Mounting barkcloth with rare earth magnets: the compression and fiber resiliency answer

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Abstract

The use of magnets to mount barkcloth is common, yet details of the specific techniques used had not been adequately documented. An investigation of magnetic systems globally found that while all current systems use 'point fasteners' on the surface of the cloth, this is where the similarities end.

The unresolved question for mounting barkcloth is the potential for compression. Compression is a significant issue for art works on paper, especially when magnets are located on the face. How are backcloth and paper different?

While researching various materials frequently placed together and used within a magnetic mounting system, otherwise known as 'the gap', some interesting ancillary results were found. Materials are typically selected for their archival value, which includes their long-term stability. Over time, a set of preferred materials became well established; these encompass both natural and synthetic materials, woven and non-woven alike. The phrase 'like with like' is often used when materials are selected. This long-held philosophy should be re-examined.

Compression relates to an object's ability to regain shape once a force is applied, one aspect of its resiliency. It appears that barkcloth is less likely to experience compression than does paper, although both media are cellulosic. Cellulose is rated as a low-resilience fiber, when compared to proteins and polyester. These materials most likely have different compression potentials due to the different ways in which paper and barkcloth are prepared.

This and other surface phenomena will be discussed. The investigation will briefly summarise why the 'point-fasteners' system appear to be favoured over 'large area pressure.'

Introduction

The conservation and mounting of barkcloth has long been a challenge. The approach used is often dictated by the experience of the practitioner, normally either a paper or a textile conservator. In addition, this broad class of artifact, encompassing both flat and three-dimensional artifacts, is made using heterogeneous plant material and decorative techniques, and varies in its thickness and size. The non-woven quality of the material results in an artifact that is neither textile nor paper and typically does not always lie flat.

When *The Conservation of Artifacts Made from Plant Materials* (Florian *et al*. 1990) was published, the recommended mounting method for barkcloths was to treat them similarly to textiles (Florian *et al*. 1990). Some suggestions presented were to use Velcro, rods, pressure clamps or 'U'-shaped Plexiglas clips (Wolf 1982, 1983; Norton 1984; Dietz and Bessant 1996; Holdcraft 2001; Dean-Jones 2006). As a material without a standardized mounting system, magnets have become the standard tool and an increasingly viable option.

However, the non-woven and paper-like quality of the material has led practitioners to oftentimes treat barkcloth as if it is paper. Another method has been to secure a Japanese tissue sleeve to the backside of the upper edge in order to receive a rod or hinges (Figure 1) (Barton and Weik 1994; Lennard *et al.* 2017; Pullman 2017). Each of these methods has a certain caveat: the artifacts must be sufficiently strong and stabile, and include some type of attachment along the upper edge. Compared to using nails and tacks, these methods do hold many advantages (Pullan 2017).

Figure 1. An early mounting system with a metal rod held in a cotton sleeve (Spicer).

All recorded magnetic systems for mounting barkcloth that were collected by the author, report using a point fastener method with the artifact positioned within the magnetic system's gap (Dean-Jones 2006, 2009; Winner 2009; Kramer 2014; Bastian et al. 2015; Zobl 2015). This method is an attractive solution due to the fact that most barkcloth is not flat. However, as mentioned earlier, a sleeve could also work. An interesting observation is that all of the former mounting systems listed, support the barkcloth along the upper edge, which if a magnetic system was used, this would be referred to as 'large area pressure.' Where as, when magnets are used they are randomly place, which I call 'point-fasteners' and placing the barkcloth within the 'gap.' This paper discusses some of the issues relating to the mounting of barkcloth with magnets.

What is a Magnetic-System?

When selecting and using permanent magnets of any type, three key components must be considered: (1) the strength of the magnet itself (measured in 'gauss'), (2) the receiving component (the ferromagnetic material that is magnetized in a system), and (3) the magnetic field distance (the space between the magnet and the magnetized metal). Also called 'the gap,' the magnetic field distance is created by the layers separating the magnet and the receiving ferromagnetic material. Balancing these three components is key to creating a successful system. Each of these components is significant in determining how the magnet behaves and performs its task (Feynman *et al*. 1964; Livingston 1996; The Magnet Story 1998). No one method can be prescribed for all situations; instead, each component must be adjusted to a particular case. Understanding the components of a system and how they interact allows one to develop an optimal system (Spicer 2010, 2016, 2019).

A magnetic system can include a variety of combinations of magnets and receiving materials. Three main categories are: a two-part system in a magnet-to-magnet design, a two-part system in a magnet-to-ferromagnetic material design, or a three-part system with a ferromagnetic material-to-magnet-to-ferromagnetic material design (Figure 2). It is important to know when designing a system that the magnetic behavior of a two-part system is distinct from that of a three-part system.

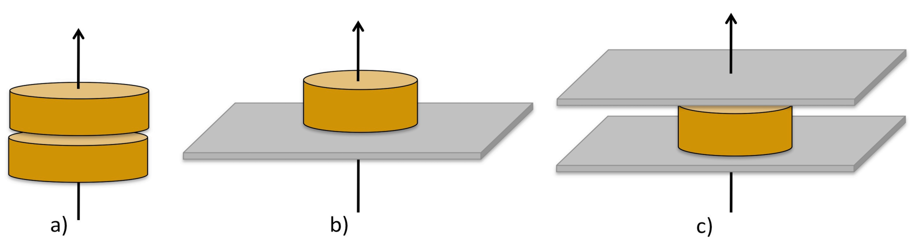

Figure 2: Variations of two-part and three-part magnetic systems; a) Magnet-to-magnetic; b) Magnet-to-ferromagnetic material; and c) Ferromagnetic material-to-magnet-to-ferromagnetic material.

Types of magnetic systems

Magnets can be used as point-fasteners or installed to exert pressure over a large area. The majority of magnet solutions involve individually placed magnets serving as point-fasteners, since this is the simplest method. A magnet used as a point-fastener is selected based on its pull force and how it interacts with the surrounding ferromagnetic material. One selects a size and grade of magnet based on its ease of handling, then adjusts the gap and designs the magnet to blend in with the artifact. Magnets can then be added or subtracted based on the amount of strength needed to support the artifact. Typically, the artifact is large enough to allow for spacing such that there is little connection between adjacent magnets, and the polar direction of individual magnets is also of no concern. When point-fasteners are employed, many magnets are used, but each acts independently from the others.

Continuous large area support is achieved by using several magnets in concert to provide overall pressure or support. Sufficient pressure can be achieved by several means, including adjusting the polar orientation of the magnets, using magnets with ancillary materials, embedding magnets within stiff materials, embedding magnets in an attached sleeve, or a combination of these methods. It is not just the magnet that creates the larger magnetic field; the magnet, when used in conjunction with a larger element, is what creates the increased pressure. A major benefit of using large area pressure methods is that a larger proportion of the artifact is being secured, which lowers the internal stresses that can be caused by point-fasteners and decreases the likelihood that the artifact gets damaged. However, implementing these methods requires additional design considerations when compared to point-fastener use.

Materials within the 'Gap' or field distance

As all of the magnetic systems used when mounting barkcloth actually place the barkcloth within the system, a better understanding of the gap is necessary. Figure 3 shows how quickly the strength of the magnetic field dissipates with distance. As the gap between the magnet and the ferromagnetic material move apart, the strength of the pull force decreases dramatically and it happens rapidly. The three lines show three different characterizes of magnets. Therefore the layers of materials within the gap can be critical to the behavior of the system.

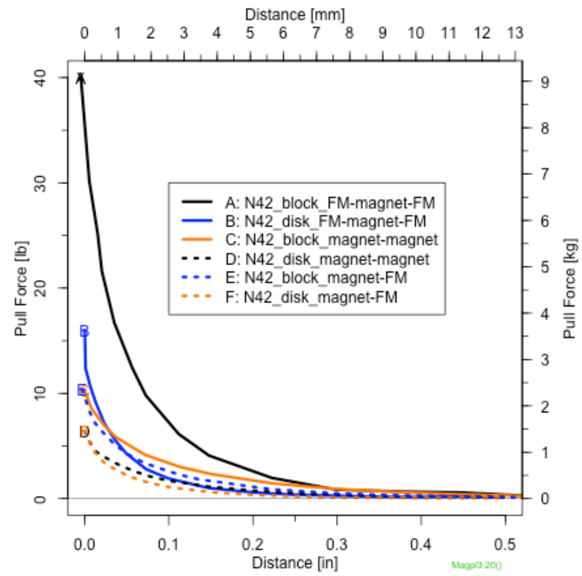

Figure 3: Field strength vs. distance relationships for two different shapes of magnets with the same grade: one block-shaped, N42, ½" x ½" x ⅛" thick; and another disc-shaped, N42, ½" diameter ⅛" thick, with another similarly sized magnet or ferromagnetic material sandwiched between ferromagnetic materials (Adapted from K & J Magnetics, Inc.: https://www.kjmagnetics.com/calculator.asp).

Resiliency

The unresolved question is compression (Tamura 2018). It appears that barkcloth is less likely to experience compression than is paper, although both media are cellulosic. Cellulose is rated as a low-resilience fiber, when compared to proteins and polyester. These materials probably have different compression potentials due to the different ways in which paper and barkcloth are prepared.

Resilience describes a fiber's ability to return to its original shape. It is a ratio of the energy of retraction to the energy of deformation and is influenced by temperature, moisture content, rate of strain, retraction, and strain history (Dillon 1947). Various fibers are rated on a scale of resiliency (Table 1) (Ballard 1995b). Fibers that show good tensile recovery also tend to have high compression recovery (Morton and Hearle 1962). Cellulosics as a group have low resiliency, as is evidenced by plate marks on prints. This may partially explain why paper conservators often see compression as a result of using mounts with magnets. They have a strong argument with evidence. Paper is made by capturing cellulose fibers in a slurry, water is shaken out and allowed to dry under felts.

Table 1: Resilience Tanking

Material	Resiliency
Polyester	High
Wool / proteins	
Nylon	
Acrylic	
Olefin (PE, PP)	
Triacetate	
Silk	
Acetate (secondary)	
Cotton	
Rayon	
Flax	Low or poor

Of course, an artifact's previous use—either historically or while in a museum—will have an effect on the extent of its compression. Yet, just the fibre being rated is not the full story. What about the materials use or method of manufacturing? Barkcloth is a cellulose, but in preparation, it is beaten and beaten to become the flexible and strong material it is. Of course further scientific studies need to be performed to fully confirm this statement. But these two illustrated material's manufacturing methods are so different that of course, their response would also be different. I often think of the difference of the bottom sole of a leather moccasin verses it upper sections.

Padded Surfaces

Many conservators prefer to create a soft surface on the mount. Both hard and soft surfaces have resistive forces that will oppose an object's motion along it. This force comes from the deformations that occur in the surfaces as rolling occurs, and also applies to mounts that are padded. Typically, physicists illustrate friction with a ball rolling across a field, but friction can also be illustrated by the flexing that a rolling force would exert on the surface of a soft mount (Morton and Hearle 1962).

Table 2 demonstrates empirical results regarding the impact of friction on different surfaces that are commonly used to mount artifacts. Each test surface had the same thickness, to keep the field distance equal. The results show that a soft, rough surface has more holding power than does a hard, smooth surface. In these tests, the soft, rough surface could hold more than double its own weight.

Table 2: Friction tests

	N42, disk ½" x ⅛" thick with 22 gauge steel	Results
Hard surface test	A 4-ply mat board covered with a plain-weave cotton fabric. Gap thickness of 1⁄16" (0.067) (1.5 mm)	Was able to hold 3 oz (85 g). Fell when adding the fourth, 1 oz (28 g) weight
Soft surface test	Two thin layers of needle-punch felt with a plain-weave cotton fabric. Gap thickness of 1/16" (0.067) (1.5 mm)	Was able to hold 113 g. Fell when adding the fifth, (28 g) weight
Hard smooth surface test	A 4-ply mat board covered with Polyester film. Gap thickness of 1⁄16" (1.5 mm)	Was able to hold 2 oz (57 g). Fell when adding the third, 1 oz (28 g) weight
Soft rough surface test	A thin layer of needle-punch felt with a top layer of Polar-fleece fabric. Gap thickness of 1⁄16" (1.5 mm) with a cotton layer on top	Was able to hold 5 oz (142 g). Fell when adding the sixth, 28 g weight

Another quality to consider when choosing gap materials is loft. The 'loft' is the amount of curvature that an artifact is required to respond to. Conservators often prepare a soft surface for an artifact to rest on; numerous materials are used for this, as discussed earlier. Figure 4 (placements of materials with magnets) illustrates padding being placed below an artifact and below the magnet. It is possible for a padded layer to prevent the compression of an artifact. Selecting the right materials and placing them in thoughtful locations in the magnetic system can reduce compression, especially with magnetic point fastener systems. For instance, one can select a padding material softer than the artifact to reduce compression. The artifact will then have at least one direction it can move in; if it is surrounded by two hard surfaces, it will have nowhere to move and will become compressed. Adding a thin, soft surface to the underside of a magnet provides additional support to the artifact by absorbing compression (Figure 4).

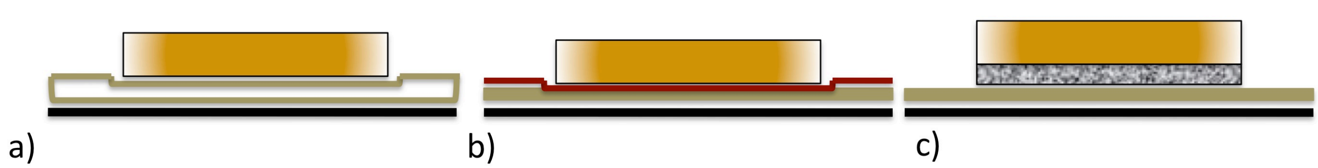

Figure 4: Cushioning and loft, schematic illustration, a) An artifact being compressed within the magnetic system; b) An artifact conforming to the magnet on a padded surface; c) An artifact with cushioning below the magnet.

Static Charge

Another potential aid to any magnetic system is electron exchange. Typically we as conservators work hard at removing static, especially with glazing. However the exchange of electrons simply happen when materials are in contact with one another. This has wider implications than just magnetic systems.

Static charge occurs when materials are in contact and then separated without any apparent rubbing or when materials are rubbed together. More static is created with rubbing than with simple contact and separation (Blythe 1974; Sello and Stevens 1984). When materials are in contact, electrical charges develop—which is usually something that a conservator seeks to avoid when working with collections. Electrical charges occur when bonds between electrons, which are established when materials come into contact, are then broken upon separation (Figure 5) (Carleton 1962) [1].

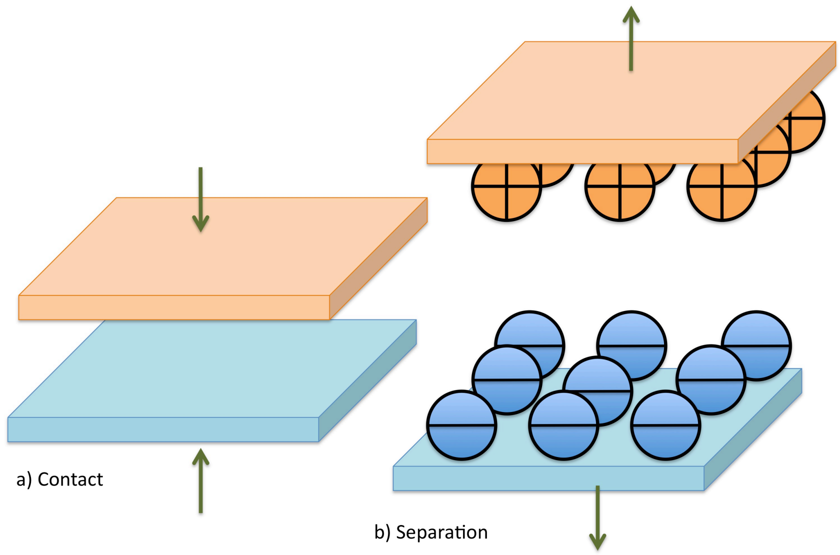

Figure 5: Schematic of electron exchange when two different materials are in contact and are then separated. The extent of this exchange is based on the materials placement on the Triboelectric series (Table 3).

All matter is composed of both positive and negative charges equally (Sello and Stevens 1984). The basis of electrostatic charging is a surface phenomenon in which the disruption of the condition of equilibrium is seen in the neutral atom (Commoner 1998). Electrons have a negative charge. When energy is applied to a material system, such as by friction or pressure, a small number of electrons can jump from one material to the other. The material whose atoms gain electrons will become negatively charged with static electricity, while the material that loses electrons will become positively charged. When two materials are in contact, a flow of electrons moves from one to the other, whether it is the same material or between two different types (figure 5).

Triboelectric Series

Materials that can gain or lose electrons are called triboelectric materials. The order of propensity to gain or lose electrons is called the triboelectric series (Sello and Stevens 1984). The series is based on the conductivity of the individual material. The level of charge is linked to a material's placement in this series (Table 3). It is the distance of the two materials from one another on the series that increases the charge effect rather than the specific location in the series. Therefore, if two materials in contact are neighbors on the scale, there is less exchange, as with cotton and steel. It also happens that steel, wool and cotton are all neutral. If they are far apart, no matter where on the scale, exchange occurs.

Table 3: Materials Order of the Triboelectric series

Charge	*Material*	*Notes*
+++	Air	
	Polyurethane foam	
	Hair	
	Nylon, Dry skin	Dry skin has the greatest tendency to give up electrons and becoming highly positive in charge.
	Glass	This is why TV screens collect dust on their surfaces.

	Acrylic, Lucite	This is why these materials are not used to frame pastels.
	Leather	
	Rabbit's fur	Fur is often used to create static electricity.
	Quartz	
	Mica	
	Lead	Surprisingly close to cat fur.
	Cat's fur	
	Silk	
	Aluminum	
	Paper	
	Cotton	Best for non-static clothes
	Wool	
NEUTRAL		
	Steel	Not useful for static electricity
	Wood	Attracts some electrons, but is almost neutral
	Amber	
	Sealing wax	
	Polystyrene	
	Rubber balloon	
	Resins	
	Hard rubber	
	Nickel, Copper	
	Sulfur	
	Brass, Silver	
	Gold, Platinum	
	Acetate, Rayon	
	Synthetic rubber	
	Polyester	
	Styrene and Polystyrene	Why packing peanuts seems to stick to everything.
	Plastic wrap	A.k.a. "Cling" wrap
	Polyethylene	
	Polypropylene	
	Vinyl, PVC	
	Silicon	
	Teflon	Teflon has the greatest tendency of gathering electrons on its surface and becoming highly negative in charge.
	Silicone rubber	
- - -	Ebonite	

How could a thick material hold more weight when it is used in the gap? This surprising result was found during workshops held by the author and during Billot's careful testing (Table 4). Many forces influence magnetic systems besides field distance. Field distance is affected by the size and shape of the magnet as well as the ferromagnetic material that is selected (Figure 3).

Using a Barrier Layer

A marked difference in the holding abilities of a magnetic system was found depending on whether a polyester film or a suede layer was placed in a gap (Spicer 2013, 2016, 2017b). In the Billot (2016) study (Table 4), the range of possible gap materials that could be used between 24-gauge steel and two magnets of the same size but different grades (disc-shaped ½" x ⅛" thick; 13 mm x 3 mm) was tested. The control was a configuration of the system with the magnet in direct contact with the steel. Each of the other samples was a single layer of the specific material. The tables below show the various weights, in grams that could be supported.

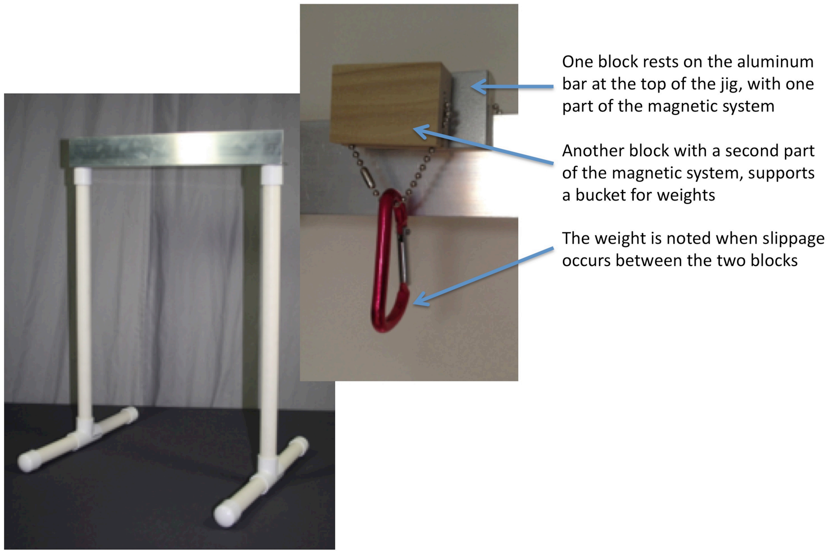

Figure 6: The jig set-up used for testing.

As expected, when organized by the amount of weight they held, the gap materials appear in the order of their thicknesses with the exception of the ultra-suede, a material similar in thickness to cotton twill tape. Polyester batting that is many times thicker than twill tape also placed higher in the table. Clearly, surface characteristics are a factor, but the material's type of fiber also plays a significant role. Polyester film presents a very slick surface, which increases the possibility for slippage, whereas the two other polyester materials have some texture.

Clearly, an exchange of electrons between steel and polyester created cohesion between the materials' surfaces. The fascinating aspect of using these materials is that the thicker ultra-suede allowed the magnetic system to hold more. The increase in magnetic strength created by the ultra-suede was relatively small, but the test demonstrates that its added affect is significant enough to impact a practitioner's decision about what materials to use.

Table 4: Various materials tested (Billot 2016)

Comparison of the two magnets (1/2" x 1/8" disc; 13 mm x 3 mm.)					
	Thickness (in.)	N42		N52	
		g	oz	g	oz
Control	0	318 g	11.21 oz	342 g	12.07 oz
Polyester film	0.003	307	10.83	293	10.34
Tissue paper	0.0036	240	8.47 oz	271	9.54
Cotton muslin	0.011	214	7.6	236	8.31
Cotton twill tape	0.02	209	7.37	224	7.9
Polyester ultra-suede	0.025	317	11.19	344	12.13
Polyester batting	0.095	214	7.54	231	8.13

Ranked in the order of weight held (grams)				
Material in Gap	**N42**		**Material in Gap**	**N52**
Control	318 g	0	**Ultra-suede**	344 g
Ultra-suede	317	-0.3 %	**Control**	342
Polyester film	307	-3 %	**Polyester film**	293
Tissue paper	240	-24 %	**Tissue paper**	271
Muslin	214	-33 %	**Muslin**	236
Polyester batting	214	-33 %	**Polyester batting**	231
Twill tape	209	-34 %	**Twill tape**	224

How Polyester Affects the Magnetic System

Several magnetic systems found used a polyester film, often to prevent one material from transferring to another, or artifacts from being scratched or marked. In a magnetic system, the polyester film's smooth surface works counter to the magnet's holding power. In addition, the applied nickel-copper coating on neodymium magnets is very durable in order to protect the magnet from corrosion.

Polyester film is used at the Musée du quai Branly due to the questionable coating on the custom-shaped magnet (Billot 2016). Little is known about the coating except that it is not standard nickel coating, and some practitioners have seen the coating cause rust staining.

With this in mind, what is the effect of polyester film if not needed as a barrier? Can the position in the series counter the smoothness of film? What force is more powerful, the location on the Triboelectric series or the friction coefficient? Plenary tests were performed on various ways of layering polyester film with barkcloth. The sequence of gap layers tested are illustrated in Figure 7 and identified in the table's first column.

Figure 7: Four methods for layering materials within a magnetic system; a) Gap material between steel and the nickel coated magnet; b) Gap material next to steel and synthetic film next to the magnet; c) Synthetic film next to steel and gap material next to the magnet; and d) Gap material sandwiched between two layers of synthetic film.

Using polyester film and polyethylene Tyvek with Barkcloth

In all tests, the steel was in a stationary position on the jig while the nickel-coated neodymium magnet was connected to the weights (Figure 6) (Spicer 2013, 2019). All tests used 24-gauge steel and a N42, ½" disc x 1/8" thick magnet. Different layering materials were found to perform distinctly, because steel and nickel are in different locations on the triboelectric series; steel is neutral, while nickel is further down the series (Figure 7 – layering). The differences in results, though small, are sufficient to demonstrate the influence that materials can have.

The beauty of tests with layering b) and c) in Figure 7, is that they have same gap distance, allowing the focus to be on the amount of the electron exchange relationship among various materials in contact. Some of the test results cited below are counterintuitive to more established museum thinking.

First the barkcloth alone, then with polyester next to the nickel-coating, next to the steel and then a full sandwich. It turns out that when the polyester film is next to the steel the holding strength is increased by 12% and when next to the nickel it is -27% (Table 5a).

Another commonly used material is Tyvek, a polyethylene. Here when place next to the nickel-coating magnet, a 31% increase was found (Table 5b). As that the best holding strengths were with these materials independently - - What about when they are used together? It seems that the 'gap' or filed distance became the overwhelming component that over rides the electron-exchange' strength.

A sample of barkcloth was tested with the layering as above with commonly incorporated materials, polyester film and polyethylene Tyvek. Interestingly the test with polyester film positioned behind, was able to hold more weight (Tables 6 and 3a-c). Tyvek performed the opposite. Note that polyethylene is further away on the series than polyester.

Using polyester film and polyethylene Tyvek with Barkcloth

Table 5a: Polyester film layer with Barkcloth

24-Gauge / N42, ½" x 1/8" disc.	Gap materials	Thickness of the materials (inches)	Weight held	Rank order	Percent change
a)	Barkcloth	0.005"	255 g / 9 oz	3	0
b)	Barkcloth - **Polyester film**	0.008	185 g / 6.5 oz	4	-27 %
c)	**Polyester film** - Barkcloth		285 g / 10 oz	**1**	**12 %**
d)	**Polyester film** - Barkcloth - **Polyester film**	0.011	275 g / 9.7 oz	2	8 %

Table 5b: Tyvek layer with Barkcloth

24-Gauge / N42, ½" x 1/8" disc.	Gap materials	Thickness of the materials (inches)	Weight held	Rank order	Percent change
a)	Barkcloth	0.005"	255 g / 9 oz	3	0
b)	Barkcloth - **Tyvek**	0.013	335 g / 11.8 oz	**1**	**31 %**
c)	**Tyvek** - Barkcloth		240 g / 8.5 oz	4	-6 %
d)	**Tyvek** - Barkcloth - **Tyvek**	0.021	260 g / 9.2 oz	2	-2 %

These tests indicate that the combinations with the strongest holding power were opposites. What if these materials are used together simultaneously (Figure 7)?

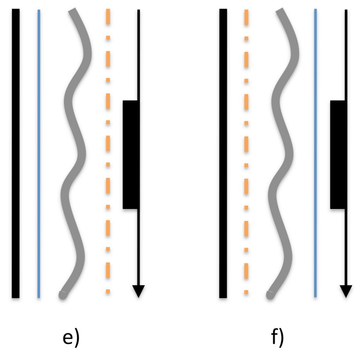

Figure 8: Gap material layering with polyester film and polyethylene, Tyvek, e) Polyester film between the steel and barkcloth and polyethylene between barkcloth and the nickel coating of the magnet; f) Polyethylene between the steel and barkcloth and polyester film between the barkcloth and the nickel coating of the magnet.

Table 6 compares the highest weight holding powers from Tables 5a and b along with the situation when these layering materials are positioned in their most efficient locations (Figure 8). Test e) does show increased holding strength over test c). However, the gap distance begins to become the dominant component, overriding the electron exchange strength. The amount of weight held is not significantly more.

Table 6: Tyvek and polyester film layers with Barkcloth

24-Gauge / N42, ½" x 1/8" disc.	Gap materials	Thickness of the materials (inches)	Weight held	Rank order	Percent change
b)	Barkcloth – **Tyvek**	0.013"	335 g / 11.8 oz	**1**	**0 %**
c)	**Polyester film** - Barkcloth	0.013	285 g / 10 oz	3	-15 %
e)	**Polyester film** - Barkcloth - **Tyvek**	0.016	315 g / 11.1 oz	2	-11 %
f)	**Tyvek** - Barkcloth - **Polyester film**	0.016	270 g / 9.5 oz	4	-24 %

Conclusion

This investigation of barkcloth mounting lead to several findings. First, barkcloth is made of a low resiliency rated fiber that is well beaten during manufacturing, in essence 'pre-compressed' rendering it less vulnerable to further compression unlike art on paper artifacts. All of the mounting methods found, used a point-fastener type of magnetic system (Table 7).

It is the consideration of the use, placement and type of synthetic material that can aid in a magnetic system. Initially used specifically as a barrier material or means to remove the individual magnet from the surface, it appears to offer the possibility of adding to the holding power of the magnetic system, one in which electron exchange can be established.

This possibility is based on the artifact materials' placement on the triboelectric series. When far down the series with nickel, its use is beneficial. Yet, as seen with barkcloth its use appears to lower the strength of the magnetic system. Nevertheless, considering results from the full group of tests, taking into consideration both the thickness and field distance of the system is critical.

The unique ways that polyester, nylon and other synthetics impact magnetic systems can only be explained by surface characteristics, frictional forces, electrical changes and resiliency. For instance, the reason paper is 'noticeably' compressed is because of its low resistance characteristics. Understanding these phenomena always involves calling on a mixture of physics and textile science. However, more research is needed to fully understand all of the forces that are present when materials come into contact.

ACKNOWLEDGMENTS

I first want to extend my thank yous to those who organized and offered me the opportunity to present at the Barkcloth conference. I want to thank both Mary Ballard, senior textiles conservator, Smithsonian Museum Conservation Institute, and Lucy Commoner, conservator emerita, Cooper Hewitt, for their direction toward static electricity as a plausible contributing factor to a mystery. Thanks also to Marion Billot who performed the careful tests, in a very systematic and scientific manner, while an intern at the Musée du quai Branly, and her advisor Eleonore Kissel, conservator. Ms. Billot's tests confirmed the results of the strong holding power of the polyester ultra-suede within a magnetic system (Spicer 2014). I also want to thank all of the conservators and other museum professionals who generously shared their magnetic systems.

NOTES

[1] An electric current is the movement or exchange of electrons from one material to another. All materials are composed of atoms with a surface phenomenon whereby there are an equal number of positive and negative charges (Sello and Stevens 1984). When energy is applied to materials in contact, such as through friction or pressure, a small number of electrons can jump from one material to the other (Figure 4). Both positive electrons, known as positrons, and negatively charged electrons flow continuously in both directions. The basis of the surface phenomenon of electrostatic charging is that the equilibrium condition of the neutral atom becomes disrupted, allowing electrons to move more freely (Commoner 1998). The material that gains electrons becomes negatively charged while the material that loses electrons becomes positively charged.

Unlike magnets, which attract only those materials that can be magnetized, a much larger range of materials can hold an electrical charge. In addition, a charged body can lose some, if not all, of its charge when touched by a neutrally charged body, while a magnet will not lose any of its efficacy from being touched.

Since ancient times, it has been known that rubbing certain materials, such as amber, would enable them to lift light objects of certain materials (Feynman *et al*. 1964), such as bits of papyrus, straw, and dust. In addition, sparks could be created if amber were rubbed long enough. At the time, the attraction was believed to be magnetic. Gilbert's work in the year 1600 determined that lodestone was magnetic and that this was distinct from static electricity produced by rubbing amber. Thus, Gilbert coined the word electricus, from the Greek word λεκτρον, for "amber," to describe the attraction between small objects that exists after being rubbed. Of course, the story eventually came full circle when later scientists found the link between magnetism and electricity (Feynman *et al*. 1964).

[2] The presence of moisture in the air limits any charge buildup on a surface. Therefore, the higher the relative humidity of the environment, the less static potential a material will have (Suh *et al*. 2010). In this way, moisture serves as a ground and reduces the static charge, thereby increasing the conductivity of the material (Commoner 1998). Natural fibers tend to be hydrophilic, or water absorbing, and are more influenced by the environment, whereas most synthetics are hydrophobic, or water resistant, and are therefore less influenced by environmental conditions and more readily build up a charge.

[3] Industries of all types are concerned with the buildup of static electricity, such as those that manufacture finely tuned, sensitive electronics, flammable vapors and dust, and printing materials, to name a few. Hospital operating rooms also work to minimize static electricity.

Table 7: **Comparison of Barkcloth Magnetic Mounting Systems (The gap layers, if included, are listed in order that they appear between the magnet (*) and the ferromagnetic material (**in bold**).) (Spicer 2019)**

	Size of Barkcloth	Magnet (Shape, Grade, Size)	Ferromagnetic material	Spacing and location of the magnet	Covering of the magnet	Gap materials
Megan Dean-Jones (2006) Australian Museum, Australia	Range of sizes and types	Disc-shaped	Flexible magnet	Unknown; along the upper edge	Unknown	*, polyester film, *artifact*, display fabric, polyester film, **flexible magnet sheet**
Éléonore Kissel (2016) Musée du quai Branly, France	Range of sizes and types	Custom-shaped magnet	Case back, steel	Magnets spaced four at the upper edge and five at each side	Painted	*, polyester film, *artifact*, **steel**
Anne Peranteau (2012) Museum of New Zealand/ Te Papa Tongarewa, NZ	197 x 160 cm W	Disc-shaped, N42, 25 mm x 2 mm	Steel strip, powder-coated with pre-drilled holes	35 – 40 cm; along the upper edge	Acrylic toned paper, secured with PVA	*, polyester film, *artifact*, polyester film, **steel**
Ann Frisina (2013) Minnisota Historical Society, USA	Barkcloth	Disc-shaped (grade is not known), 9 mm x 5 mm thick	1" wide (2.5 cm) Foil attached to the mount with polyester batting and display fabric covering	Unknown; along the upper edge	Covered with paper, toned with acrylic	*, ***artifact***, display fabric, polyester batting, **foil**
Roswitha Zobl (2013) Weltmuseum – World-museum, Vienna	Range of sizes and types	Disc-shaped (grade and size unknown)	Screws recessed into a wooden support panel	Unknown; along the upper edge	Painted	*, Hostaphan (polyester film), *artifact*, Molleten, display cotton fabric, **screw head**
Ana Carolina Delgado Vieira (2016) Museu de Arqueologia e Etnologia, MAE/USP, Brazil	Ticuna, 112 x 92 cm W	Disc-shaped (grade and size unknown)	Steel sheet, with wrapped cotton	20-30 cm; along the upper edge and sides, five along the upper edge and two at each side; 9 total	Covered with photography paper image with PVA	*, Tyvek, *artifact*, cotton, **steel**
Monique Pullan (2017) British Museum, UK	115 cm W	Disc-shaped, 15 x 2 mm	Stainless steel (430 ferritic), 0.9 mm	20 cm; along the upper edge and sides	Covered with toned tissue, with bottom layer of thin knitted cotton fabric	*, flannel, display fabric, *artifact*, knitted cotton **stainless steel**
Liz Wild and Rhiannon Walker (2017) Queensland Art Gallery, Australia	Barkcloth	Block-shaped, N 38, 10 mm x 3 mm x 1.5 mm	5 cm wide steel bar, screwed to the wall horizontally	Unknown; along the upper edge	Barkcloth over archival paper tape	*, *artifact*, paper, **steel**

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