The increased cost will be small and could represent the difference between success and failure.

Tests have recently been carried out in Victoria, Australia, on horizontal stay assemblies with 270cm (9') long driven end posts. From results available it is anticipated that arrangements using deep driven posts will be of particular importance in black soil plains where excessive surface cracking can seriously affect shallower posts.

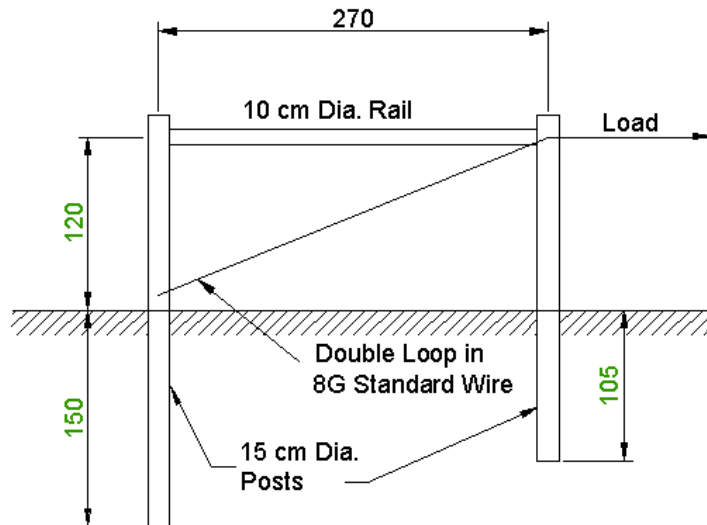


FIG. 2.

Fig 3.

It must be realised that any strainer assembly will settle to some degree when first installed and loaded. The extent and duration of this movement varies with the type of soil but, if the strainer is adequate, should reach equilibrium within two or three days while still maintaining at least the desired tension. The tension allowance necessary for this consolidation is a matter of experience and knowledge of soil condition.

### Strain Length

For reasons of convenience 400 metre (1/4 mile) strains have become very common and are quite satisfactory. However, strains of up to 1350 metres (1500 yards) may conveniently be used to advantage where the terrain permits.

The comparative effects of end structure settlement of various gauges over various strain lengths are illustrated by Table (b). These results of tests carried out by Mr. A.H. Bishop at Hamilton, Victoria.

Table (B) - Effect of fence length - Initial Tension to give 140kg (300lb) final tension

TABLE (B)

Wire Diameter		100m	5 Ch	200m	10 Ch	400m	20 Ch	800m	40 Ch	1600 m	80 Ch
Mm	Gauge	kg	(lb)	kg	(lb)	kg	(lb)	kg	(lb)	kg	(lb)
4.0	8	475	1050	305	675	220	487	178	393	157	346
3.55	9	340	750	240	525	185	412	162	356	148	328

3.15	10	325	720	230	510	184	405	159	352	147	326
2.8	11	300	670	220	485	178	392	157	346	146	323
2.5	12 1/2	270	600	205	450	170	375	153	337	144	318

Apart from the advantages of long strains, the results emphasise once again the value of light gauge wire.

### **Wire Tension**

Tension of 140kg. (300lb.) Per wire has come to be accepted as a satisfactory working value, which provides a stock proof fence while leaving a reasonable margin for elastic stretch. Also, it is sufficient to keep sag within acceptable limits over spans up to 30m (100ft.).

The actual measurement of tension is a factor that has long been neglected but is one which assumes major importance in elastic and suspension fences. Tension measuring equipment is therefore regarded as essential with these types.

### **Intermediate Post Spacing**

Provided the basic requirements of materials, tensions etc., for the elastic fence are adhered to, considerable latitude is allowable for post spacing in various conditions, but it is necessary to examine the physical properties of the fence as post spacing varies.

The stock proof characteristics of various post spacing can be accurately determined by suitable research and will of course depend on type of wire, wire spacing, dropper spacing, type of stock and stocking rate. However, spacing of posts or droppers is very important. The economics of substituting droppers for posts is discussed in "costs" but it is also necessary to examine the physical properties of the fence as the post spacing varies. This is of particular interest in low-density country and it is probable that the stock-proof qualities would improve as the density decreases.

In many low density areas damage to fences by stock and pests is of major importance. An elastic fence with long panels may be subjected to very large lateral deflections and recover undamaged. Figure 4 illustrates such a condition.

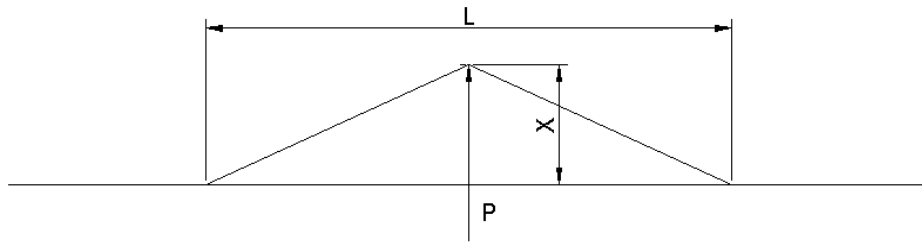


FIG. 4

It is assumed that:

1. Strain Length is 400 metres
2. Wire is plain 2.5mm HT 550kg
3. Wire is free to move through holes or ties on posts

“x” is the lateral deflection made available by increasing the wire tension from 140kg to 365 kg.

‘p’ is the force required to produce this condition. The two adjacent posts must share the reaction to “p”.

Table (C) gives theoretical values of “x’ and “p” as post spacing “L” is varied under these conditions.

TABLE (C)

Post Spacing “L” Metres	Available lateral deflection “X” Metres	Force “P” Kgs/wire
4	1.4	436
6	1.7	364
12	2.3	273
20	3.0	209
30	3.7	173
36	4.1	159

From these it may be seen that under impact conditions of penalties of small Post spacing are twofold -- i.e. not only are more posts required but also they must be stronger. The magnitude of "x" required to escape damage is very nebulous and must be such that beast can fall with the wires and stretch them to the ground.

The introduction of barbed wire to this type of fence raises some difficulties, for reasons already explained. It is therefore desirable that spans be as long as possible but in our opinion other considerations limit this to 100 ft.. These items may be of limited interest in high-density areas and in any case extremely wide posts basing would probably not be sufficiently stock proof under high-density conditions. However, the elastic fence has the virtue of being adaptable to varying post spacings within the same strain length. Sections of fence around gates, etc will be subjected to extreme density conditions and post and dropper spacings may be drastically reduced to suit. However in sections of the same fence to promote from such trouble spots, post and dropper spacings may be increased to whatever economic limit prevailing conditions allow. It must be remembered that as span is decreased in high-density locations, post strength must be increased accordingly.

### **Temperature Effect**

A fence will be considerably tighter in cold conditions than in hot; e.g. a temperature change of 28° C (50° F) would produce a tension change in 2.5mm (12 1/2 G) plain wire of 32kg (170lb). However, because of its greater cross section area, a 4.0mm (8G) wire would be subjected to a tension change of 86kg (190lb) in the same conditions.

Graziers in areas subject to wide variation may use the above example as a basis of adjustment if tension-measuring equipment is used, but in most areas temperature is not likely to present a major problem. However, it is clear that in the consideration of temperature there are definite advantages in using light gauge high tensile wire of heave gauge standard fencing wire, i.e.

- Light gauge wire acquires less tension change from a given temperature change and being of high tensile material, it is better able to withstand the stress change involved.
- The smaller tension change induced in light gauge wires is less likely to overstrain the end assemblies in cold conditions.

### **Droppers**

From the foregoing it is obvious that the weight of the fence droppers is of paramount importance. Also, for the droppers to escape damage under conditions of impact, they must be either very rigid or very flexible. Rigidity is not consistent with the requirement of minimum weight and so, apart from the usual considerations of economy, ease of application etc. the basic concern in dropper design should be "minimum weight and maximum flexibility". We believe the solution to be **a wire dropper of quite light gauge but extremely high quality.**

With these considerations in mind, our company set out to develop the ideal fence dropper. The result of our research and development was the **Lightning Dropper** made

from 4.0mm (8G) Drawn Heavily Galvanised Spring Wire. It is the lightest, most resilient dropper yet produced. At the same time its unique loop provides the quickest, easiest and most positive fixing without the use of special tools. Being heavily galvanised, the problem of corrosion of line wires is minimal compared with black steel or timber posts.

**National Lightning Droppers** are now manufactured under our overseas patents in New Zealand, Argentina and Venezuela where millions of droppers are giving outstanding service.

**Knots**

Tests carried out on various wire knots demonstrated the general superiority of the "figure of eight" knot over all others. However, on short strains the tension loss due to space required to tie the knot may be prohibitive, and it may be necessary to strain and tie directly to the post. Where possible this is good practice, regardless of the strain strength.

**Costs**

Freights comprise a major component of cost in many areas and vary widely. In the tabulation of material costs comparative weights are therefore included for freight calculations.

**TABLE (D)**

**Approximate Wire Pricing as at August 1997**

Wire Type	Cost per Km F.O.R. Capital City \$	Weight per Km (kg)
2.5mm (12 1/2G) 850lb High Tensile	114.75	39
2.5mm (12 1/2G) 1250lb High Tensile	121.10	39
2.8mm (11G) 1800lb High Tensile	200.90	48
3.15mm (10G) Standard	187.10	61
4.0mm (8G) Standard	279.30	98

1.6mm (16G) Heavy Gal Barbed High Tensile	271.60	42
2.5mm (12 1/2G) Standard	406.15	107

Apart from the various technical advantages of light high tensile over heavier standard materials, the above table illustrates their considerable economic advantage. Also it may be noted that 2.5mm (12 1/2 G) 1250lb plain HT wire is less than half the price per km of 1.6mm (16G) HT barbed wire. Two plain wires are heavier than one barbed but remain cheaper in areas where freight is less than \$100 per tonne.

### Posts and Droppers

Costs of posts and other timber components depend of availability of local material and therefore must be considered in the light of these conditions. However, it is necessary to consider the savings made possible by substituting droppers for posts. The cost and weight of droppers varies with the number of line wires, the distance between top and bottom wires and the type of dropper. However, a selection of **Lightning Fence Droppers** and star steel posts will be used for this comparison. Current retail prices and weights are as follows:

TABLE (E)

Approximate retail price as at August 2003

	Size	Retail Price Each (approx.)	Weight per 100
Steel Star Posts	165cm	\$5.50	330
Steel Star Posts	180cm	\$6.70	360
Lightning Droppers	8 Wire - 120cm	\$1.90	20
Lightning Droppers	7 Wire - 100cm	\$1.80	17
Lightning Droppers	6 Wire - 91cm	\$1.50	15
Lightning Droppers	5 Wire - 76cm	\$1.30	12
Lightning Droppers	4 Wire - 61cm	\$1.05	11
Lightning Droppers	3 Wire - 61cm	\$1.05	10

In the average cost of say, a 6-wire 91cm (36') fence, timber and sheet metal droppers are approximately 20 per cent more expensive than the **Lightning Dropper** and several times the weight. However, on average it would be true to say that droppers are less than 1/3 the price of posts and a much smaller fraction of their weight. It is therefore obvious that post spacing should be kept as wide as practicable and the wires controlled

by droppers between the posts.

## **Conclusions and Recommendations**

The principal result of this investigation is the over-whelming technical and economic evidence in favour of light, high tensile materials and the emergence of what we call the "elastic fence" as a means of efficiently utilising the very useful properties of these materials.

To summarise the topics:

### **Plain Wire**

In every respect thin high tensile wires have definite advantages over thicker standard wires. While there may be special cases where 2.8mm (11G) HT 1800lb or 2.5mm (12 1/2) HT 850lb. wires are suitable, we believe the best general recommendation to be 2.5mm (12 1/2 G) H.T., 1250lb. wire.

### **Barbed Wire**

As in plain wire, light high tensile barbed wire has definite advantages over its standard counterpart. However, it must be noted that two plain 2.5mm (12 1/2 G) H.T 1250lb wires cost less than one 1.6mm (16G) HT barbed wire, and of course, the plain wire is considerable stronger and more elastic. This must surely lead graziers to a closer study of stock proof characteristics if two plain wires replace one barbed wire. Freight must be considered in this comparison and the weights per kilometre of the various materials are listed for this purpose.

From the point of view of cost, elasticity and structural efficiency, the plain wire component in a fence should be kept as high as possible. However, where barbed wire is required **use light gauge high tensile material.**

### **Strain Length**

This of course, depends upon local topography but strains up to 1600 metres (one mile) are practicable and have certain advantages. Strains of substantially less than 400 metres (1/4 mile) suffer serious loss of elasticity and efficiency.

### **End Assemblies**

It is suggested that the double span assembly as illustrated in Figure 2. be adopted as the general standard. However, in good soil conditions and fences with few wires, the single span assembly will be quite satisfactory. Also, the deep driven post with horizontal stay has an important part to play in black soil plains subject to extreme cracking. This type is illustrated in Figure 3.

### **Intermediate Posts**

The choice of post is not important to this argument, provided that it is of suitable strength. Posts may therefore be chosen simply on the basis of cost. But post spacing should be kept at a maximum that is stock proof, up to a limit of 30m (100ft).

Whatever the means of attachment of wires to intermediate posts, it is vital that plain

wires be free to move through holes or ties such that the entire strain length is available to stretch.

### **Wire Tension**

Strain plain and barbed high tensile wires to a final working tension of 140 kg. (300lb.) Make allowance for tension loss due to settlement of end assemblies. For consistent results the use of tension measuring equipment is essential.