Recent Advances in Barkcloth Conservation and Technical Analysis

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Mounting Barkcloth with Rare Earth Magnets: Compression, Fibre Resilience and Material Choice

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Introduction

The approach used to mount barkcloth has long been dictated by the experience of the practitioner, usually either a paper or a textile conservator. Barkcloth objects belong in a broad class of artefacts, encompassing both flat and three-dimensional artefacts, made using heterogeneous plant material and decorative techniques, and variable in thickness and size: features that enhance the challenge. The non-woven quality of the material results in an artefact that is neither textile nor paper and typically does not lie flat, making standard methods inadequate to address all of the needs of barkcloth artefacts.

When *The Conservation of Artifacts Made from Plant Materials* was published, the authors recommended a textile mounting method with a hook and loop fastener such as Velcro® (Florian et al. 1990). Other conservators at that time suggested the use of an attached sleeve to the back of the barkcloth for a rod, or pressure clamps or 'U'-shaped Plexiglas clips (Figure 1; Wolf 1983; Norton 1984; Dietz and Bessant 1996; Holdcraft 2001; Dean-Jones 2006). The non-woven, paper-like quality of barkcloth has led practitioners to treat it as if it is paper. Japanese tissue hinges or a sleeve have also been secured to the backside of the upper edge of the barkcloth (Barton and Weik 1994; Lennard et al. 2017).[1] Each of these methods has drawbacks; the artefact must be sufficiently strong and stable, and include some type of attachment along the upper edge which must be secured to the object. However, compared to using nails and tacks, these mounting methods do hold many advantages.[1]

As this material did not have a standardized mounting system, magnets have become the standard tool and an increasingly viable option. However, details of few magnetic systems have been published or fully documented. Magnetic systems for mounting barkcloth were thus collected by the author. Those systems include a point fastener method often used for display, with the artefact positioned between the elements of the magnetic system (known as 'the gap') (Dean-Jones 2006; 2009; Winner 2009; Kramer 2014; Bastian et al. 2015; Zobl 2015; Meller in this volume).[2] The most commonly mentioned magnets were disc-shaped in a wide range of sizes: 8-25 mm in diameter and 1-5mm thick (Spicer 2019a). This method is an attractive solution as most

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[1] Personal communication with M. Pullan, object conservator, British Museum, London, UK, 2017.
[2] Personal communication with: A. Peranteau, Textile conservator, Museum of New Zealand/Te Papa Tongarewa, Wellington, New Zealand, 2013; N. dela Fuente, Conservation assistant, Bernice Pauahi Bishop Museum, Honolulu, HI 2014; I. Kirkwood, Textile conservator, National Museums of Scotland, Edinburgh, Scotland, 2016; Vieira, A. Conservator, Museu de Arqueologia e Etnologia, MAE/USP, Sao Paulo, Brazil, 2016; E. Kissel, Conservator, Musee du quay Branly, Paris, France 2017; R. Hand, Collection Manager, Museum of Archaeology & Anthropology, University of Cambridge, Cambridge, UK 2018; K. Miller, Textile conservator, Victoria and Albert Museum, London, UK 2018; L. Wild and R. Walker, Conservators, Queensland Art Gallery, Queensland, Australia 2018.

Figure 1. An early mounting system with a metal rod held in a cotton sleeve, with a single machine-stitch row to the upper edge of the barkcloth. © Spicer.

Figure 2. Cross section of the Mag Slat. The steel is inserted into a sleeve attached to the upper edge of the reverse-side of the artefact. The lower edge of the steel is supported by the lip of the aluminium ‘L’ and the counter-sunk disc-shape magnets keep the steel vertical. This is an example of large area pressure. © Spicer.

barkcloth is not flat, and the magnets can be randomly placed on the surface of the artefact. Alternatively, mounting systems support the barkcloth along the entire upper edge of the artefact, referred to as 'large area pressure.' An example of such a magnetic system is the Mag-Slat in which a sleeve is created for a steel sheet (Figure 2; Spicer 2013a; 2016; 2019a; Spicer and Dunphy 2015). The lower lip of the aluminium wall support carries the steel, while the magnets fastened to the aluminium hold the steel sheet in a vertical position. All documented magnetic systems for mounting barkcloth collected by the author report using a point fastener method with the artefact positioned within the magnetic system's gap as an alternative to using a sleeve (Dean-Jones 2006; 2009; Winner 2009; Kramer 2014; Bastian et al. 2015; Zobl 2015). Let us consider 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, whether for barkcloth or any other artefact, 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; EMAJ 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; 2013b; 2016; 2017; 2019a).

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 3). It is important to know when designing a system that the magnetic behaviour of a two-part system is distinct from that of a three-part system (Spicer 2016; 2017; 2019a).

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 adjacent 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 artefact. Magnets can then be added or subtracted based on the amount of strength needed to support the artefact. Typically, the artefact 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.

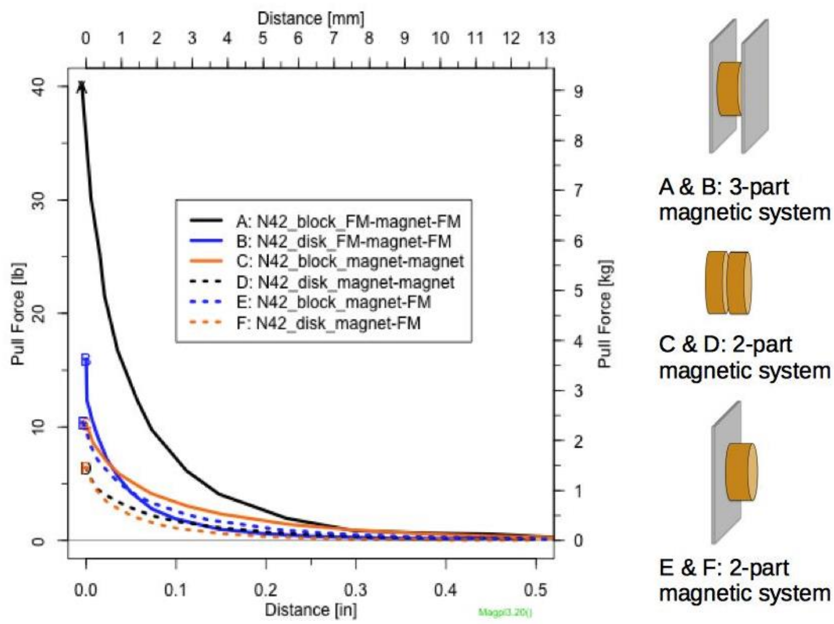

Figure 3. Field strength vs. distance relationships for two different shapes of magnets with the same grade: one block-shaped (N42, ½” x ½” x ⅛” thick) and another disc-shaped (N42, ½” diameter ⅛” thick) with another similarly sized magnet (C & D) or ferromagnetic material (E & F); or sandwiched between ferromagnetic materials (A & B). © Spicer, adapted from https://www.kjmagnetics.com/calculator.asp.

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 (Figure 2; Spicer 2016; 2017; 2019a). It is not the magnet alone that creates the larger magnetic field; the magnet, in conjunction with a larger element, creates the increased pressure. A major benefit of using large area pressure methods is that a larger proportion of the artefact is secured, which lowers the internal stresses that can be caused by point-fasteners and decreases the likelihood of damage. 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 increases, the strength of the pull force decreases dramatically - and it happens rapidly, whether a two- or three-part magnetic system. Therefore the layers of materials within the gap can be critical to the behaviour of the system.

Resilience

Recall that an unresolved question is compression.[3] It appears that barkcloth is less likely to experience compression than is paper, although both media are cellulosic. Compared to proteinaceous fibres or polyester, cellulose is rated as a low-resilience fibre. The different compression potentials of these materials is probably due to the different ways in which paper and barkcloth are prepared. Resilience describes a fibre's ability to return to its original shape after compression. 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 fibres are rated on a scale of resilience (Table 1; Ballard 1995). Fibres that show good tensile recovery also tend to have high compression recovery (Morton and Hearle 1962; Spicer 2019b). Cellulosics as a group have low resilience, as 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 fibres in slurry, water is shaken out and allowed to dry under felts. Even as the layers of paper and felts are held under pressure while drying, the paper sheets retain a lofty structure.

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

Table 1. General resilience ranking by material.

Barkcloth is also a cellulose, but in preparation it is repeatedly beaten to become the flexible and strong material it is. Of course, further scientific studies are needed to fully confirm this statement. However, these two examples indicate that distinct manufacturing methods can lead to distinct physical properties. Of course, an artefact's previous use — either historically or while in a museum — will also have an effect on the extent of its compression.

Padded surfaces

[3] Personal communication with M. Tamura, conservator, Science Museum, London, UK, 2018.

Several conservators mounting barkcloth prefer to create a soft surface on the mount (Zobl 2015).[4] Both hard and soft surfaces have resistive forces (friction) 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; Barker 2005; Spicer 2019a). Rolling forces require additional energy to begin movement. Table 2 demonstrates empirical results regarding the impact of friction on different surfaces commonly used to mount artefacts. Each test surface had the same thickness, so that the field distance remained 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 due to the behaviour of rolling friction.

	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)	Supports 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)	Supports 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)	Supports 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	Supports 5 oz (142 g). Fell when adding the sixth, 28 g weight

Table 2. Friction tests comparing various surfaces showing the influences of rolling friction. Tests were performed with a jig, while adding 1oz increments of weights (1oz equals 28.35g) (see Figure 6; Spicer 2016; 2019a).

Another quality to consider when choosing gap materials is loft. The loft is the amount of curvature that an artefact or other material is required to respond to. Conservators often prepare a soft surface for an artefact to rest on; numerous materials are used for this, as indicated above. Figure 4 illustrates padding being placed either below an artefact or below the magnet. Selecting the

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[4] Personal communication with A. Frisina, Textile conservation, Minnesota Historical Society, St. Paul, MN, US; M. Pullan, object conservator, British Museum, London, UK, 2017.

correct materials and placing them in appropriate 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 artefact to reduce compression. The artefact will then have at least one direction it can move in whereas, 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 artefact by absorbing compression.

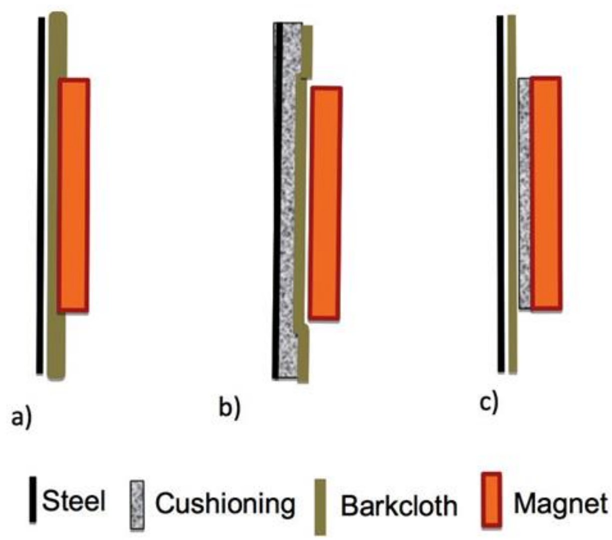


Figure 4. Schematic illustration of cushioning and loft: a) barkcloth being compressed within the magnetic system; b) barkcloth conforming to the magnet on a padded surface; c) barkcloth with cushioning below the magnet. © Spicer.

Static charge and the triboelectric series

Another potential aid to any magnetic system is electron exchange. The exchange of electrons occurs when materials are in contact with one another. Electrical charges, or static, occur when bonds between electrons, which are established when materials come into contact, are then broken upon separation (Figure 5; Carleton 1962; Allen 2000; Spicer 2018a; 2018b; 2019a).[5]

[5] 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 5). 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.

More static is created when materials are rubbed together than with simple contact and separation (Blythe 1974; Sello and Stevens 1984; Ioanid et al. 2005). This is usually something that a conservator seeks to avoid when working with collections, especially with glazing (Norton and Cronholm 2005; Margariti and Loukopoulou 2016; Jenkins 2018; Garcia-Vedrenne and Thompson 2019).

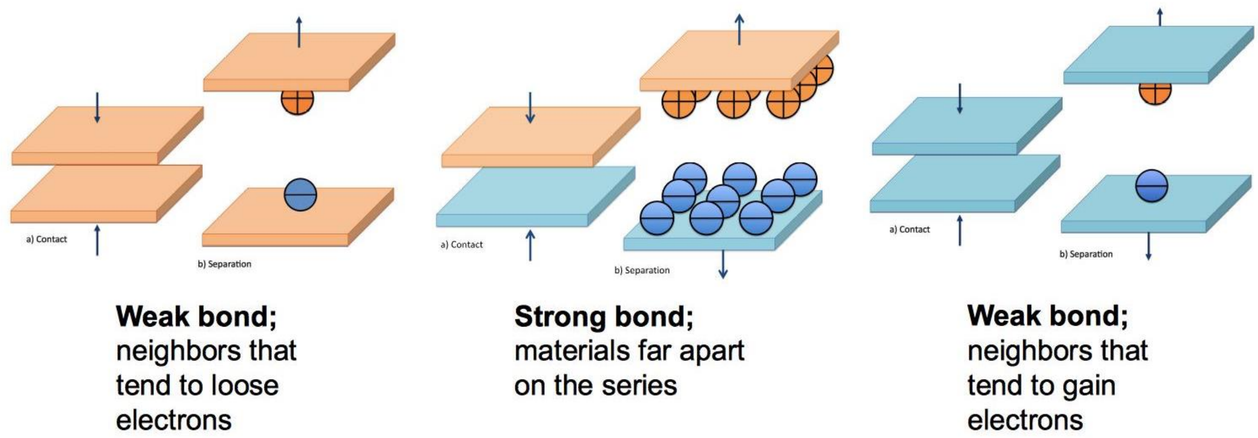


Figure 5. Schematic of electron exchange when two different materials are in contact and are then separated. The extent of this exchange and ability to create weak or strong bonds is based on the materials' placement on the triboelectric series, shown in Table 3. © Spicer.

All matter is composed of both positive and negative charges equally. 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; Spicer 2019a). 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). The more electrons that are shared the stronger the bond between the materials. When mounting artefacts, one wants the most electron sharing (Spicer 2019a).

The presence of moisture in the air limits any charge build-up 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 fibres 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.

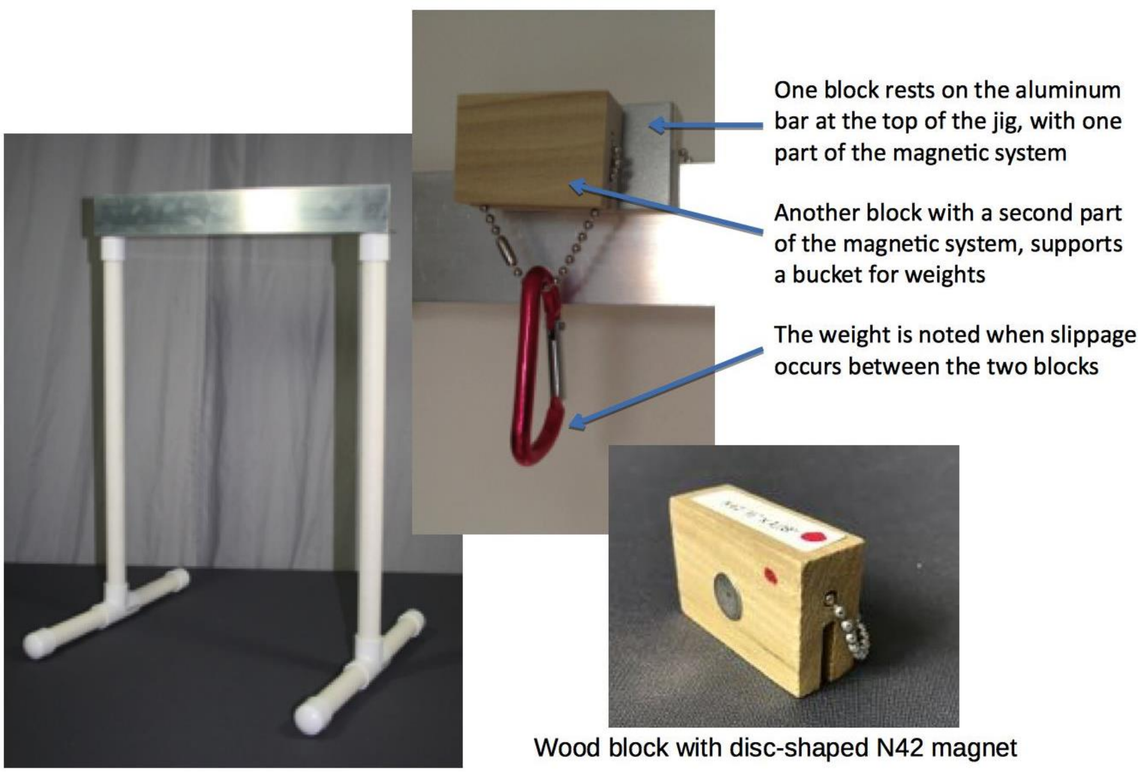
Charge	Material	Common Museum Uses	Notes
+ + + Tends to **lose** Electrons	Air		
	Polyurethane foam		
	Hair		
	Nylon Dry skin	**Dukeries' Net**	Dry skin has the greatest tendency to give up electrons and becoming highly positive in charge.
	Glass		This is why TV screens collect dust on their surfaces.
	Acrylic Lucite	**Plexiglas**	
	Leather	Artifact	Proteins commonly located at the upper area of the table
	Rabbit's fur		Fur is often used to create static electricity.
	Quartz		
	Mica		
	Lead		Surprisingly close to cat fur.
	Cat's fur		
	Silk	**Backing Fabric;** Artifact	
	Aluminum	**Support Panel**	
	Paper	Artifact	
	Cotton	**Backing Fabric;** Artifact	Best for non-static clothes;
Neutral	Wool	Artifact	
	Steel	**Ferromagnetic Material**	Not useful for static electricity
- - - Tends to **gain** Electrons	Wood		Attracts some electrons, but is almost neutral
	Amber		Greek word for amber is 'electricus'
	Sealing wax	**Museum Wax**	
	Polystyrene		
	Rubber balloon		
	Resins		
	Hard rubber		
	Nickel		
	Copper		
	Sulfur		
	Brass Silver		
	Gold Platinum		
	Acetate Rayon	Artifact	
	Synthetic rubber		
	Polyester	**Batting; Mylar Film; Backing Fabric;** Artifact	
	Styrene Polystyrene		Why packing peanuts seems to stick to everything.
	Plastic wrap		A.k.a. "Cling" wrap
	Polyethylene	**Ethafoam**	
	Polypropylene	**Tyvek**	
	Vinyl PVC	Artifact	
	Silicon		
	Teflon	**Plumbers Tape**	Teflon has the greatest tendency of gathering electrons on its surface and becoming highly negative in charge.

Table 3. The 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; Mahmoud and Ibrahlm 2016; Spicer 2019b). 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 neighbours on the scale, there is less exchange and a weaker bond, as with cotton and steel. If they are far apart, no matter where on the scale, greater exchange occurs and a stronger bond is created. Steel, wool and cotton are all neutral, being located at the centre of the series.

Using a barrier layer

Field distance is affected by the size and shape of the magnet as well as the ferromagnetic material that is selected (Figure 3). In addition, many forces influence magnetic systems besides field distance. How is a thick material like ultra-suede, used in the gap, able to support more weight? This surprising result was found during workshops held by the author and during Billot's careful testing (Spicer 2013; 2016; Billot 2016).



Wood block with disc-shaped N42 magnet

Figure 6. The jig set-up used for testing. A stationary block of 24-gauge steel is supported on the jig, while another block has a N42 disc-shape 1/2” x 1/18” neodymium magnet incorporated. © Spicer.

In Billot’s 2016 study a marked difference in the holding abilities of a magnetic system with barkcloth was found depending on whether a polyester film, like Melinex® or Mylar®, or a suede layer was placed in the gap (Spicer 2013b; 2016; 2017b). A range of possible gap materials that could be used between 24-gauge steel and two magnets, N42 and N52, of the same size (disc-shaped ½” x ⅛” thick; 13 mm x 3 mm) but different grades, was tested, using a single layer of the specific material. In the control, the magnet was in direct contact with the steel. Weights were added in small increments, until the wooden block fell and the system failed. Table 4a shows the various weights that could be supported. Figure 6 shows the testing equipment.

As expected, when organized by the amount of weight they held, the gap materials appear in order of their thickness with the exception of the ultra-suede, a material similar in thickness to cotton twill tape (Table 4b). Polyester batting that is many times thicker than twill tape was also placed higher in the table. Clearly, surface characteristics are a factor, but the material’s fibre type also plays a significant role. Polyester film (such as Mylar®) presents a very slick surface, which increases the possibility for slippage, whereas the two other polyester materials have more 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 weight. The increase in magnetic strength created by the ultra-suede was relatively small, but the test demonstrates that its added effect is significant enough to impact a practitioner’s decision about which materials to use for both barrier and padding (Spicer 2019c).

Comparison of the two magnets (1/2” x 1/8” disc; 13 mm x 3 mm.)					
		N42		N52	
	Thickness (in.)	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	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

Table 4a. A comparison of the weight held by two different magnet grades, N42 and N52, with a range of materials in the gap between them (Billot 2106).

Ranked in the order of weight held (grams) (1/2” x 1/8” disc; 13 mm x 3 mm.)					
Material in Gap	Thickness (in)	**N42**	Relative percent change	**Material in Gap**	**N52**
Control	0	318 g	0	**Polyester Ultra-suede**	344 g`
Polyester Ultra-suede	0.025	317	-0.3 %	**Control**	342
Polyester film	0.003	307	-3 %	**Polyester film**	293
Tissue paper	0.0036	240	-24 %	**Tissue paper**	271
Muslin	0.011	214	-33 %	**Muslin**	236
Polyester batting	0.095	214	-33 %	**Polyester batting**	231
Twill tape	0.02	209	-34 %	**Twill tape**	224

Table 4b. Gap materials listed in order of the amount of weight held by two different magnet grades, N42 and N52. The stronger N52 grade was able to hold more weight with the thick ultra-suede than even with no gap material.

Using polyester film and polyethylene Tyvek® with barkcloth

Several magnetic systems found used a polyester film, often to prevent one material from transferring to another, or artefacts from being scratched or marked. Polyester film is used at the Musée du quai Branly as a barrier layer between the magnet and the artefact, due to the questionable coating on the custom-shaped magnet (Billot 2016). Neodymium magnets have an applied nickel-copper coating which is critical to their performance ; it is very durable in order to protect the magnet from corrosion. In a magnetic system, the polyester film’s smooth surface works counter to the magnet’s holding power. 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? Which force is more powerful, the location on the triboelectric series or the friction coefficient? Tests were performed on various ways of layering polyester film with barkcloth. The sequence of gap layers tested is illustrated in Figure 7 and identified in the first column of Table 5a below.

In all tests, the steel was held in a stationary position on the jig while the nickel-coated neodymium magnet was connected to the weights (Figure 6; Spicer 2013b; 2019a). Small increments of weight were carefully and systematically added. The weight was calculated at the point of complete failure of the system (Spicer 2014; 2016; 2019a). Each test was performed three times. All tests used 24-gauge steel and a N42, ½” disc x 1/8” thick nickel-coated magnet. The samples tested were composed of: first the barkcloth alone, second with polyester next to the nickel-coated magnet, third with polyester next to the steel and fourth, a full sandwich (Figure 7). 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. The differences in results, though small, are sufficient to demonstrate the influence that materials can have. The beauty of tests b) and c) is that they have the same gap distance, allowing the focus to be on the electron exchange relationship among the various materials in contact. Some of the test results cited below are counterintuitive to more established museum thinking. Results showed that when the polyester film is next to the steel, the holding strength is increased by 12% but when next to the nickel it is increased by 27% (Table 5a).

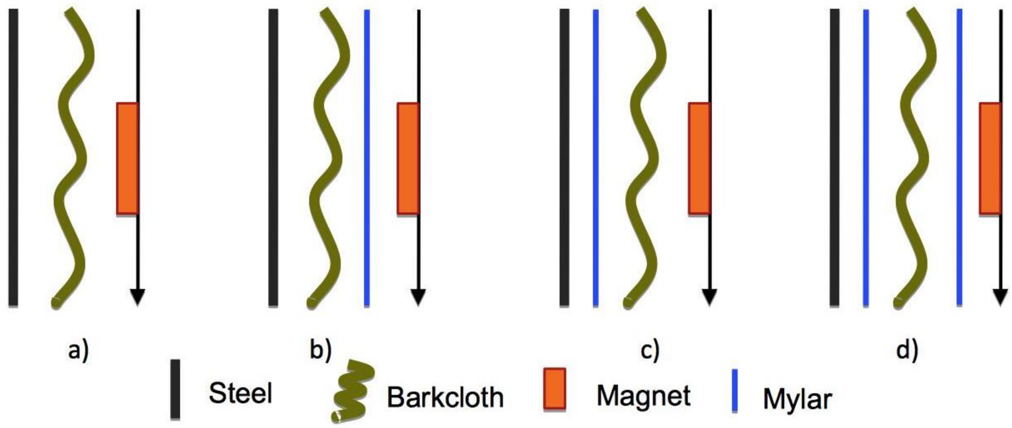


Figure 7. Four methods for layering materials within a magnetic system: a) barkcloth between steel and the nickel coated magnet; b) barkcloth next to steel and polyester film (Mylar®) next to the magnet; c) polyester film next to steel and barkcloth next to the magnet; and d) barkcloth sandwiched between two layers of polyester film. © Spicer.

24-Gauge / N42, ½" x 1/8" disc.	Gap materials	Thickness of the materials (inches)	Weight held	Rank order	Relative 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** - arkcloth	0.008	285 g / 10 oz	**1**	**12 %**
d)	**Polyester film** - Barkcloth - **Polyester film**	0.011	275 g / 9.7 oz	2	8 %

Table 5a. The weight held using a polyester film layer in different layering systems with barkcloth (see Figure 7). The final column shows the percentage increase in holding strength compared with barkcloth alone.

Another commonly used material is Tyvek®, a polyethylene. When Tyvek® was placed next to the nickel-coated magnet, a 31% increase in holding strength was found (Table 5b). Interestingly, test c), with polyester film positioned behind the barkcloth, was able to hold more weight (Table 5a) while Tyvek® could hold more weight when it was placed between the barkcloth and the magnet in test b) (Table 5b). The best holding strengths were with these two materials – and so we questioned what happened when they are used together. It appears that the 'gap' or filled distance becomes the overwhelming component that overrides the degree of electron-exchange (Table 6). A sample of barkcloth was tested with the different layers as above, with the addition of polyethylene Tyvek® (Figure 8).

24-Gauge / N42, ½" x 1/8" disc.	Gap materials	Thickness of the materials (inches)	Weight held	Rank order	Relative 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	0.013	240 g / 8.5 oz	4	-6 %
d)	**Tyvek®** - Barkcloth - **Tyvek®**	0.021	260 g / 9.2 oz	2	-2 %

Table 5b. The weight held using a Tyvek® layer in different layering systems with barkcloth (see Figure 7). The final column shows the percentage increase in holding strength compared with barkcloth alone.

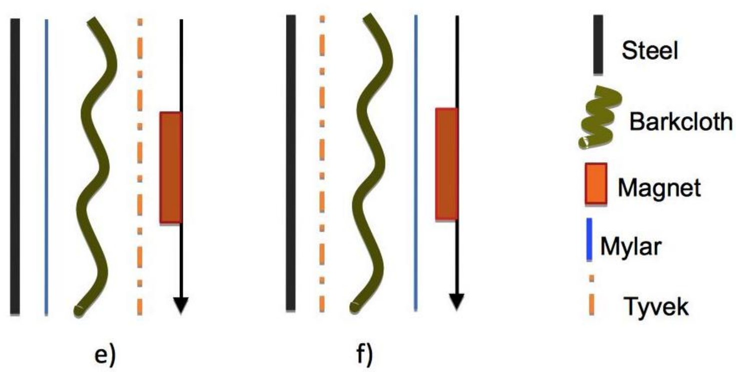


Figure 8. Barkcloth with both polyester film and polyethylene Tyvek® : e) polyester film between the steel and barkcloth and polyethylene between barkcloth and the nickel coating of the magnet; f) polyethylene between the steel and barkcloth and polyester film between the barkcloth and the nickel coating of the magnet. © Spicer.

Table 6 compares the highest weight holding powers from Tables 5a and 5b when these layering materials are positioned in their most efficient locations (as shown in Figure 7). Test e) shows increased holding strength over test c). However, the gap distance begins to become the dominant component, overriding the electron exchange strength, and the amount of weight held is not significantly higher.

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

Table 6. The weight held using polyester film and Tyvek® in different layering systems with barkcloth (see Figures 7 and 8).

Conclusions

This investigation of barkcloth mounting led to several findings. First, barkcloth is made of a low resilience rated fibre that is well beaten during manufacturing, in essence 'pre-compressed', rendering it less vulnerable to further compression, unlike art on paper artefacts. All of the mounting methods found, used a point-fastener type of magnetic system. To bring all of the above information together, one can say that the point-fastener has become the magnetic system of choice for barkcloth.

What suggestions can be made to improve the methods for mounting barkcloth with all of this combined information? These are a few ideas. This author has begun to lean towards the use of smaller sized magnets, spaced closer together. This has been less for reasons of support and more for improved aesthetics. As I have seen the increase in the uses of magnets in museums, I have found that once the magnet is an inch or larger in size they are quite visible even with the best camouflage. This can detract from the viewing of the artefact. For a low profile mount, I would suggest placing the magnets behind the barkcloth on the ferromagnetic material with the addition of stainless steel discs on the surface of the barkcloth, creating a three-part system.

Tests show the benefit of a padded mount. Not only can the padding help to support the undulations of barkcloth, but can also increase the holding power of a magnetic system due to rolling friction. Not all artefacts can be placed on a padded surface, but when it is appropriate it is yet another force available. Another take away is separating the aesthetic needs of camouflage from the potential of increasing the success of the magnetic system. With the use of the trioboelectic series a material positioned below the magnet, or ferromagnetic material on the surface, can enhance the holding power.[6] Yet, keep in mind the thickness of materials placed within the 'gap'. A point will be reached where the forces of the field distance will override any benefit of the electron-exchange.

Considering the use, placement and type of synthetic material can also aid in a magnetic system. Initially used specifically as a barrier material or as a means to remove the individual magnet from the surface, the addition of synthetic material appears also 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 artefact materials' placement on the triboelectric series. When far down the series, as with nickel, its use is beneficial. Yet, as seen with barkcloth, the presence of nickel 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 examining surface characteristics, frictional forces, electrical changes and resilience. 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.

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Gwen Spicer is a textile, paper, upholstery, and objects conservator in private practice. She earned her MA in Art Conservation from Buffalo State College, and has since taught and lectured around the world. In her private practice, she assists many individuals and organizations of all sizes with storage, collection care, and exhibitions, and has become known for her innovative conservation treatments. A recent project was overseeing of the inaugural textiles displayed at the National Museum of African American History and Culture in Washington, DC. She has received a Kress fellowship that enabled her to write the 2019 book on the use of magnets in conservation, *Magnetic Mounting Systems for Museums and Cultural Institutions*. She is a Fellow of AIC and the Flag Research Center.