matter

sean o'connell
2019

worlds of potential,
within various mundane substances,
as utilised in the creation of a great many things,
and herein explored through high voltage
discharge imaging

“If you don’t understand what is earthen, how do you understand what is heavenly?”

- Anton Josef Kirchweger, *The Golden Chain of Homer,* 1781.

worlds of potential

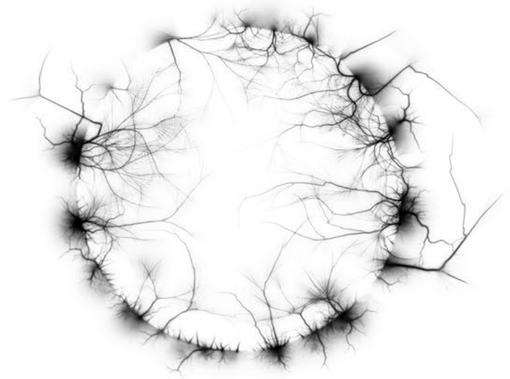
Matter is a tricky thing to define, because it surrounds us. It makes up our bodies and is continually replenished by food and breath. Through matter, we encounter the world. We touch, taste, see - we build, cut, grind, bind and join. When we act in the world, we act upon matter - using tools that are made of matter. We build cities and houses to inhabit, weave and sew clothes to wear, manufacture cars to drive, and launch satellites of metal and glass to direct our vision from empty space - we bind matter into almost every aspect of our lives.
In interacting with the world of matter, we are constantly negotiating new possibilities. Our use of matter allows us to realise and extend our needs and desires, through the natural qualities of various materials - qualities which are revealed through experience over time. We become familiar with materials - what they can do, where they are found, how they are processed, their natural tendencies, limits of strength and durability - we get to know them. With this familiarity we work them, with our hopes and desires, adjusting to the way these materials work. The qualities of a material not only determine what we can do with it, but give rise to new ideas and desires, possibilities expanding as the relationship of working deepens. This understanding, of processes and potentialities, is passed to other makers, down generations, through time and across cultures. Ways of working become cultural, and whole periods of history are defined by dominant materials, such as bronze or iron.
At an immediate and personal level, our direct connection with matter is sensual. The cold steel of the knife with which we slice our vegetables, the smooth pliant leather of our couch, the warm wooden panelling of our room. Our worlds are full of materials which lend their qualities to our lives, adapting our environment, enabling our needs, and extending our possibilities. Materials such as glass - used through history for optics and telescopes - have totally altered our understanding of reality. We have extended our vision through glass, incorporating it into the way we see the world. Through the use of matter, its qualities are folded into the fabric of our experience and our being.

Creating with matter - making - requires understanding and compromise. It is a relationship, and an action, based on many forms of knowledge. In this relationship, there is a fine line between a mutual exploration of possibility, and that of manipulation for a predetermined purpose. Manipulation of matter is centred on thinking about ourselves, of our immediate needs and desires, without respecting the materials being used, or their place in the greater environment. A mutual exploration creates a place of awareness and flexibility, where material qualities and human desires are allowed to dance with one another, opening new possibilities and furthering understanding.
We tend to think that matter is there simply for our use, that the world is a blank slate ready for manipulation - it is there to be *made useful*. A particular myopia of power, perhaps. But however little respect we lend the material world, it is undeniable that its use is bound into our ways of living - the built environment completely encapsulates our existence. The materials of our houses and cars, our clothes and furniture, tools and machinery, all mediate our needs and extend our abilities. This relationship is further complicated by our immense global network of manufacturing and consumption, that

separates us from any direct individual understanding of how we gather and process the materials that shape our experience of the world.
The vast scale of our modern endeavours makes it difficult to personally comprehend how we manipulate the material world. Our minds and understanding have evolved for the small sphere of action that we wield as individuals and small communities - our ability to interact directly with the world, physically. It is incomprehensible, to those who have not experienced it first-hand, the monstrous scale of an open copper mine, or the immense capacity of a large automated manufacturing plant. We have not yet caught up with the magnitude of our actions, intellectually or morally, and we become ever more divorced from direct experience and understanding of these aspects of our lives, the more our world develops. We prioritise efficiency, draw clear boundaries of personal (ir)responsibility, and create abstractions of what we know is real, in order to maintain the illusion of control at such grand scales. Throughout these simplifications of reality, we relegate matter to the lowly mundane, and raise the value of thoughts and actions above the materials through which they are realised. We run wild in pure systems of thought, play games with global commerce, and create myths of desire through endless consumer goods and feats of technological prowess. Amidst these audacious undertakings, the role of matter is simply there to be of use - to enable our will. We create a rift between the material world and ourselves. A separation of understanding. So how do we reconnect with matter, and begin to build a healthy relationship with it?

I make stuff, daily, in metal, and also in everything else I can find. It helps me feel useful and whole, and allows me to see where I am. It helps me understand many things. But I cannot fathom the complexities of large-scale mining or manufacture, or the development of the consumer goods that surround me. I do not know how to comprehend such immensity. In interacting with matter, however, at an intimate and personal level, I become more aware of the richness of the world in which I live. I become aware of the basic nature of materials, and some of the intricate relations between them, and I become connected, and invested, in the world of which I am a part. I extend my senses, through making. I seek respect, in the process of making, which leads to greater truth and beauty, as in any relationship. In such small ways, I move towards bridging the divide between myself and matter.
The materials contained in this book are the stuff with which we make things. Some are pure elements, some rough chaotic mixtures, complexly structured organics, or simple synthetic composites. There is no fundamental, basic state of matter, except what we decide - copper ore has gone through extensive and complicated processes to become elemental metal, while the clay dug from the creek bank on my property has had minimal processing, and is a ragged mix of multiple materials. Whether it is pure refined gold, the naturally growing cellulose structures of timber, the mix of heated minerals and aggregates we call concrete, or the man-made composites of carbon fibre embedded in resin, this is all matter for making. With each of these materials there is a deep relationship of use, often developed over hundreds of generations.
These discs were worked by hand or simple machinery, in order to experience the way they feel under saw or hammer, the way they pour when molten, the way they mix and set, their smell, their texture, and how they change over time. Most of these materials I know and use, while some are from other makers. I worked them very tightly (I am sometimes a jeweller, after all), forming them into small sample discs 30mm in diameter and 3mm thick, gauging how they cope with this. The process was very sensual - the slippery silver dust of graphite coating my fingers, the pasty slurry of stone as it is cut with a wet diamond blade, trails of glittering meteoric stardust falling off my jeweller's saw, the lingering smell of the sea as kelp dries in my workshop, the warmth and holy glow of gold as it grabs on the ridges of my file, fragrant huon pine dust floating gently in the air. Some materials have been bent beyond their will to make such a tight disc shape, such as the reinforced concrete, of which fourteen attempts were made to keep the steel from crumbling out of the concrete matrix. I am of course still learning to listen, and to be flexible.
The discharge images alongside these samples are an extension of my experience of making. The process of working with a material creates an understanding, and these images extend that. Through high voltage electrical signals exposed directly onto photographic emulsion, the materials reveal another side of themselves. The images portray a different perspective to that of light reflected off an outer surface, which our eye sees in everyday experience. Here, the electricity moves *through* matter, coursing along internal structures, vibrating deep in the density of its substance - this is an energetic perspective. The flow of energy is revealed. This is beyond our natural senses - we do not usually apprehend matter like this. But this is how electricity apprehends matter - this is a glimpse of another way of being. Of being electric. And there are of course many other ways of being. Through experiencing matter from different perspectives, I hope to understand it better, and to expand myself - to blur my senses with other worlds and ways of encountering them. If we can assimilate such alternate perspectives at a cultural level - perspectives that are not centred purely on use and consumption - we may be better able to find balance and harmony as part of the material world in which we live.

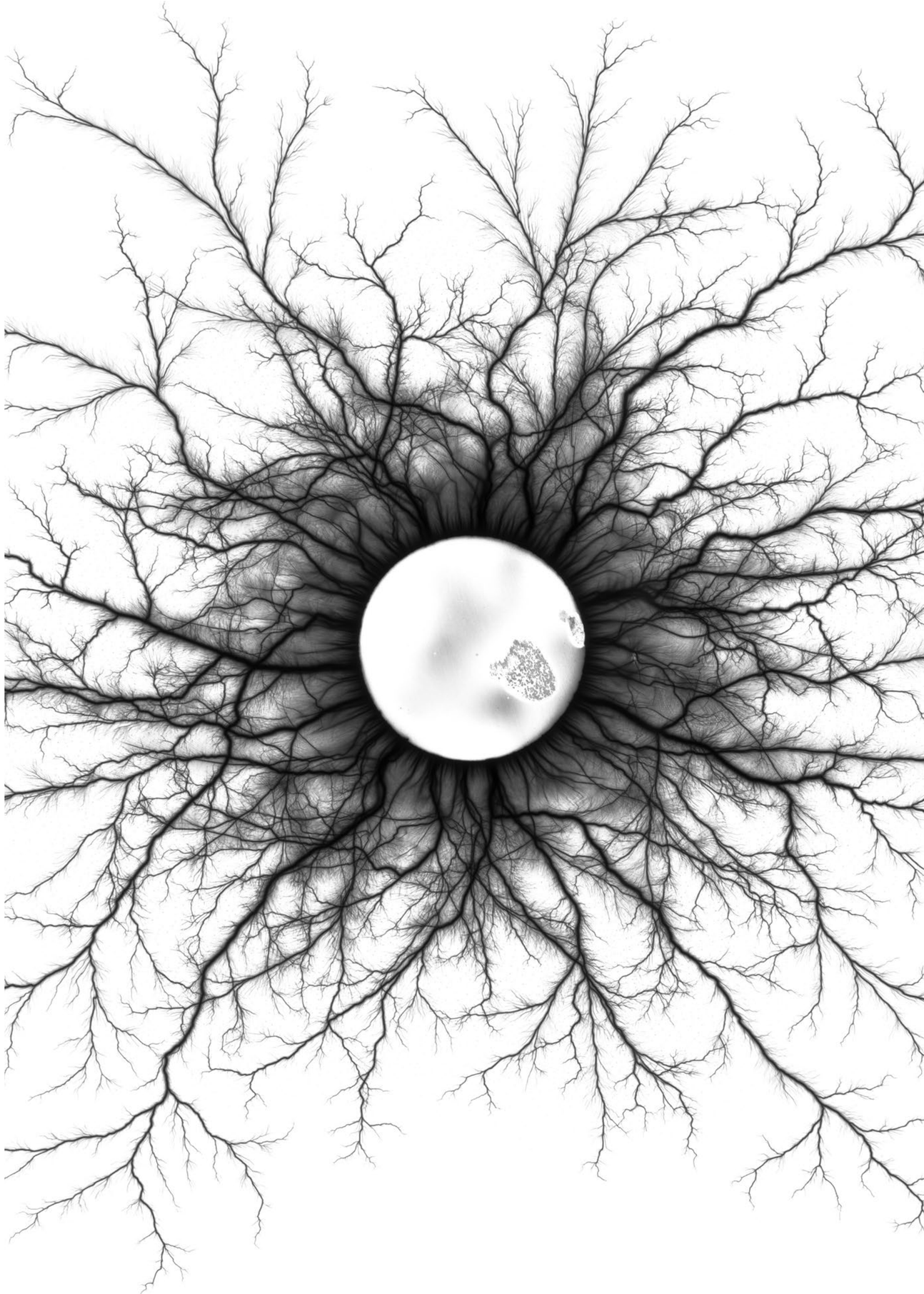
acrylic



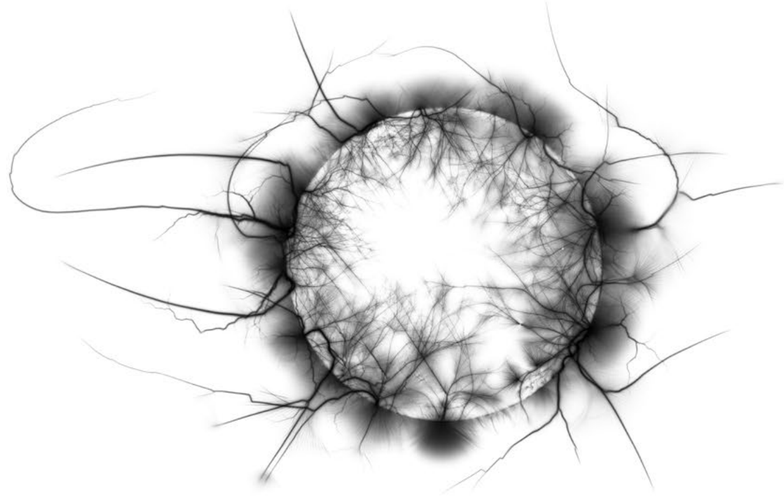
acrylic, scavenged from engraving master guides, as used by my grandfather in his work as a 3-d pantograph engraver
10,000 volts AC at 2500Hz over Arista orthographic film.

aluminium

aluminium, the only sample to deteriorate through imaging, the applied voltage depositing very thin patches of aluminium splatter over the emulsion, as can be seen... this is low quality matter
30,000 volts DC over Arista orthographic film.

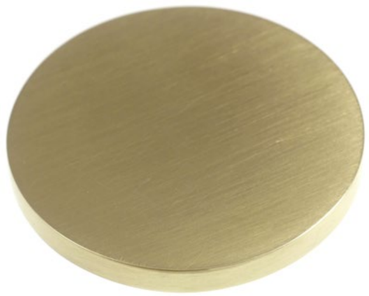


bone
(bovine)

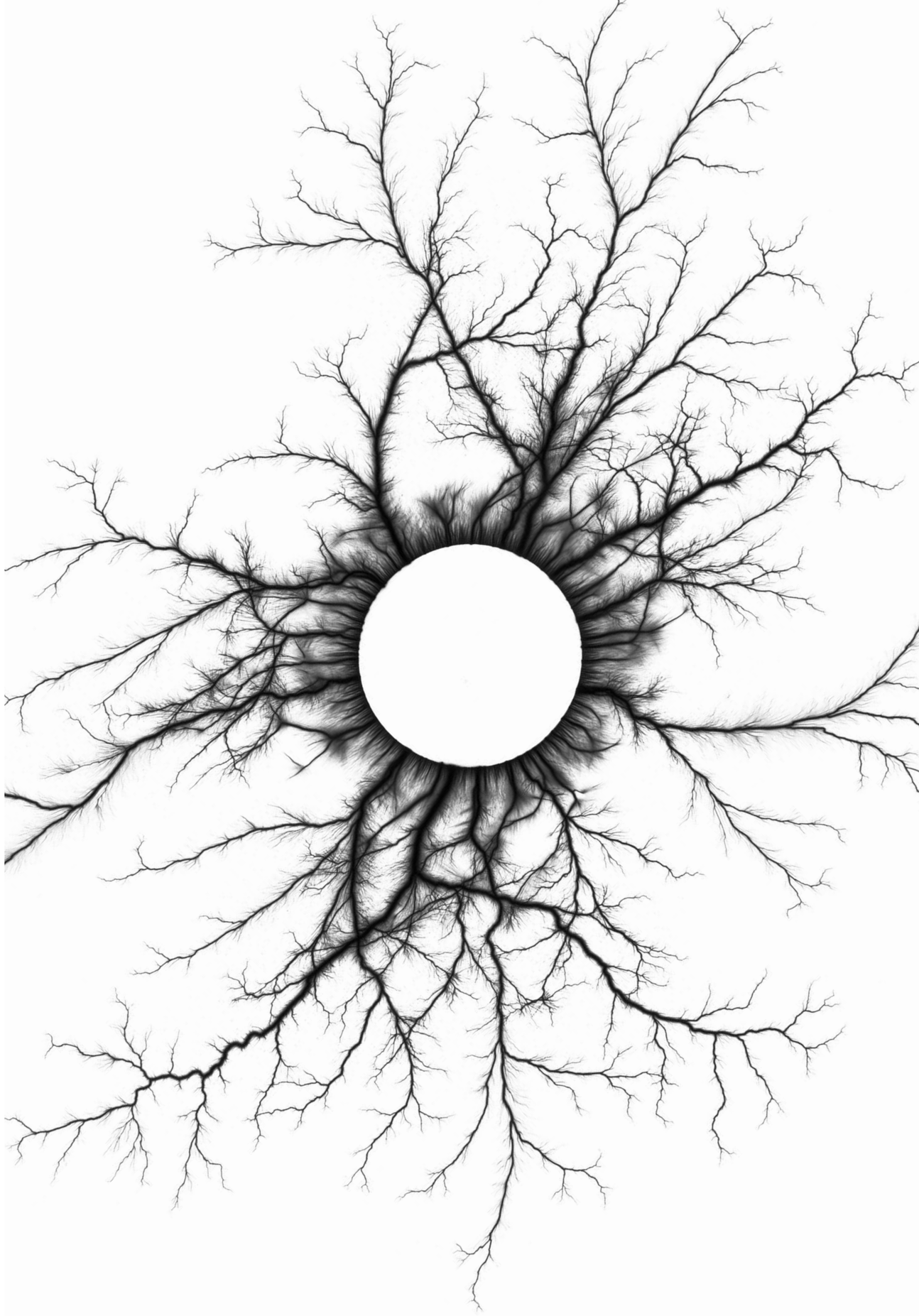


cow bone, prepared from grisly butcher's offcuts by a long-term vegetarian
15,000 volts AC at 400Hz over Regent Royal orthographic film.

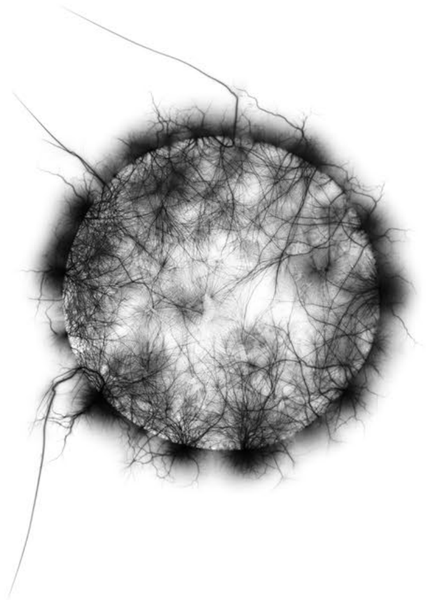
brass



brass, cut from scrap bar in my workshop, used for making machine parts
25,000 volts DC negative over Arista orthographic film.

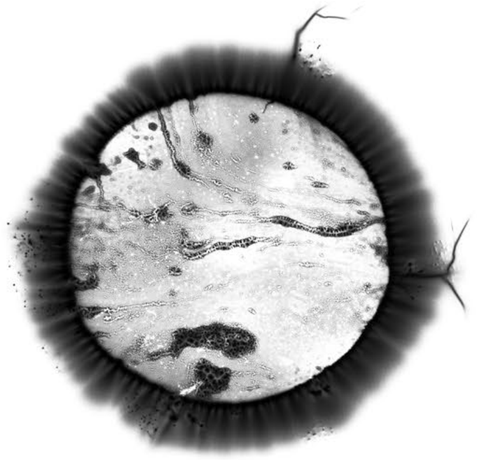


brick



modern brick found on my property in South-West Tasmania, from a burnt-out building
15,000 volts AC at 80Hz over Regent Royal orthographic film.

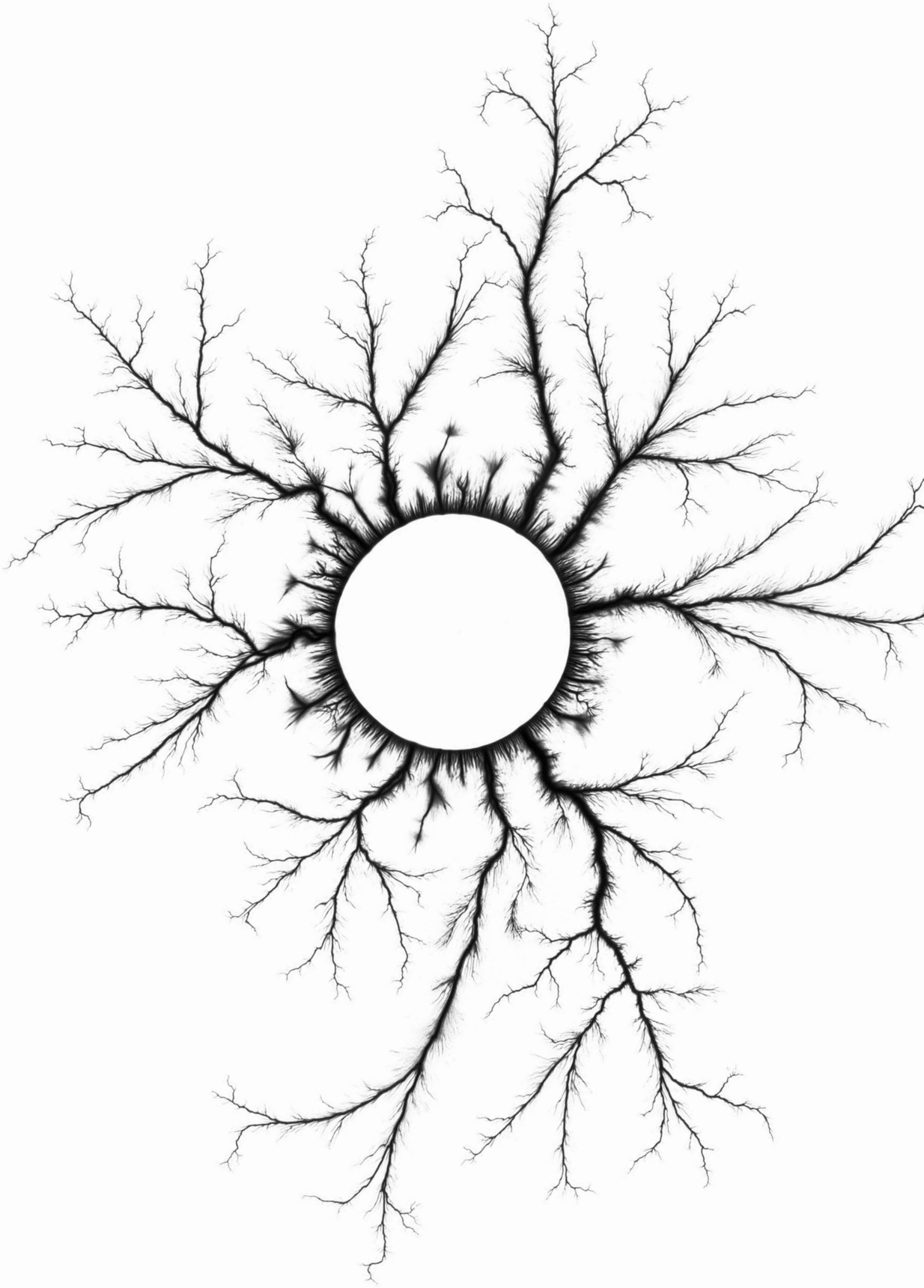
brick
(old, hand-made)



old hand-made brick found on the far coast of Southern Tasmania by Beatrice
15,000 volts AC at 250Hz over Regent Royal orthographic film.

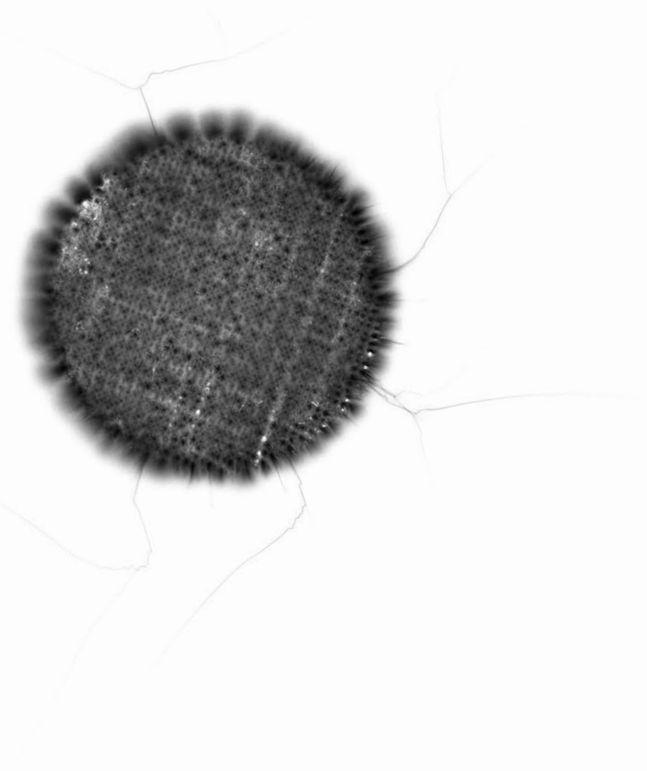
bronze

phosphor bronze disc cast for these experiments
22,000 volts DC negative over Arista orthographic film.

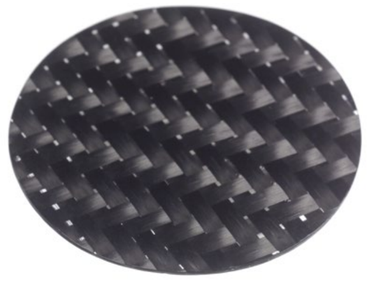


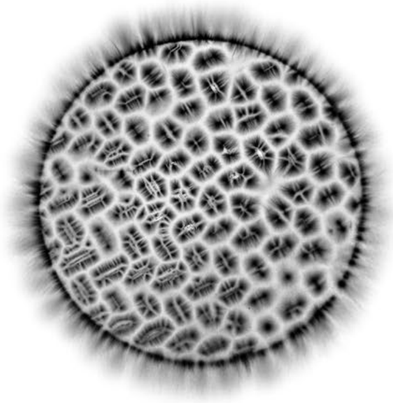
canvas
(cotton)

medium weight cotton canvas as used in an artist's painting frame
15,000 volts AC at 1200Hz over Aristatone orthographic film.



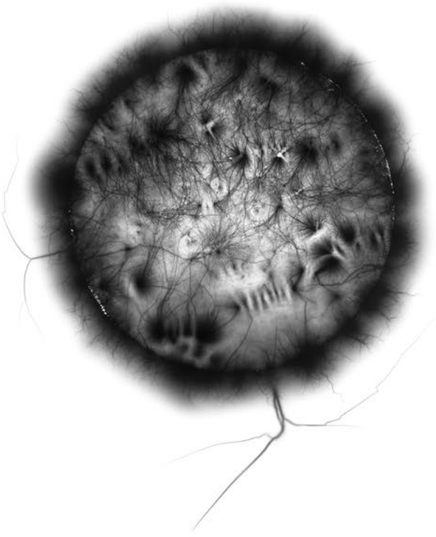
carbon fibre composite





carbon fibre woven roving set in epoxy resin, for a drill press switch cover
12,000 volts AC at 40Hz over Arista orthographic film.

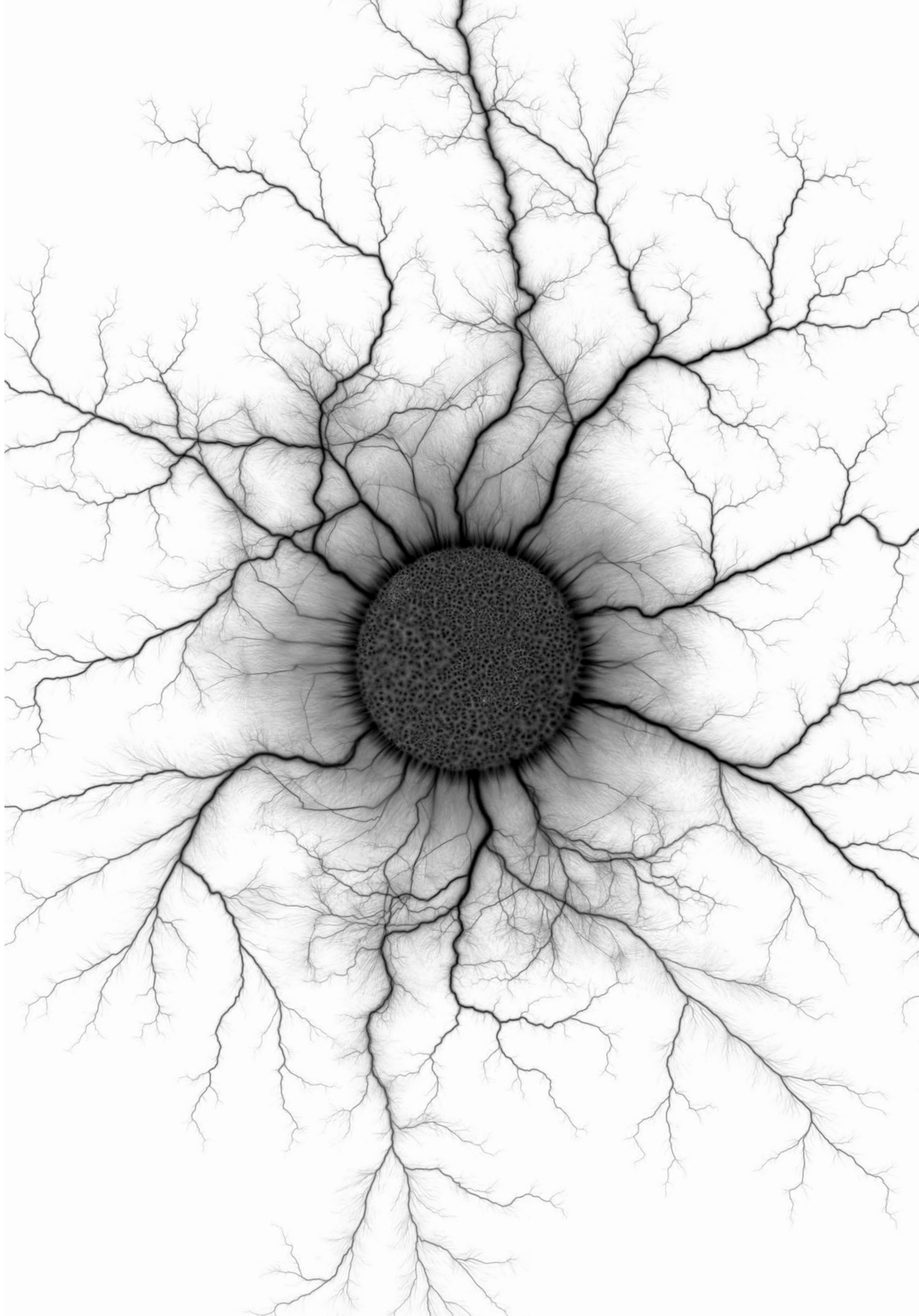
cardboard



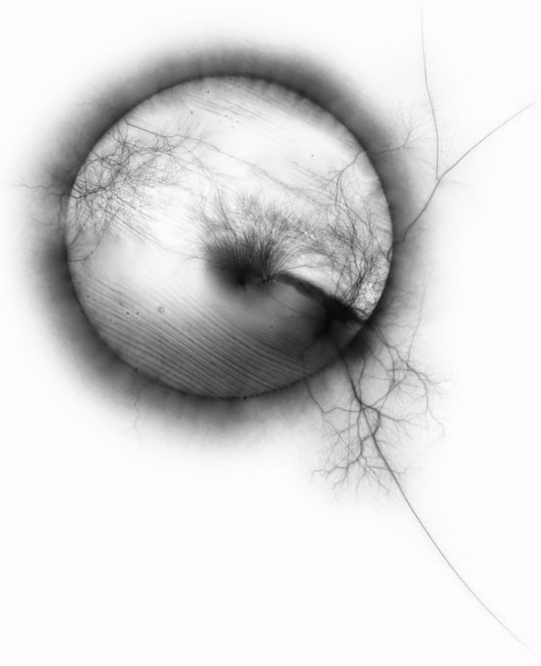
plain cardboard cut from packaging from The Book Depository, once containing a book by Michel Serres
15,000 volts AC at 150Hz over Avitone orthographic film.

cast iron

cast iron, cut from a broken old wood stove that refused to keep me warm during winter
25,000 volts DC and 15,000 volts AC at 200Hz over Regent Royal orthographic film.

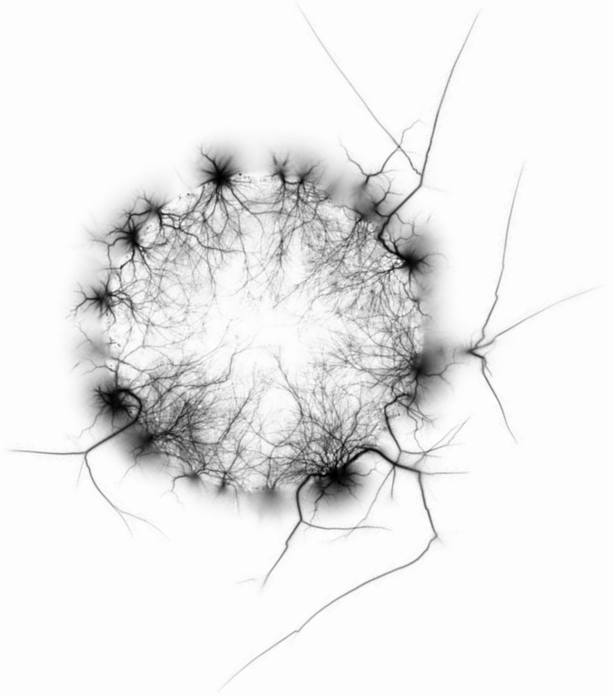


celerytop pine



celerytop pine from cladding used on my outhouse, supplied by Andrew at a local mill up the road
15,000 volts AC at 100Hz over Aristatone orthographic film.

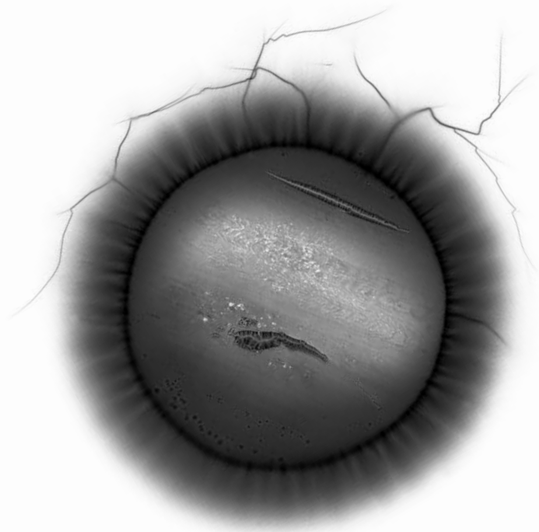
cement



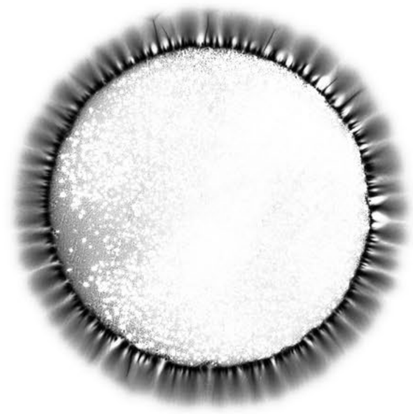
cement render bought from Bunnings
15,000 volts AC at 300Hz over Regent Royal orthographic film.

charcoal

charcoal made from celerytop pine at 700 degrees reduction
15,000 volts AC at 1000Hz over Rollei Ortho 25 film

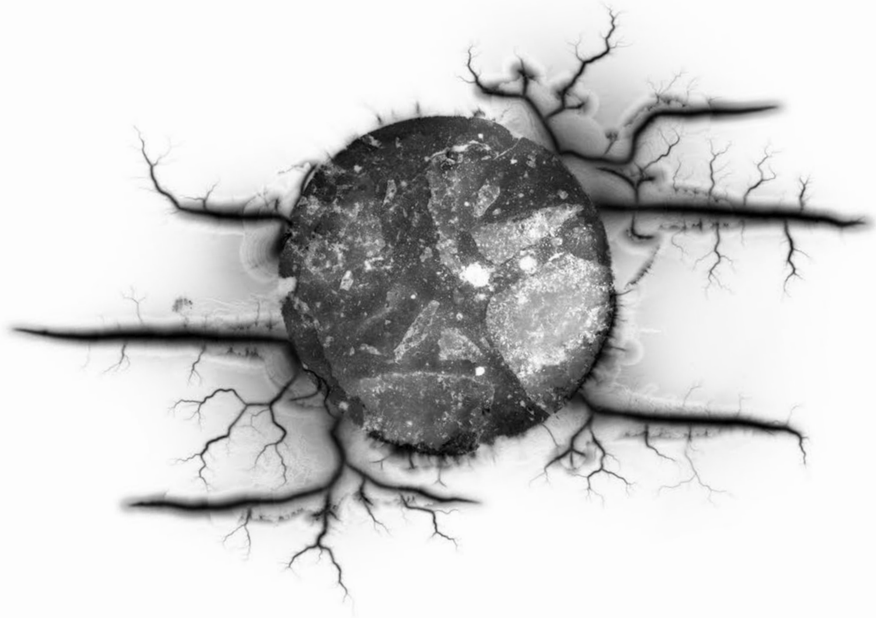


clay
(unfired)



clay dug and processed from the creek that runs through my property which is on Pottery road
10,000 volts AC at 300Hz over Regent Royal orthographic film.

concrete

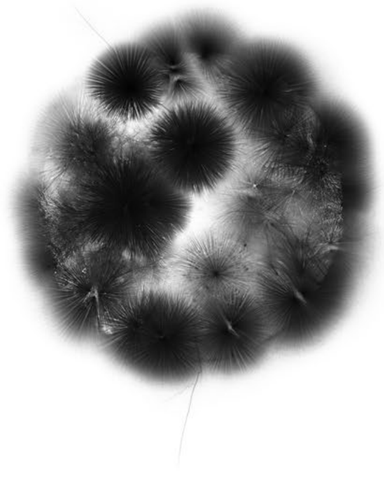


concrete cut from footings of an old house in the neighbourhood
20,000 volts AC at 80Hz over Ilford Ortho film.

copper

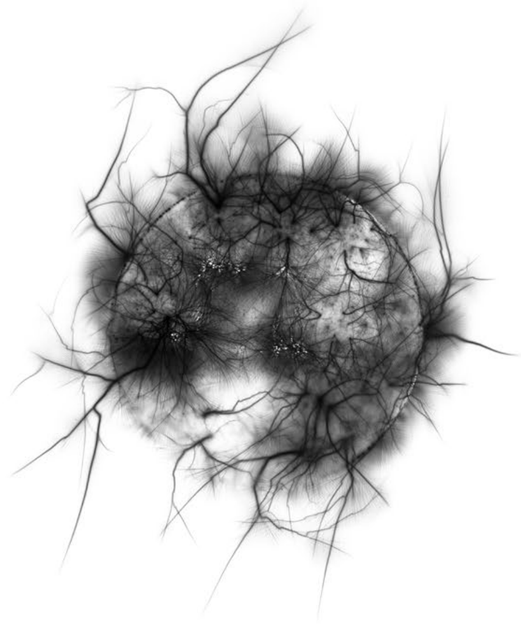
copper sliced from solid bar used for welding jigs, because of its high electrical and thermal conductivity
35,000 volts DC over Foma 100 panchromatic film.

cork



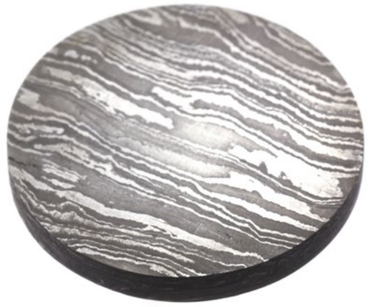
compressed cork cut from an ikea floor tile
12,000 volts AC at 300Hz over Aristatone orthographic film.

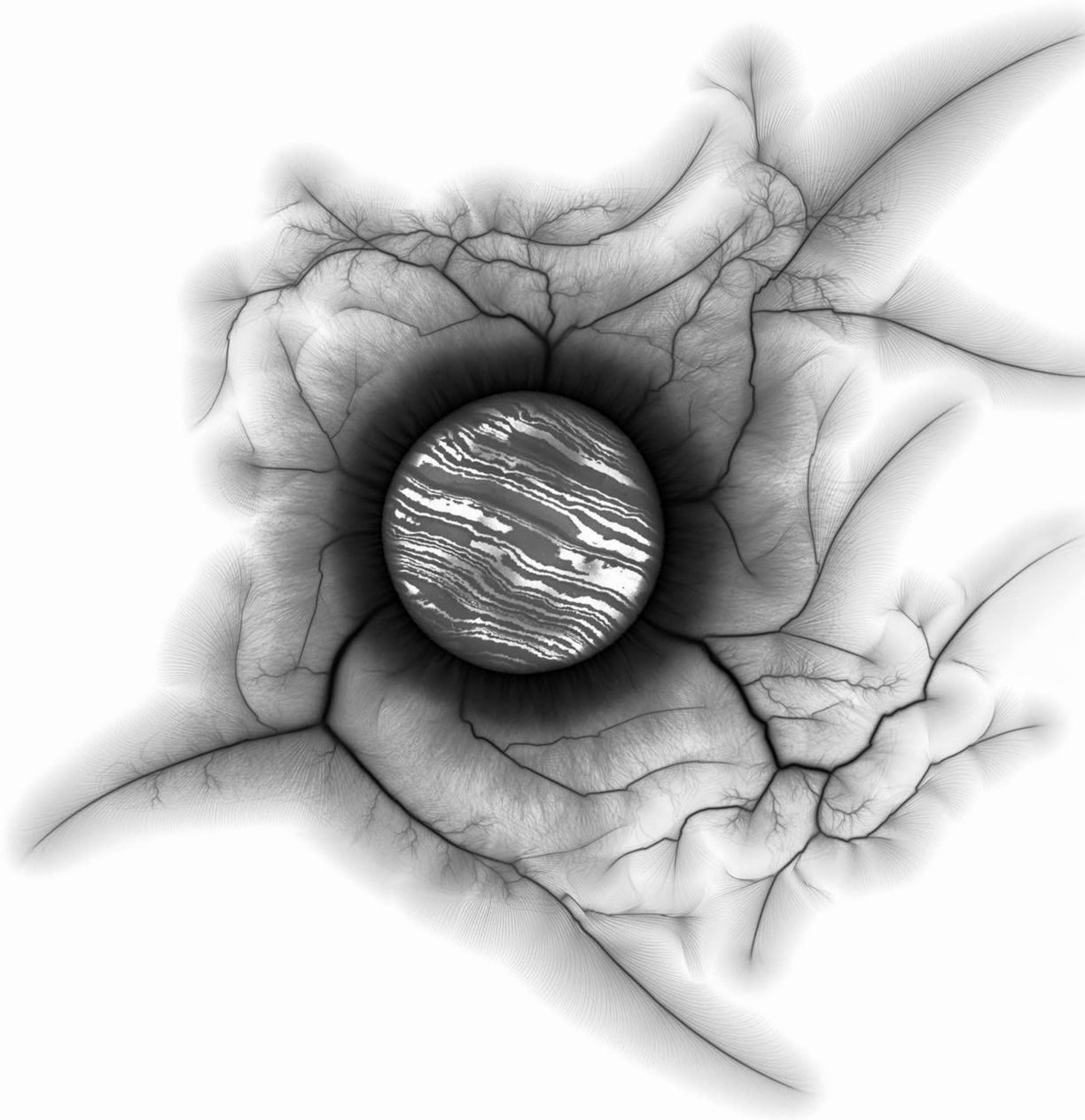
corrugated cardboard



corrugated cardboard cut from packaging from Poland once containing obscure old electronics components
15,000 volts AC at 200Hz over Regent Royal orthographic film.

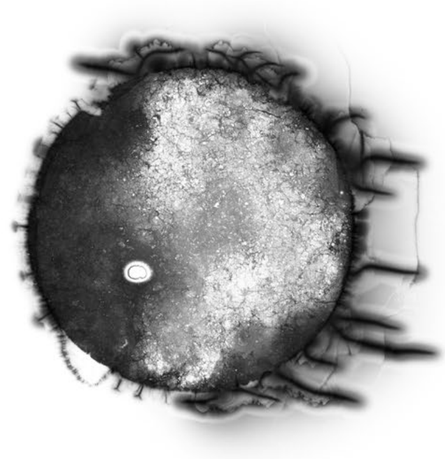
damascus steel





damascus steel layered from medium-carbon tool steel and low-carbon nickel steels, made cheaply in India,
etched and hardened, but untempered
25,000 volts DC negative resonant pulse over Regent Royal orthographic film.

dolerite

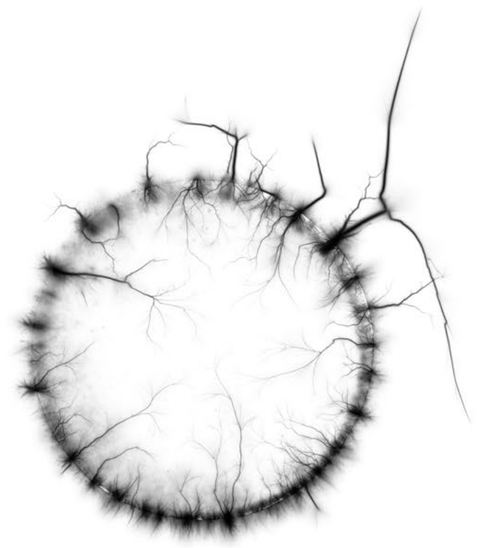


dolerite, a predominant stone in South-West Tasmania, found in eroded pieces on the highest hill of my property
15,000 volts AC at 500Hz over Ilford Ortho film.

ebony

black african ebony from offcuts collected through friends, previously used in creating an articulated jewellery chain
10,000 volts AC at 400Hz over Aristatone orthographic film.

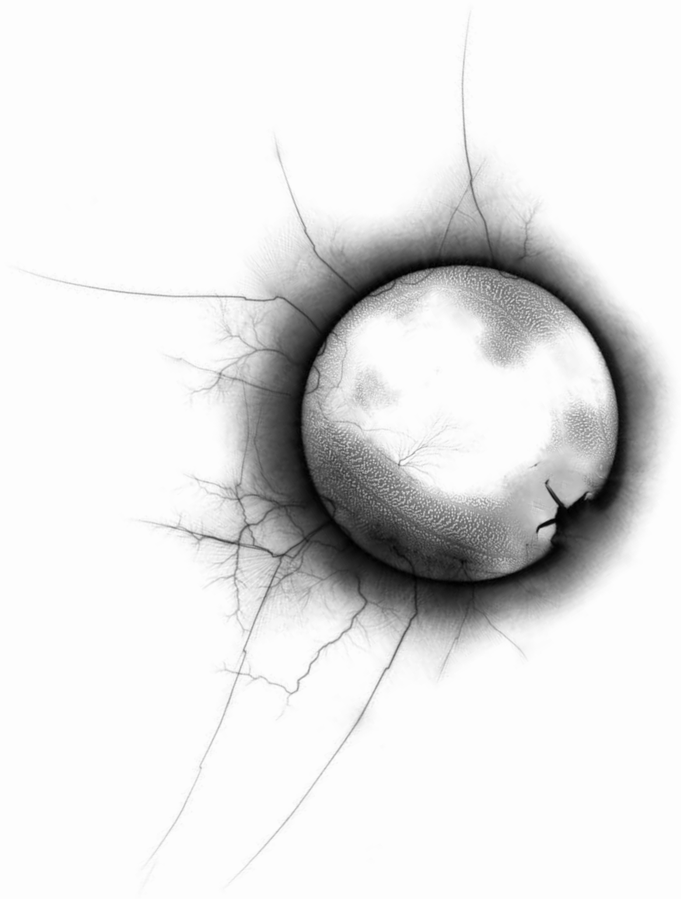
fibreglass



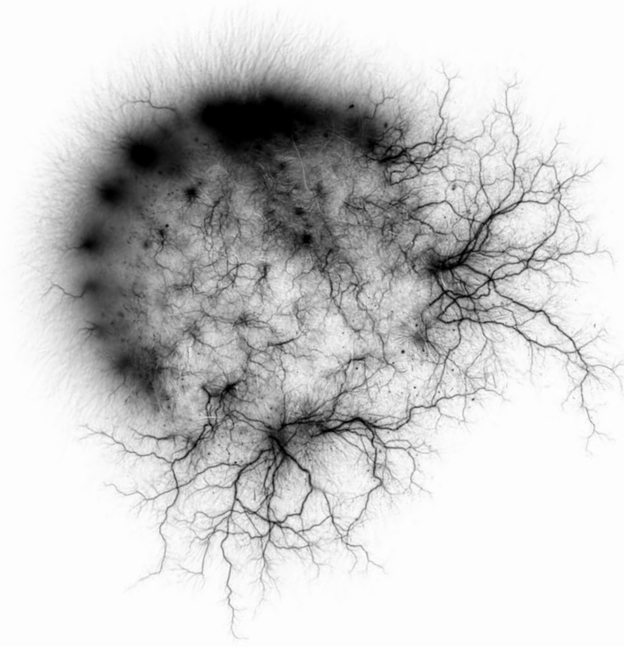
fine woven fibreglass roving set in epoxy resin
10,000 volts AC at 800Hz over Arista orthographic film.

firewood
(eucalyptus globulus)

firewood out of my wood-pile, from one of several dead trees felled on my property, destined for a small wood stove
25,000 volts AC at 120Hz, over Aristatone orthographic film.

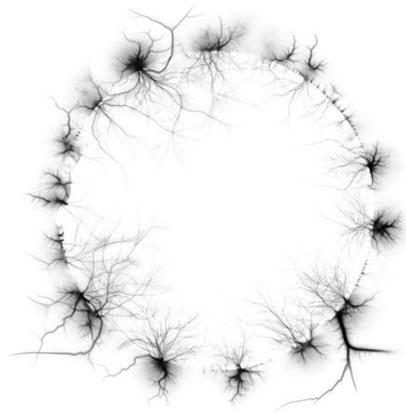


fur
(pademelon)



pademelon fur, processed by contemporary jeweller Nataša, from roadkill in Southern Tasmania
15,000 volts AC at 800Hz over Rollei Ortho 25 film.

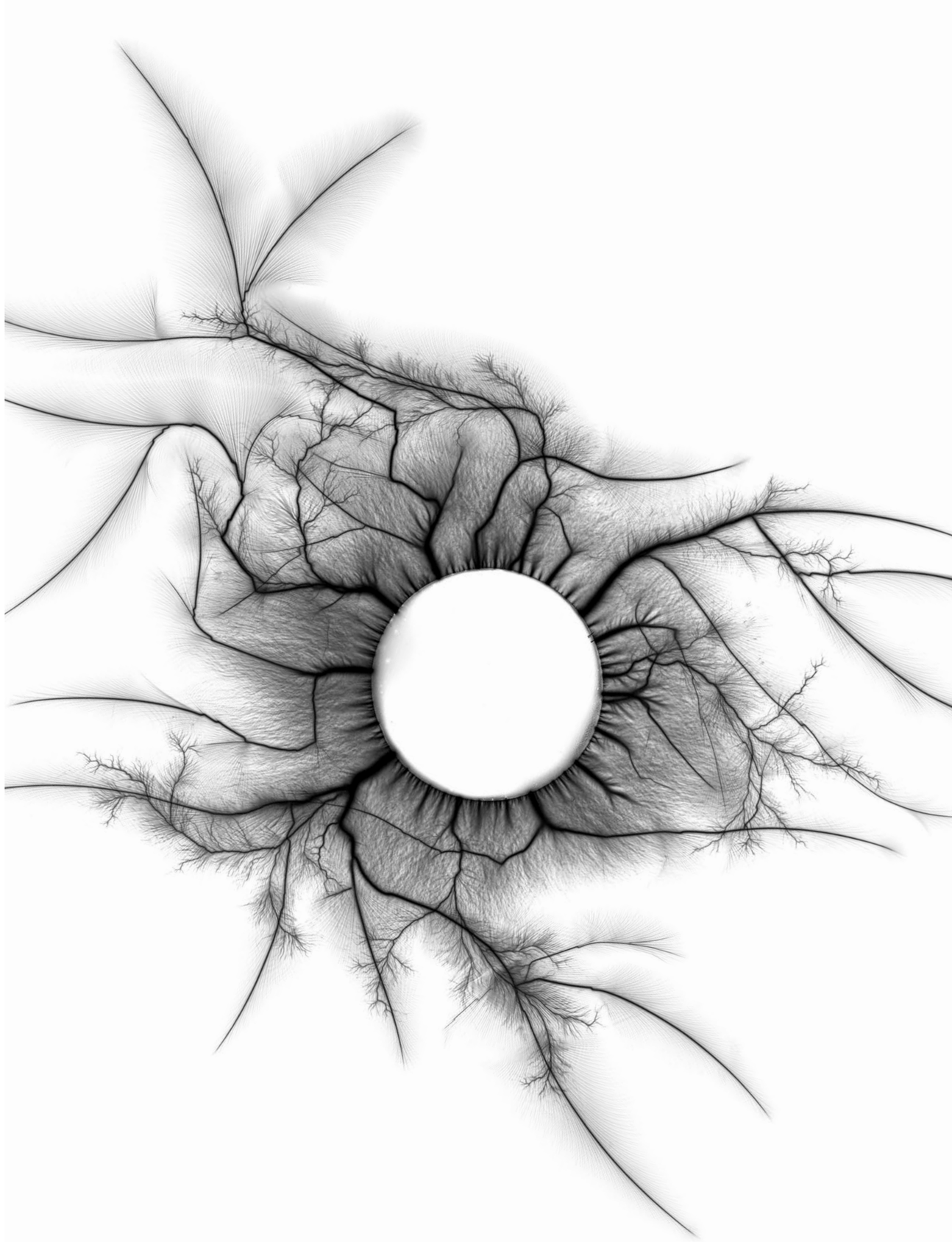
glass



glass from stained glass window maker Brigitte, my mother
5,000 volts AC at 20,000Hz over Arista orthographic film.

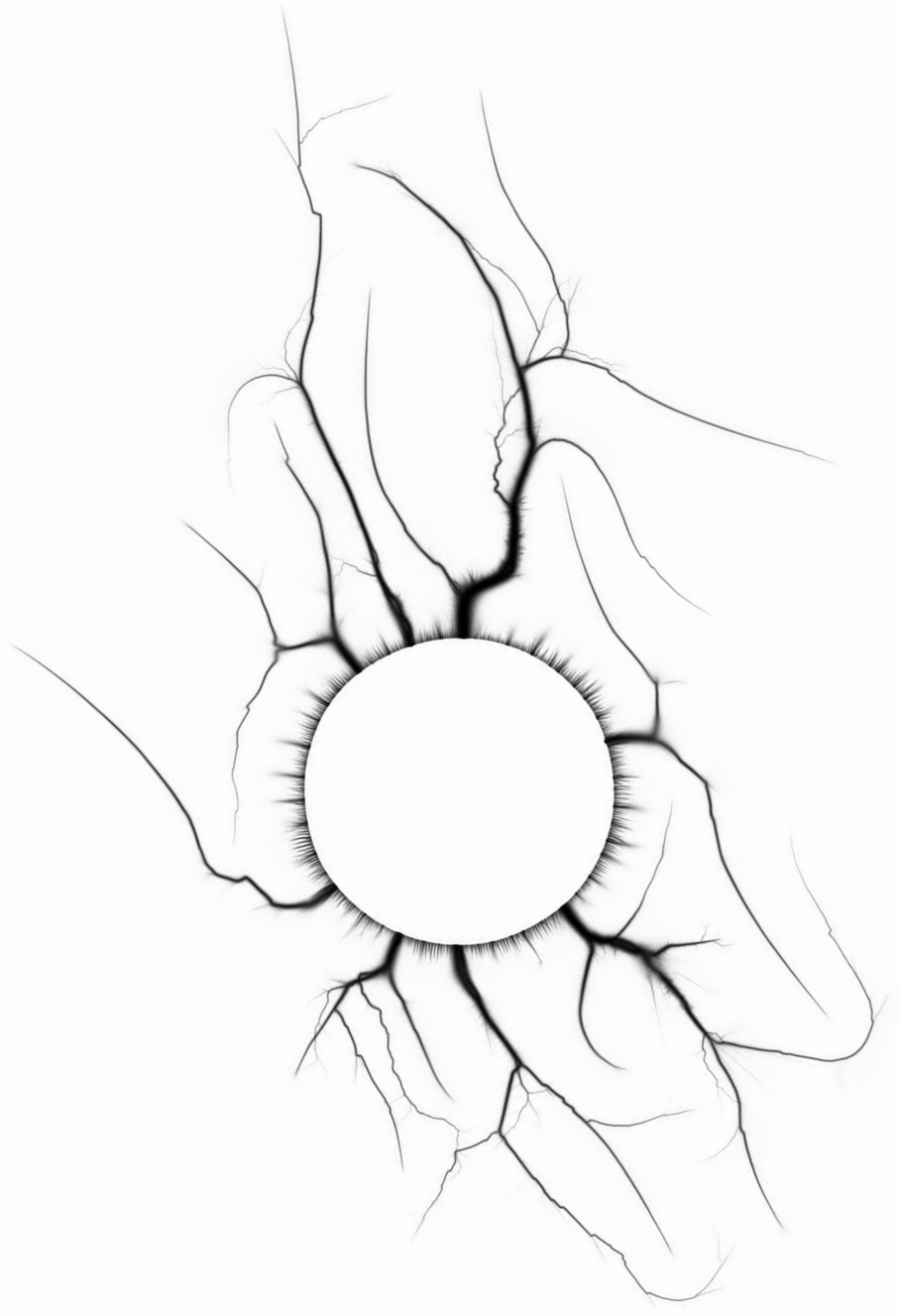
gold

pure gold disc, cast for this study, and stunningly beautiful
22,000 volts DC over Foma 100 panchromatic film.

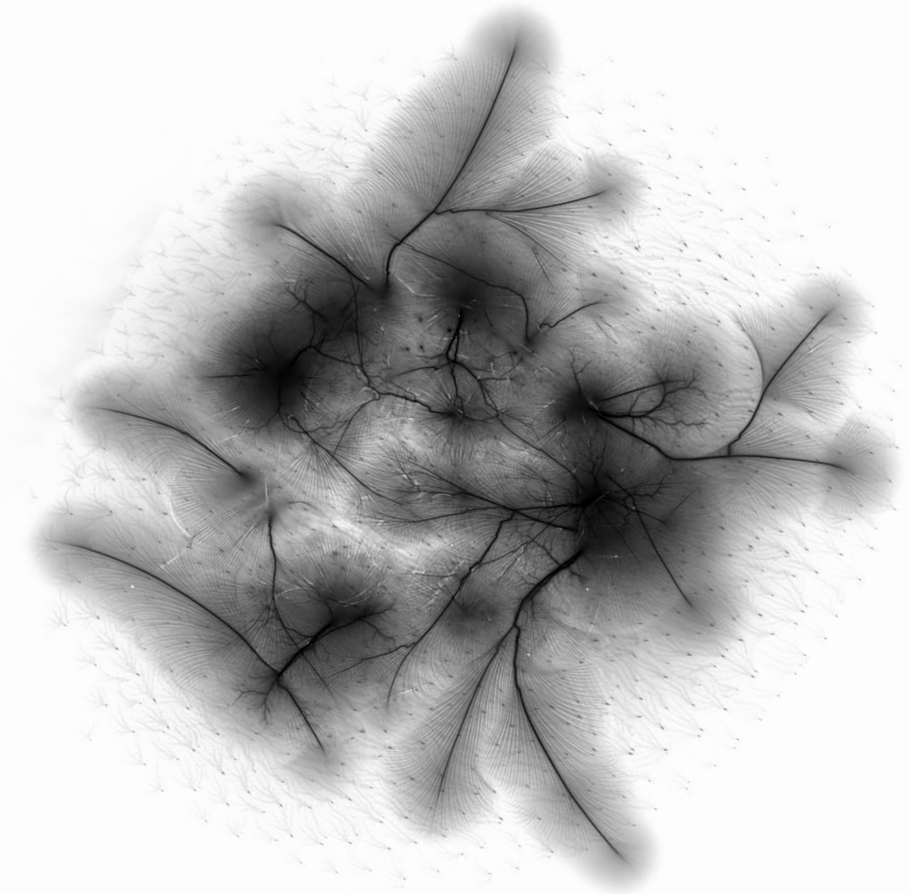


graphite

graphite cut from a block used as a solid industrial lubricant
25,000 volts DC over Regent Royal orthographic film.

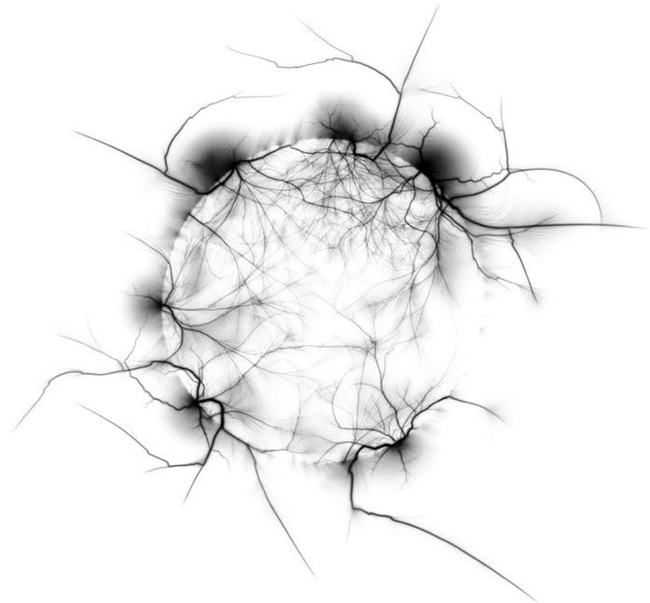


hair
(human)



hair massaged and felted, from a bad 70's pornstar ponytail cut off the top of my head
18,000 volts AC at 600Hz over Rollei Ortho 25 film.

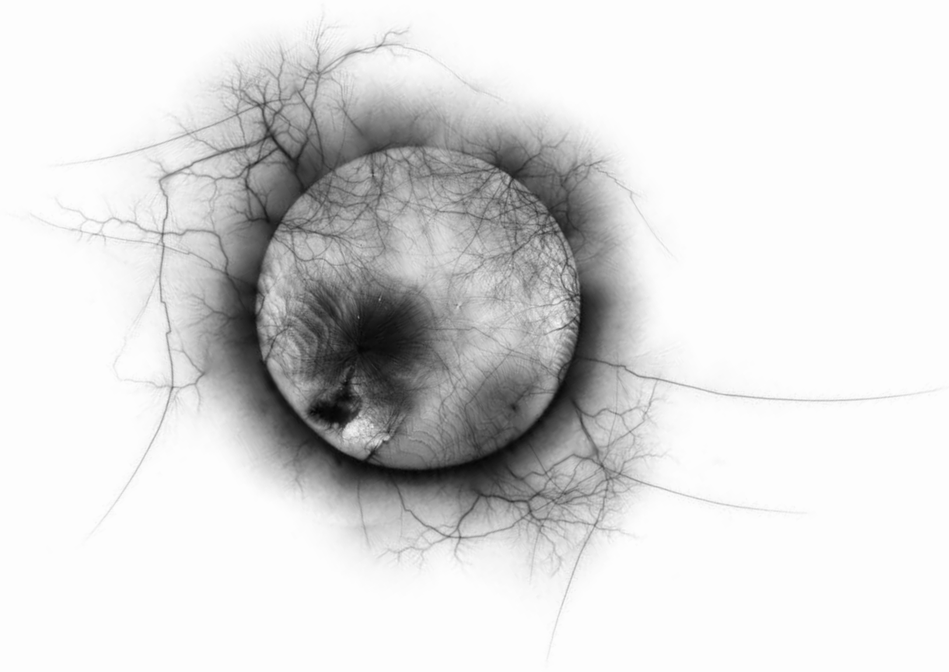
horn
(water buffalo)



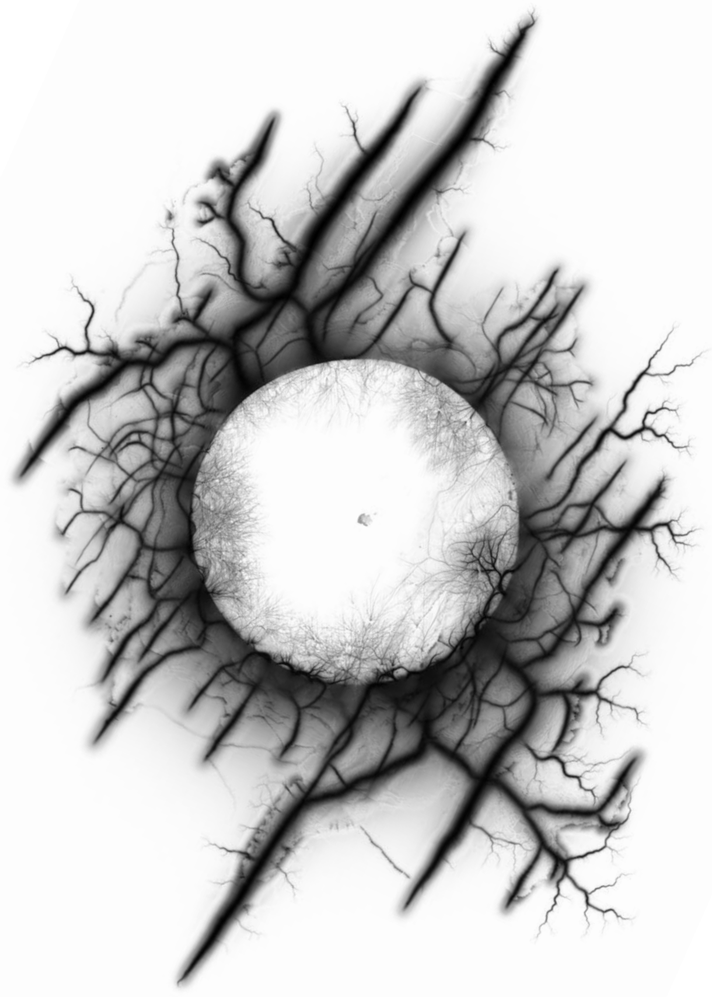
water buffalo horn from an awful mantelpiece object bought at a Salvos store, and subsequently
re-purposed for contemporary jewellery
15,000 volts AC at 400Hz over Regent Royal orthographic film.

huon pine

huon pine from fine woodworker Conrad, who scavenged all the tasty offcuts while working on a large boat in Hobart
15,000 volts AC at 140Hz over Aristatone orthographic film.

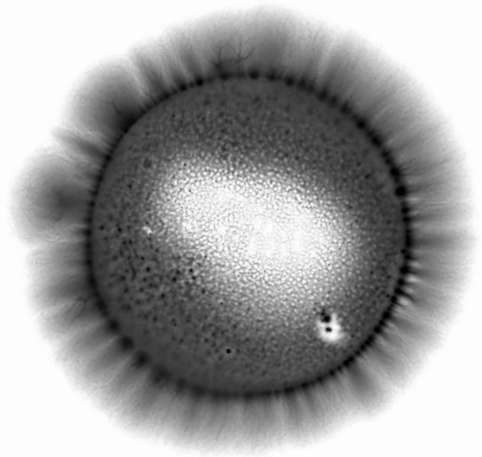


jet



jet stone from wales, showing signs of its flammable nature with a feint mark from sparking evident in the sample
15,000 volts AC at 300Hz over Rollei Ortho 25 film.

kelp

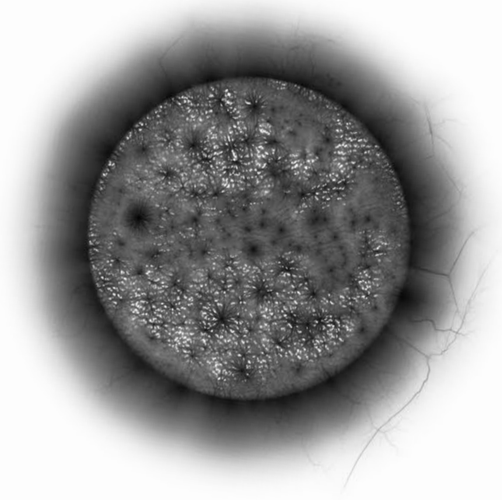


bull kelp as suggested by Joshua, harvested from South-West Tasmania, stretched and dried as sheet, and very tasty when used as a soup stock
12,000 volts AC at 240Hz over Avitone orthographic film.

lead

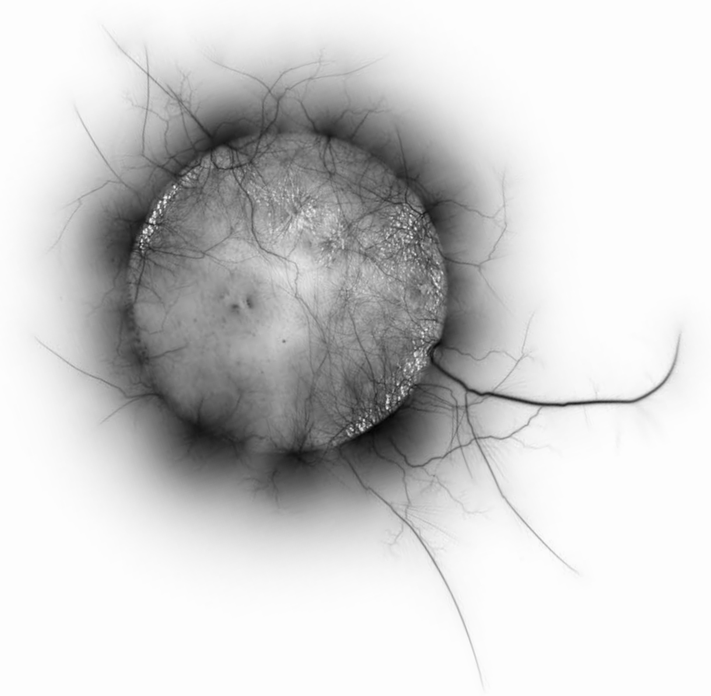
lead, remelted from my late grandfather's stock of roofing flashing
15,000 volts AC at 100Hz over Kodak Tri-X panchromatic film.

leather
(chrome-tanned)



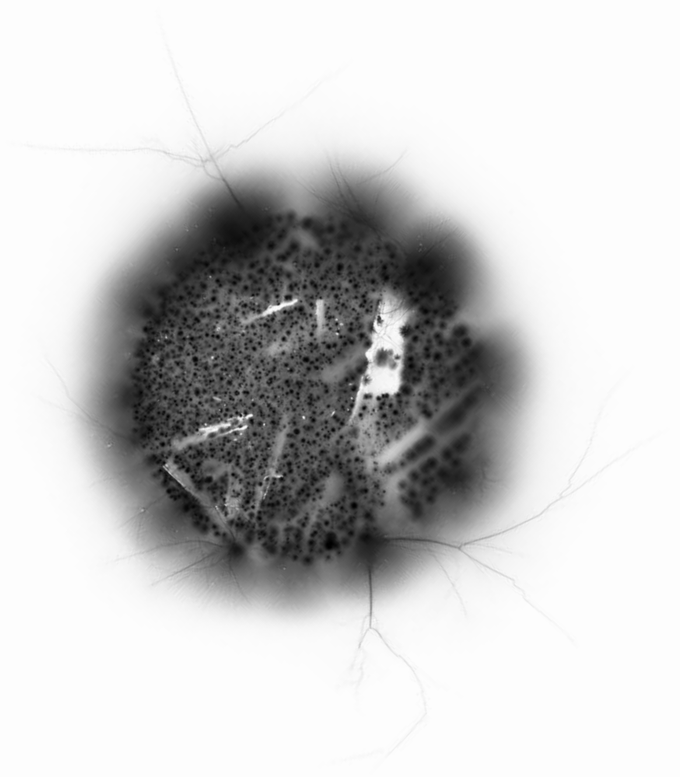
beautifully orange chrome-tanned leather used in making several handmade shoes and books
10,000 volts AC at 400Hz over Rollei Ortho 25 film.

leather
(vegetable-tanned)



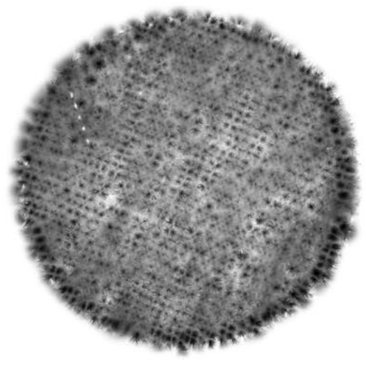
thick vegetable-tanned leather from leatherworker Keith, used in carved and dyed figurative work as well as belts and satchels
10,000 volts AC at 100Hz over Rollei Ortho 25 film.

lime render



lime render with sand and straw, from building designer and worker Lukasz, as used for the internal and external rendering of his home
12,000 volts AC at 150Hz on Avitone orthographic film.

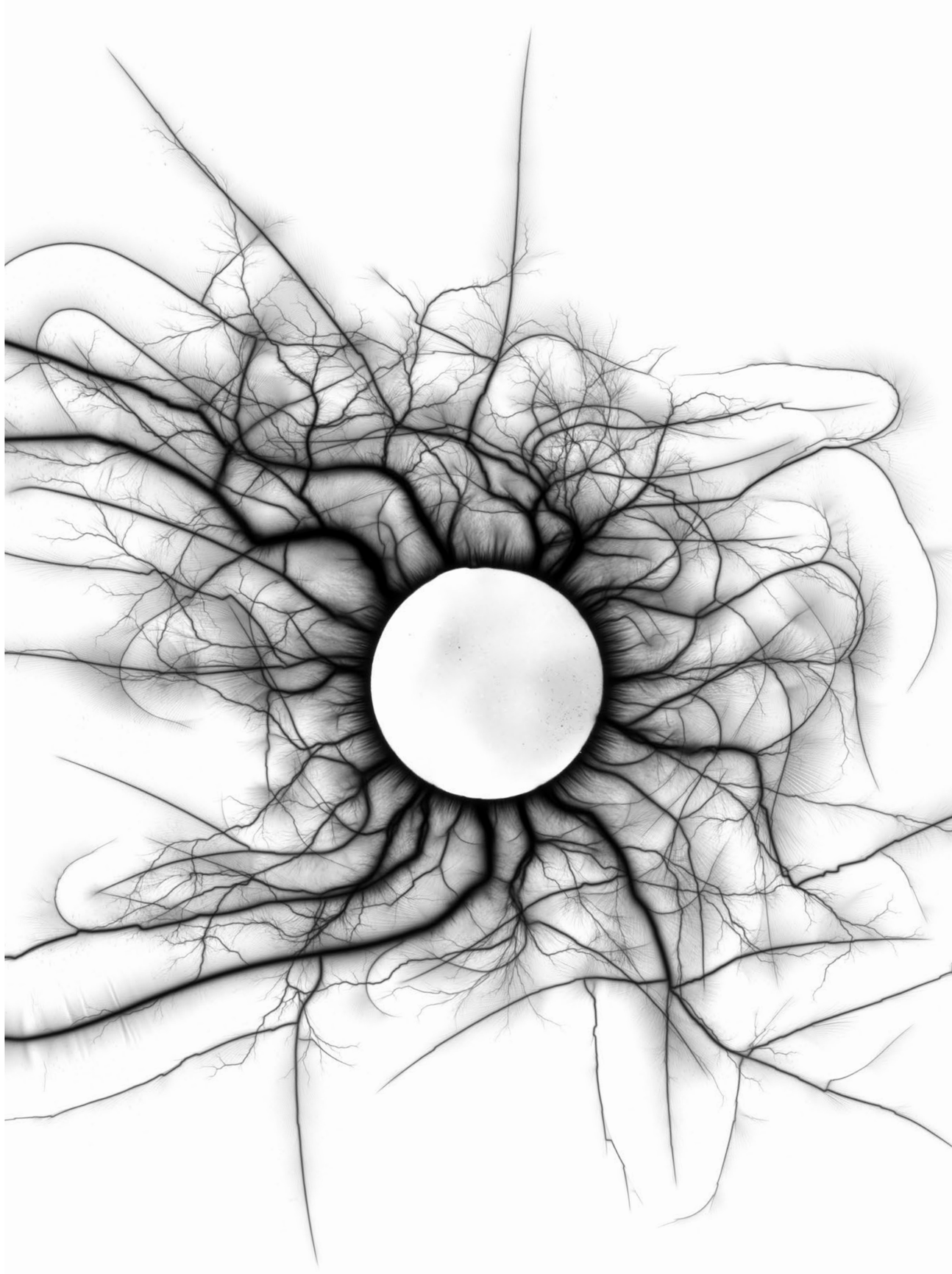
linen



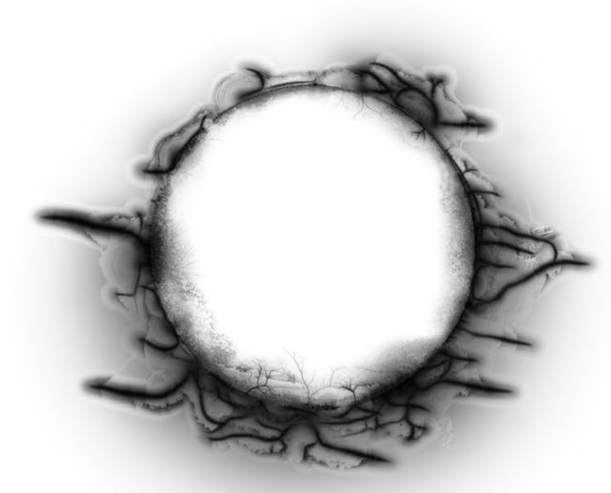
lightweight woven linen from Russia, used in the sewing of a summer shirt
10,000 volts AC at 800Hz over Avitone orthographic film.

magnet
(neodymium)

neodymium-iron-boron magnet with nickel plating, made in China, extracted from a pair of experimental planar-magnetic loudspeakers that sounded ok, but not great, and the magnets thus repurposed as super fridge magnets
30,000 volts DC negative over Arista orthographic film.

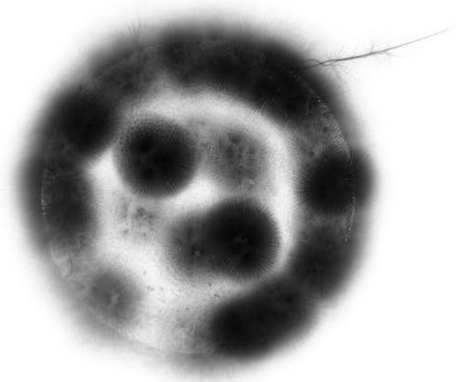


marble

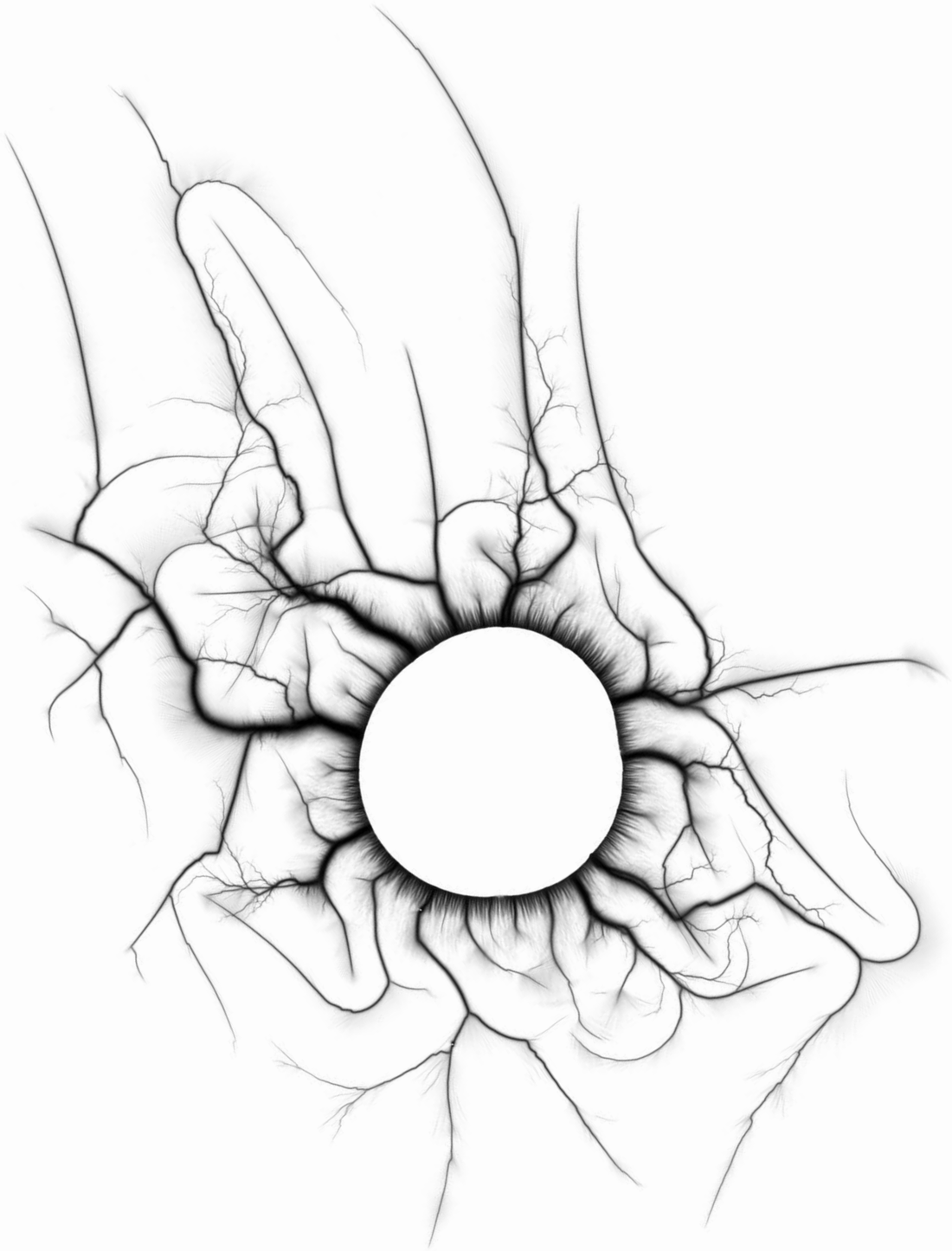


carrara marble, cut from Italian floor tiling
15,000 volts AC at 120Hz over Ilford Ortho film.

mdf



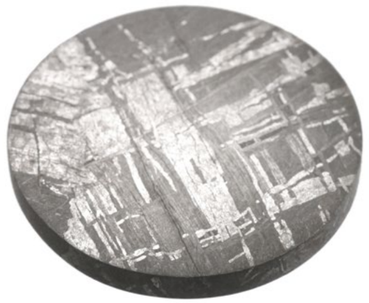
medium density fibreboard bought from bunnings, used indiscriminately, and often disposed of similarly
10,000 volts AC at 400Hz over Aristatone orthographic film.



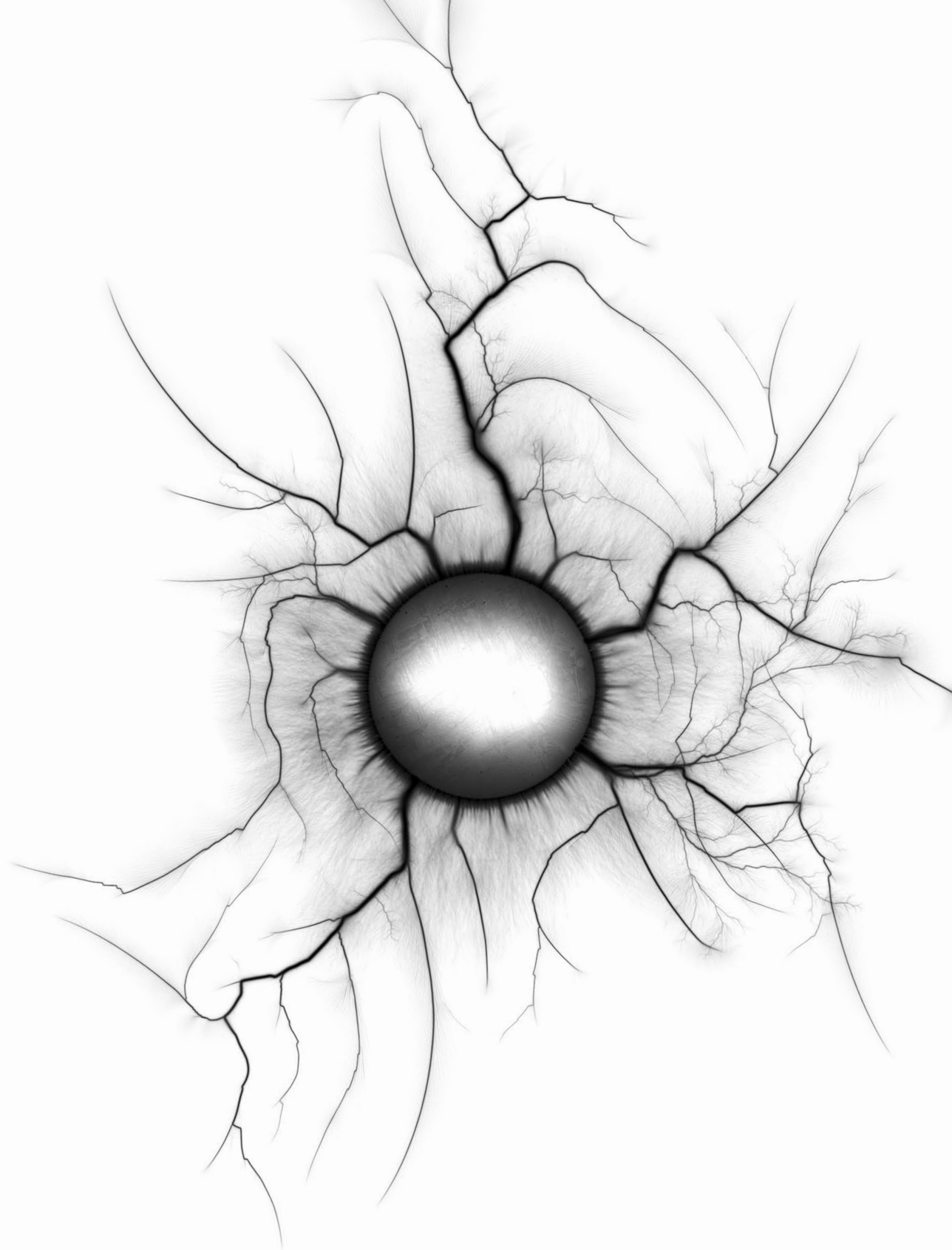
mercury

mercury from my 3Kg stash, obtained dodgily, previously used in a rippling shiny kinetic puddle artwork
25,000 volts DC over Artista orthographic film.

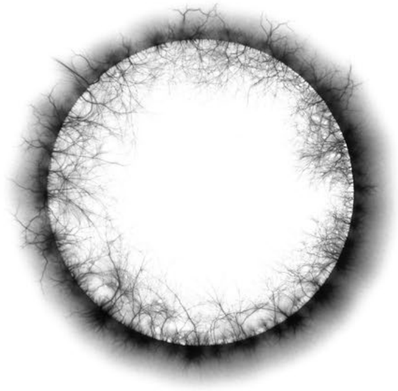
meteroite ore
(gibeon)



meteoric ore from Gibeon, Namibia, etched to show its structure, small pieces of which were once used for jewellery,
but which I am now reluctant to cut due to its rare and irreplacable nature....
30,000 volts DC and 10,000 volts AC at 600Hz over Regent Royal orthographic film.

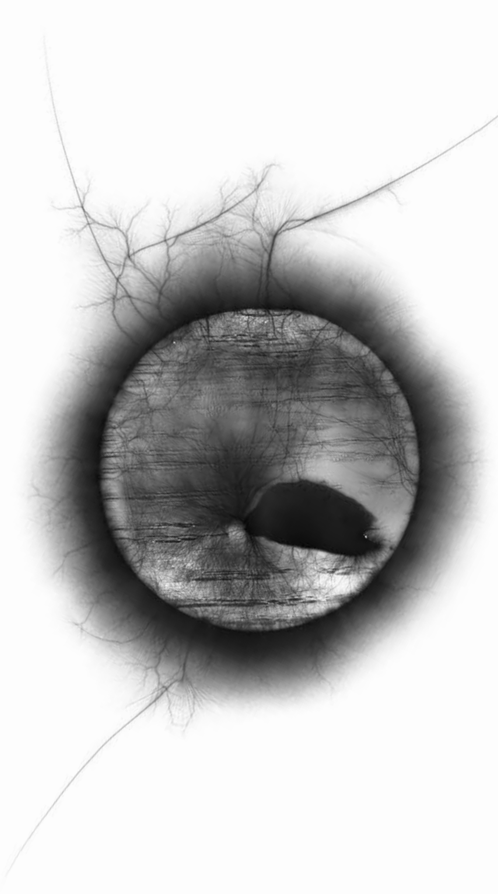


neoprene rubber



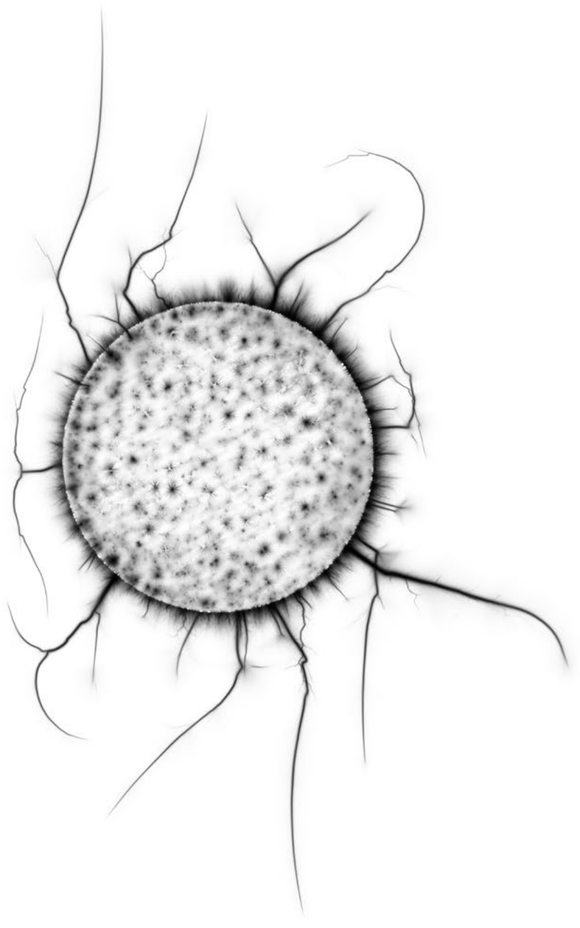
neoprene rubber from my stock of sheet used for making various seals and gaskets
8,000 volts AC at 5000Hz over Arista orthographic film.

oak



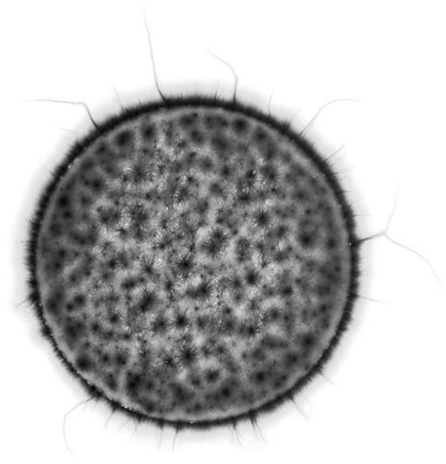
oak grown in Penrith, NSW, by retired engineer and all-round excellent nutter Ted
15,000 volts AC at 250Hz over Aristatone orthographic film.

paper
(canson ingres)



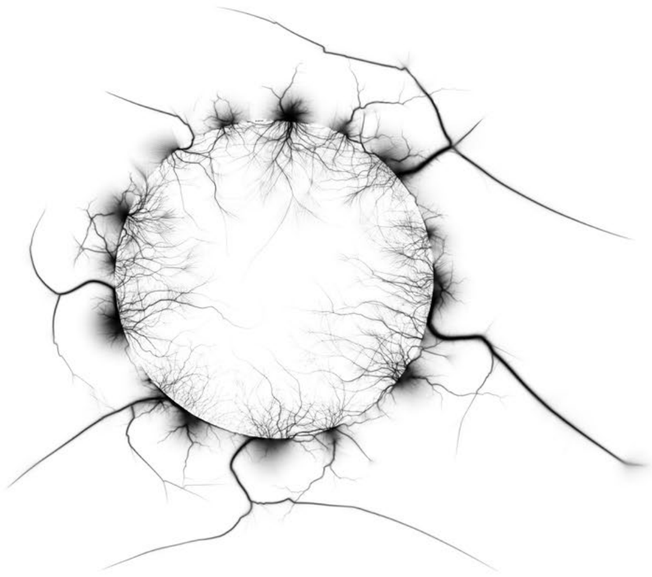
black canson ingres paper from artist and lecturer Ben, used for pen and laser machine drawings
15,000 volts AC at 150Hz over Avitone orthographic film.

paper
(cotton rag)



paper, hand laid with cotton fibres, for watercolour painting
10,000 volts AC at 80Hz over Avitone orthographic film.

perspex

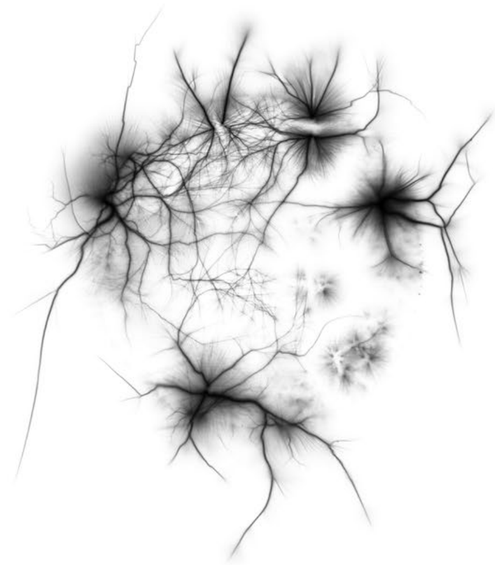


clear polymethyl methacrylate (perspex), salvaged from a broken picture frame found at the local garbage tip
12,000 volts AC at 1000Hz over Arista orthographic film.

pigment
(cobalt)

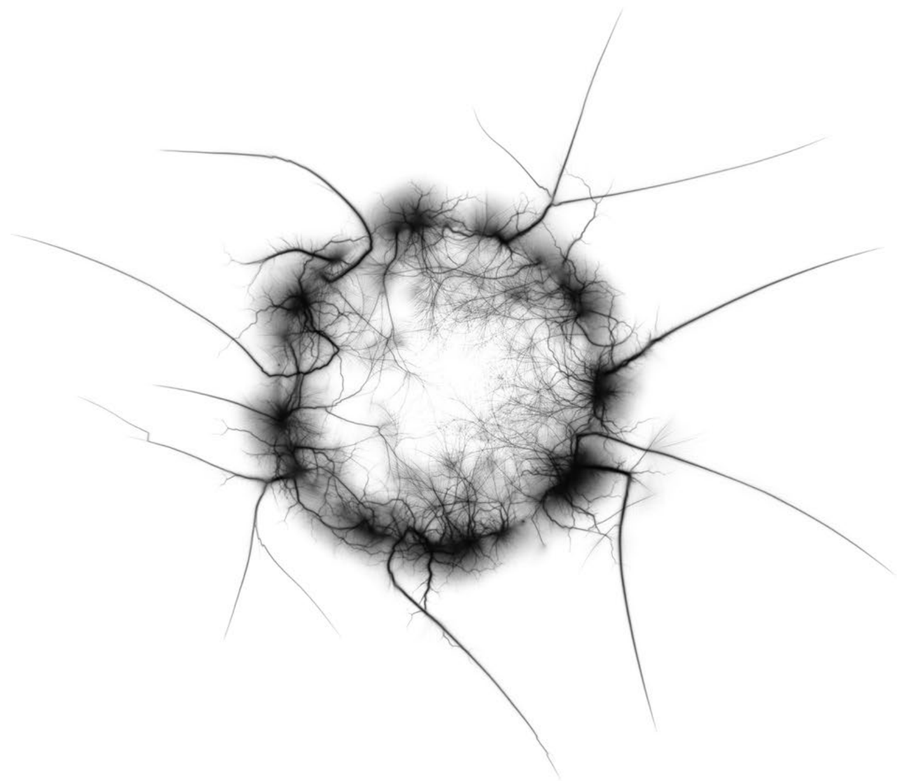
cobalt watercolour pigment from children's book illustrator Owen, bound with gum arabic and assorted fillers
10,000 volts AC at 400Hz over Arista orthographic film.

plaster



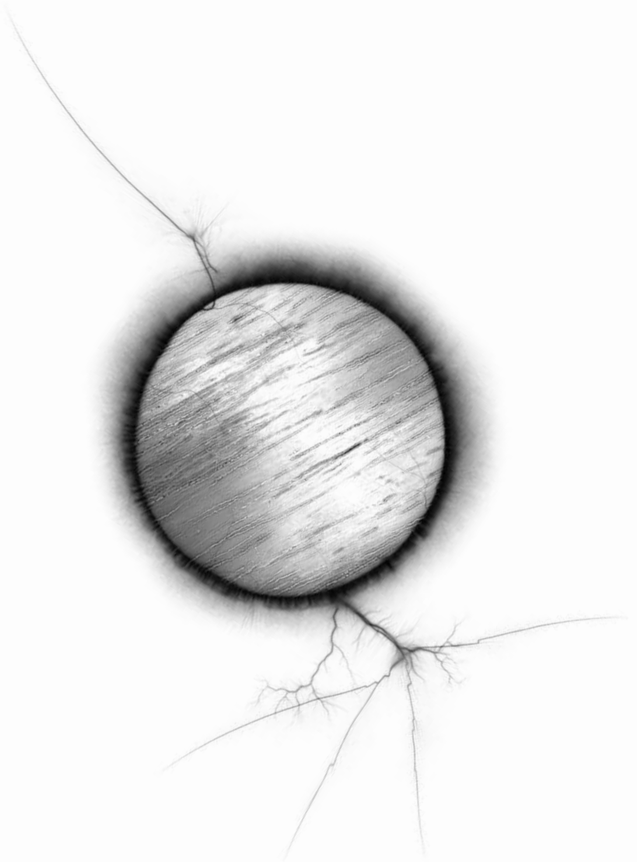
gypsum plaster cut from an old mould once used to create plastic jewellery parts
15,000 volts at 120Hz over Regent Royal orthographic film.

plastic
(unknown kind)



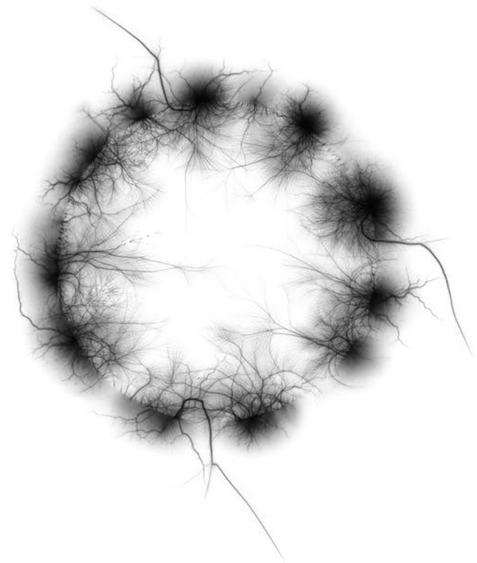
unused plastic drink token from Berlin nightclub Postbahnhof, of unknown composition, found in my jacket pocket 2 years later, setting the basic size parameters for all other sample discs explored here
20,000 volts AC at 150Hz over Arista orthographic film.

plywood



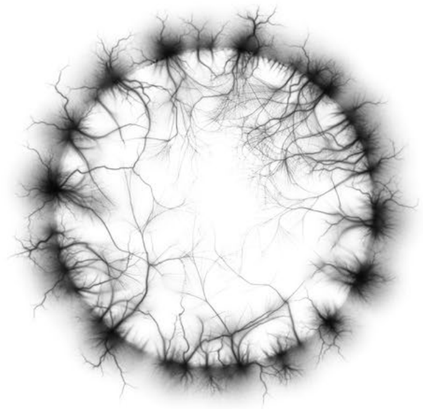
plywood from small boat builder Sam
15,000 volts AC at 800Hz over Arlstatone orthographic film.

polyethylene
(high density)



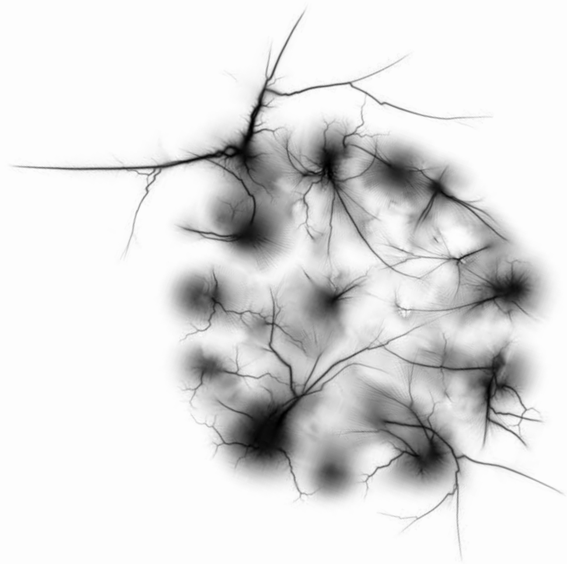
high density polyethylene from contemporary jeweller Mark, formed by fusing used milk containers into sheet under heat and pressure in his kitchen oven (the use-by-date ink shows through in embedded layers), to be used for making contemporary jewellery artwork stuff
10,000 volts AC at 2000Hz over Arista orthographic film.

polypropylene



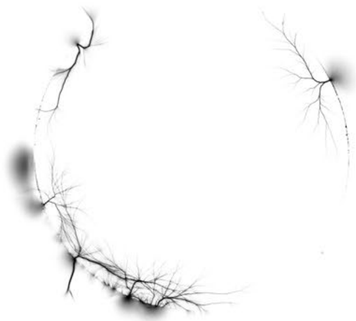
polypropylene salvaged from the base of a broken electric kettle
10,000 volts AC at 2000Hz over Arista orthographic film.

polystyrene
(expanded)



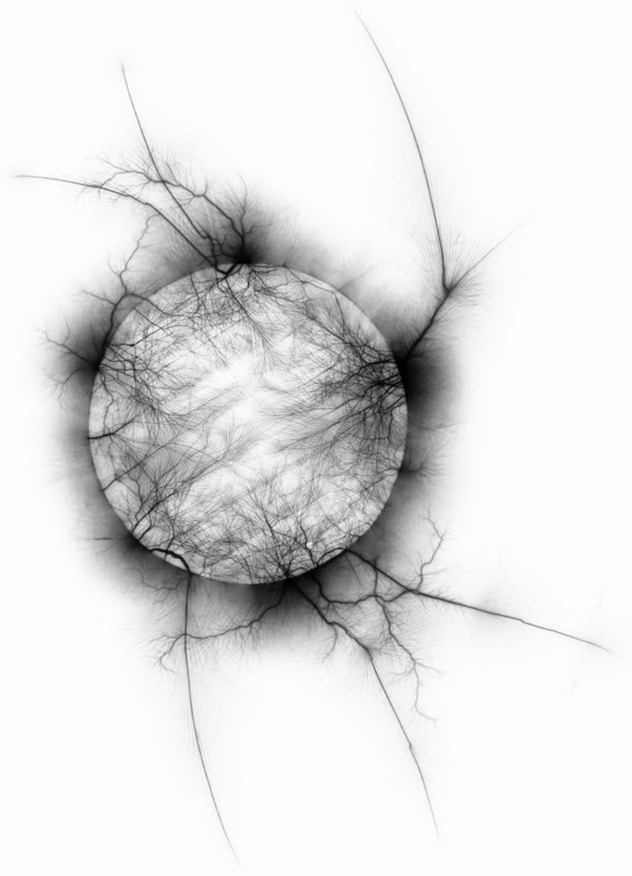
expanded polystyrene foam cut from the thermal insulation in my bus, where it really doesnt work very well to protect
from the cold Antarctic winds that blow over the frosty fields in front.....
15,000 volts AC at 1000Hz over Arista orthographic film.

porcelain



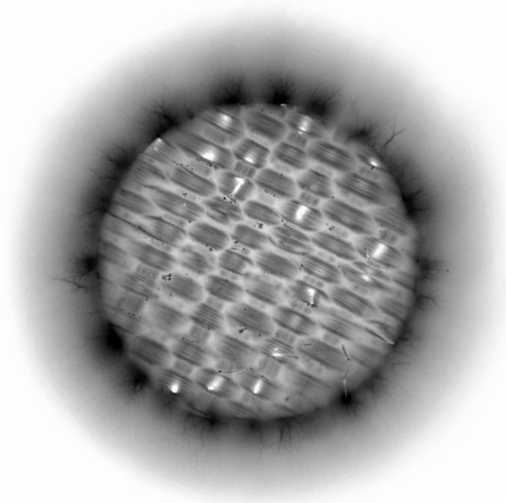
porcelain from my favourite plate which broke under the weight of a dense gluten-free chocolate cake
5,000 volts AC at 5000Hz over Regent Royal orthographic film.

radiata pine



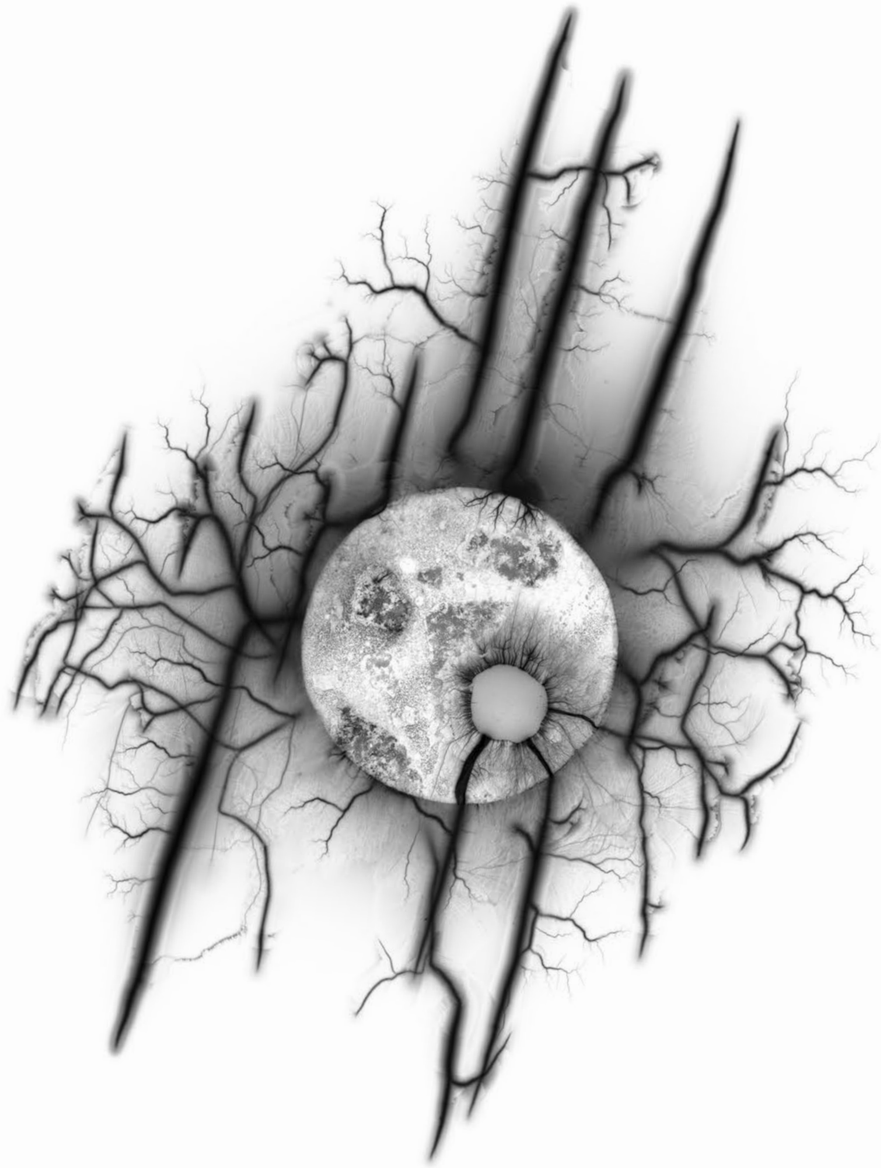
radiata pine from framing offcuts, the lengths of which were of course bought from Bunnings
15,000 volts AC at 250Hz over Aristatone orthographic film.

reed grass
(lomandra longifolia)



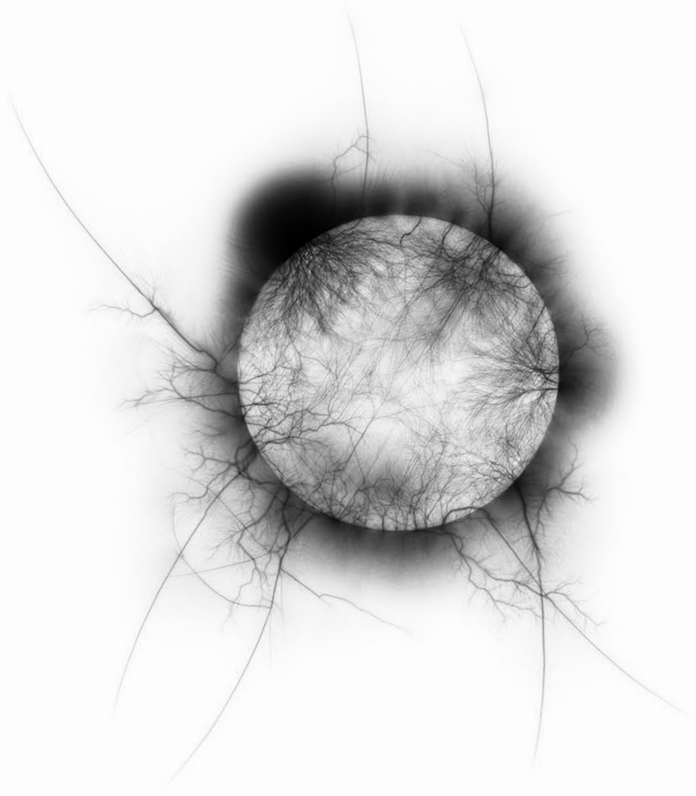
lomandra growing where I live, the leaves finely stripped, soaked, dried, and woven into a plain basket weave
12,000 volts AC at 100Hz over Arlstatone orthographic film.

reinforced concrete



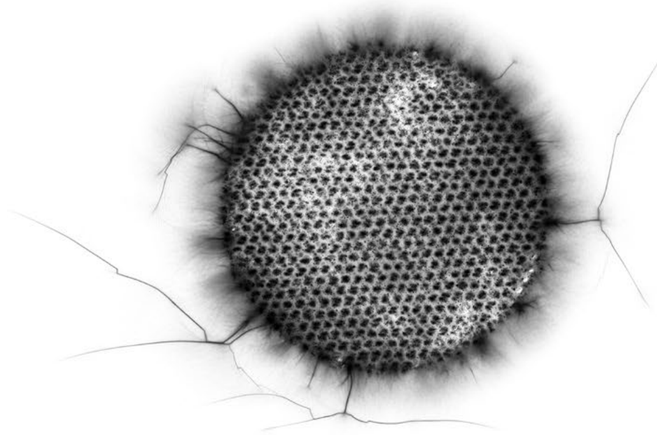
reinforced concrete cut from the footings of a demolished building outside the Huonville coin-operated laundromat
25,000 volts AC at 60Hz over Ilford Ortho film.

rock maple



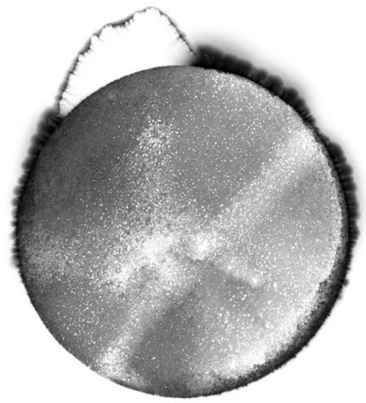
rock maple, taken from a length of timber used to make a baroque recorder that I never learned to play and subsequently burnt in frustration, from a tree grown in Canada
15,000 volts AC at 250Hz over Aristatone orthographic film.

sailcloth
(cotton)



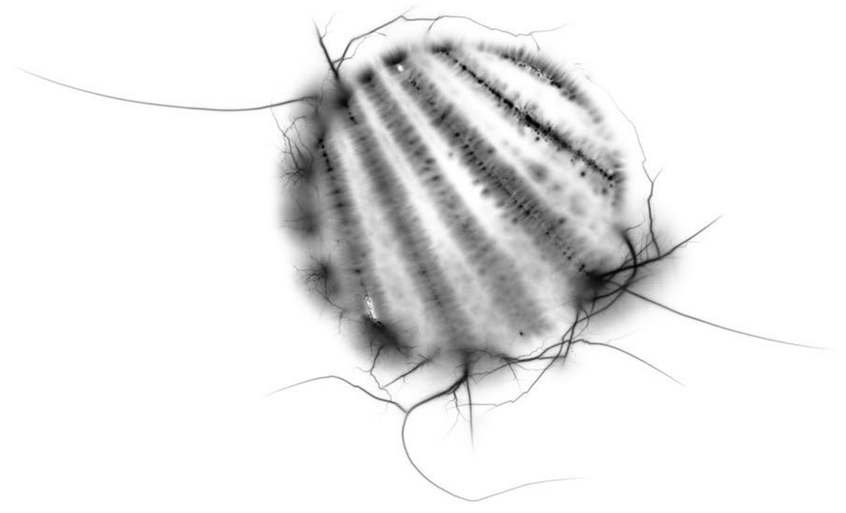
traditional woven cotton sailcloth, collected from tent-making offcuts
15,000 volts AC at 300Hz over Aristatone orthographic film.

sandstone



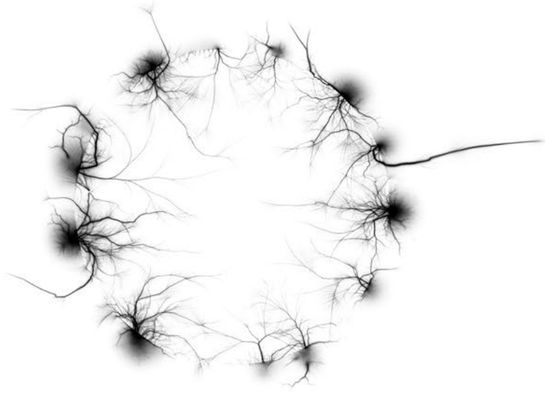
sandstone found along the lower ridges of my property, above where the alluvial earth has been laid down
15,000 volts AC at 2500Hz over Ilford Ortho film.

shell
(scallop)



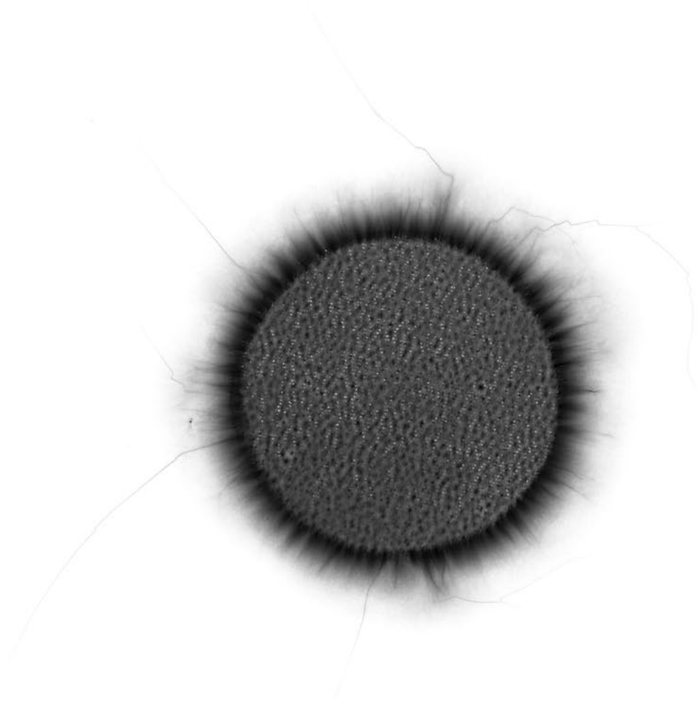
scallop shell found on the coast near Hobart airport, which was later used to cut kelp leaves for another sample....
15,000 volts AC at 300Hz over Regent Royal orthographic film.

silicon rubber



silicon rubber sheet bought from Tokyu Hands many years ago, used for cutting custom gaskets for
old Italian stovetop coffeepots
10,000 volts AC at 5000Hz over Arista orthographic film.

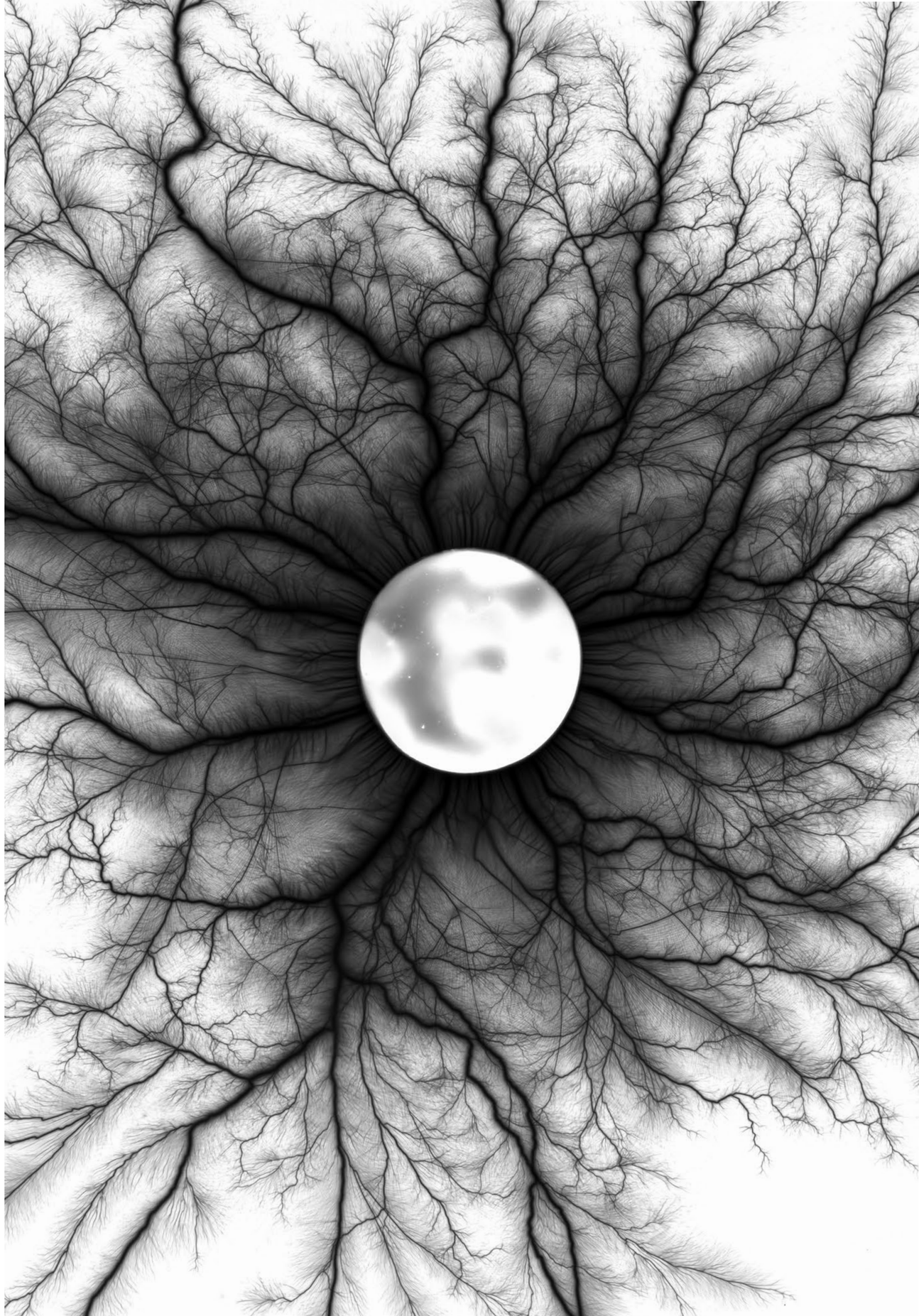
silk



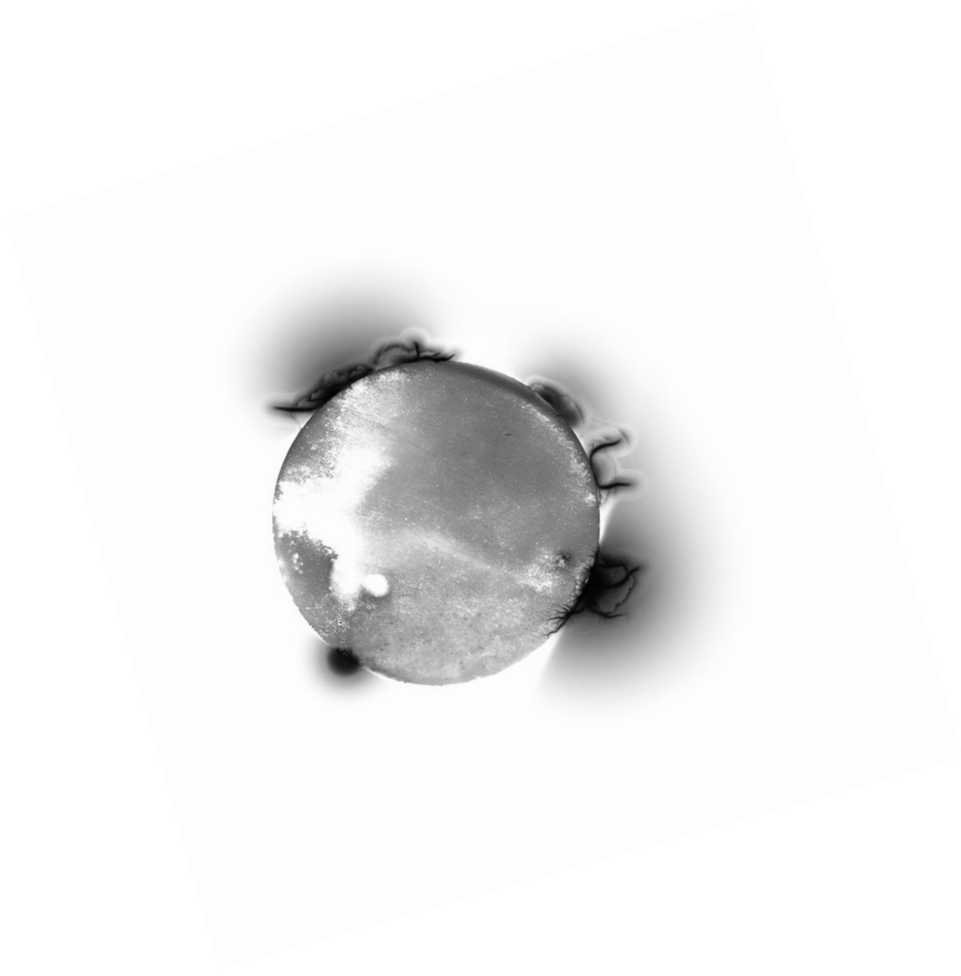
orange silk from a secondhand kimono bought at the Hanazono shrine market in Tokyo, repurposed for jacket lining
10,000 volts AC at 600Hz over Regent Royal orthographic film.

silver

pure silver disc, cast for these experiments, here displaying the fact that it is the most conductive metal in existence
40,000 volts DC over Foma 100 panchromatic film.

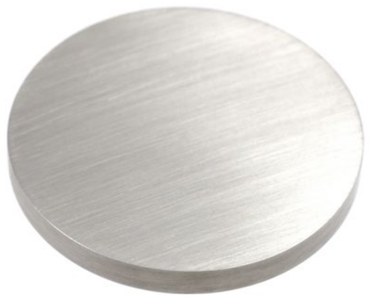


slate

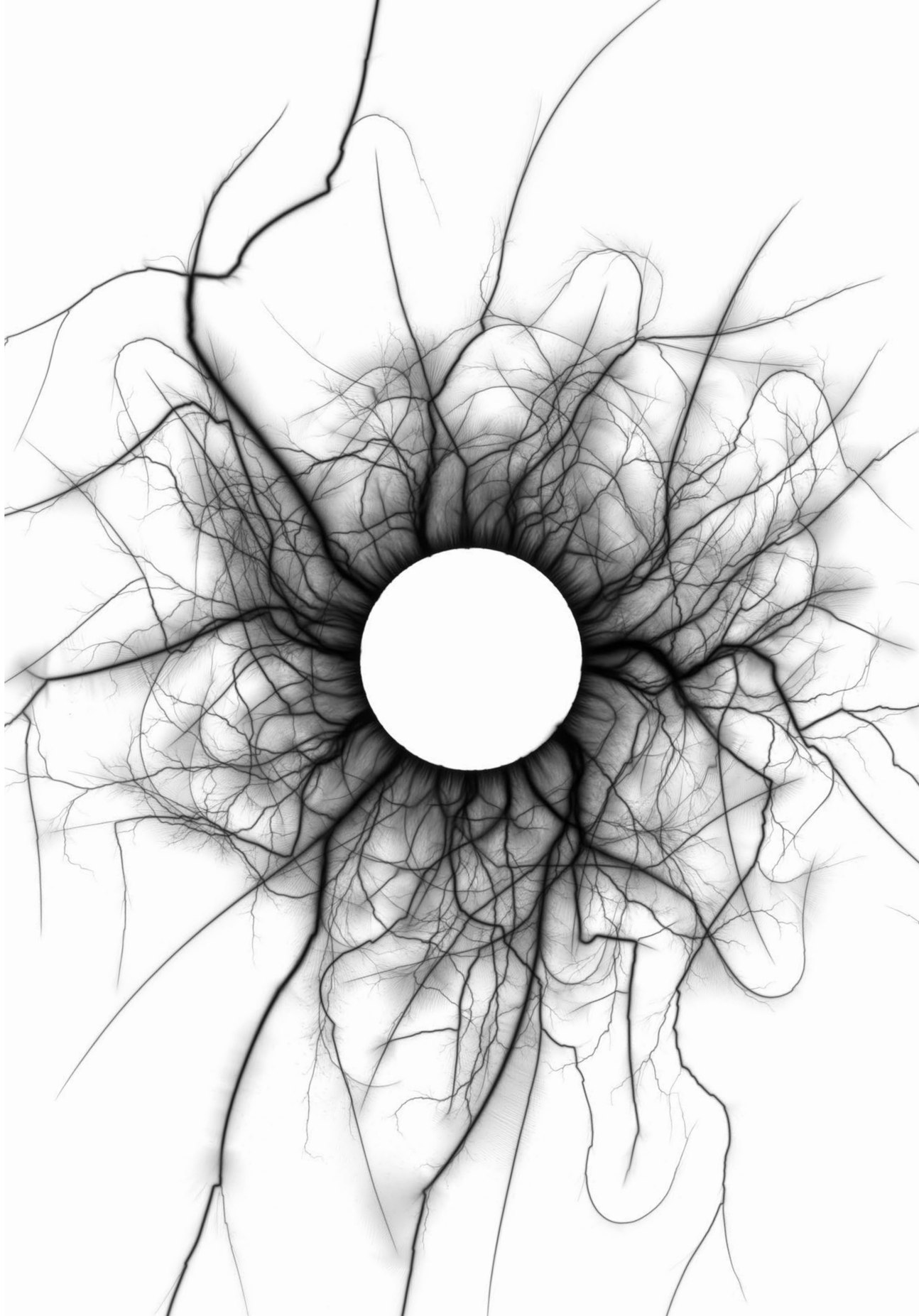


dark grey slate, carved from a piece of floor tile that I hoped would be part of the house I one day build...
15,000 volts AC at 1800Hz over Ilford Ortho film.

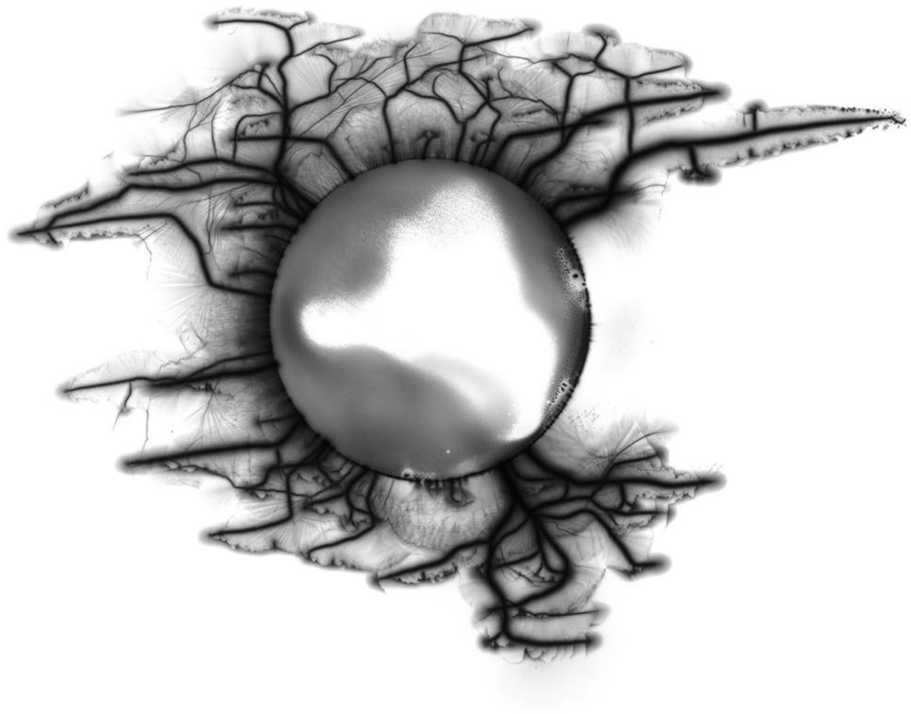
stainless steel



316 grade austenitic stainless steel lathed from bar stock, sourced from Australian manufacture, and previously used for lathеing complicated kinetic ball race jewellery
30,000 volts DC over Arista orthographic film.

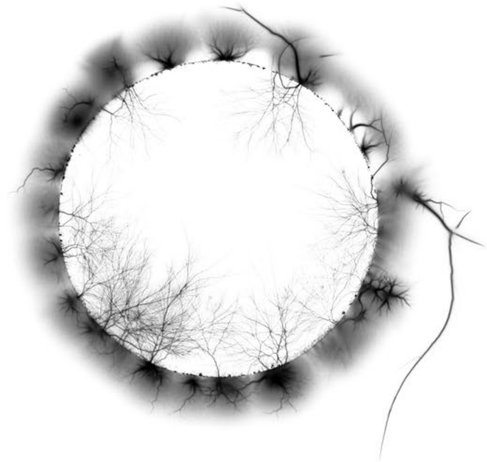


tantalum



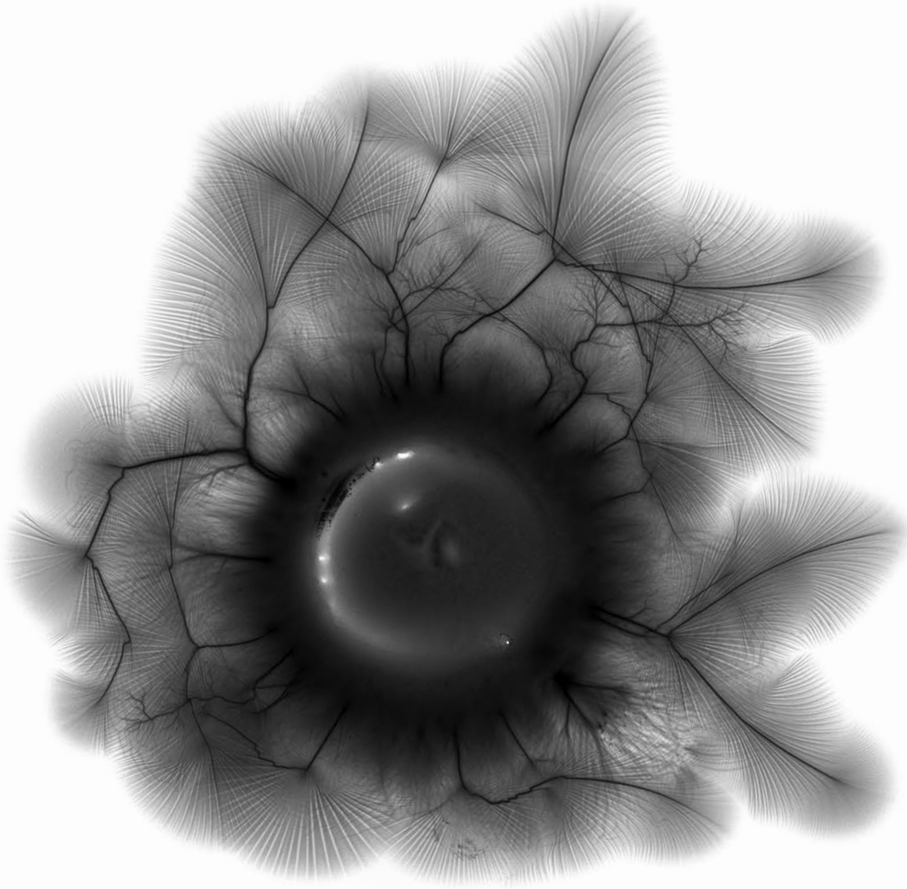
tantalum, one of the most beautiful metals i have ever worked, cut from plate stock i once kept for making jewellery,
sourced from a refinery in Jiujiang, China, that has a mine directly on site
20,000 volts DC negative polarity resonant pulse, over Ilford FP4 panchromatic film.

terracotta



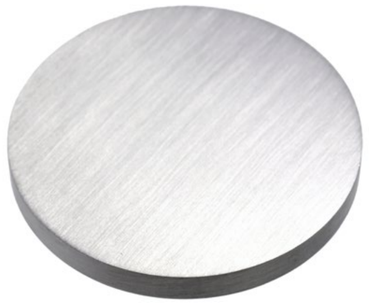
terracotta low-fired clay, from a broken planting pot originally made in Spain and shipped all the way to Australia
10,000 volts AC at 400Hz over Regent Royal orthographic film.

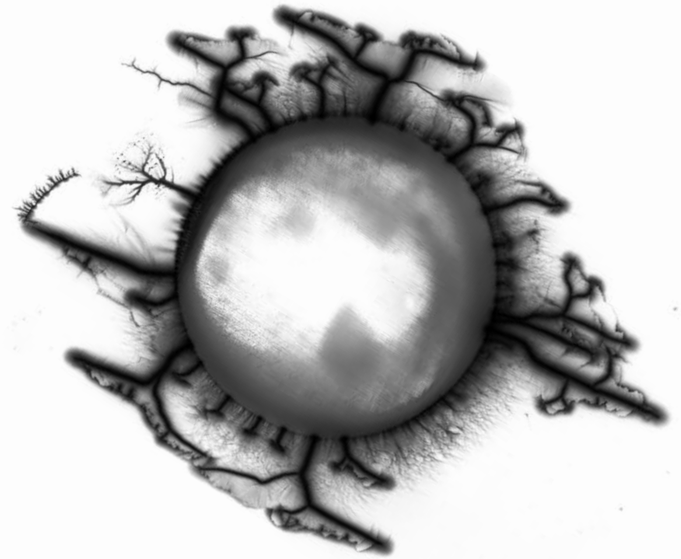
tin



tin sourced from a scientific element seller, melted in an empty baked bean tin and poured into a mould
20,000 volts AC at 20Hz over Kodak Tri-X panchromatic film.

titanium

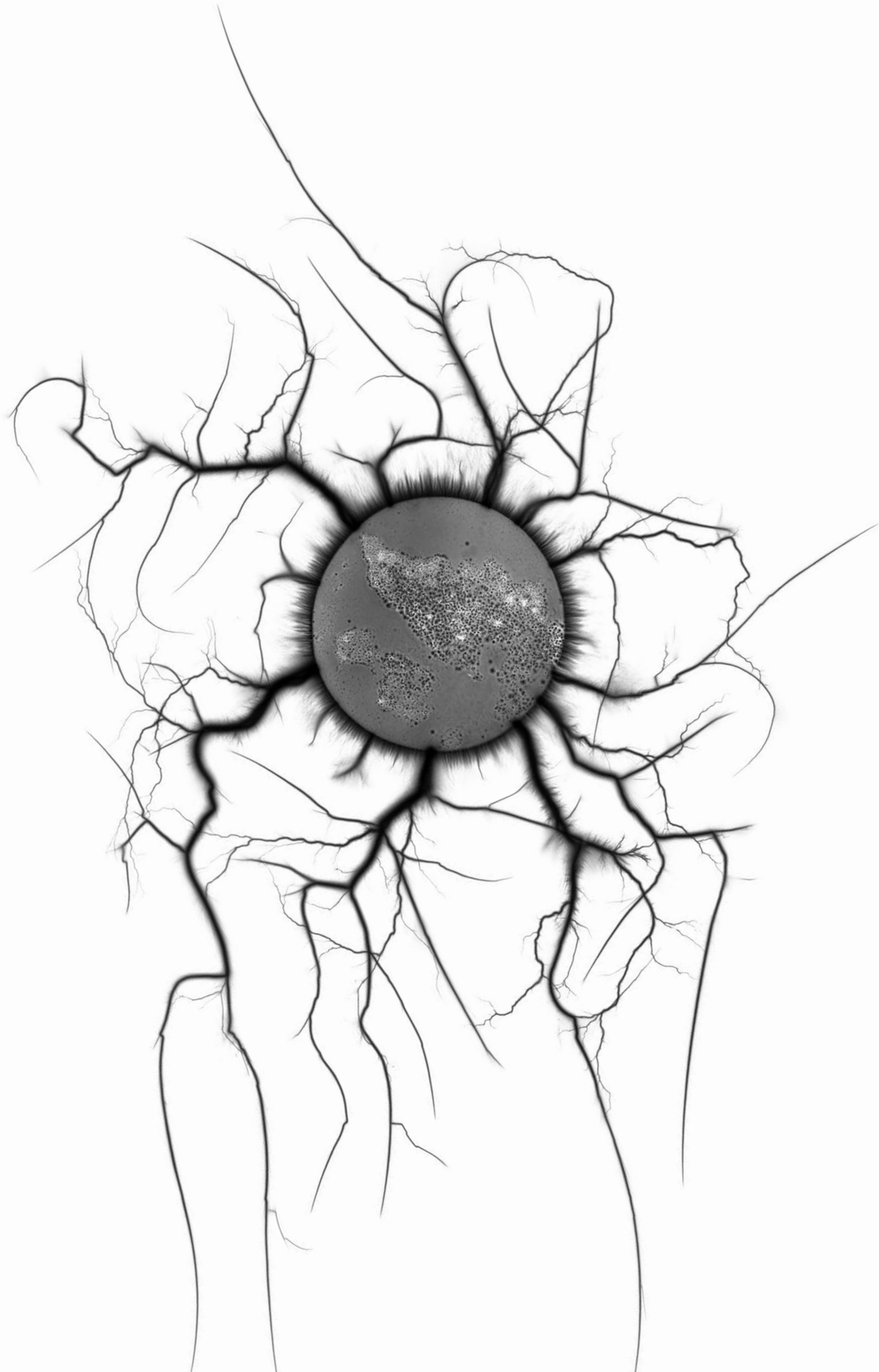




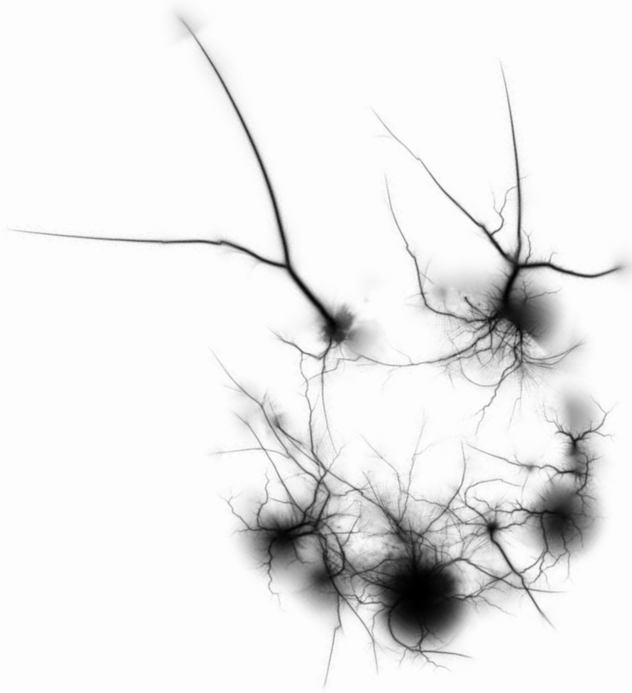
grade 5 titanium from my stock of metal round bar, bought through ebay and difficult to trace the origin of,
used in the latheing and fabrication of intricate lightweight jewellery
20,000 volts DC negative polarity resonant pulse, over Ilford FP4 panchromatic film.

tool steel

oil hardening medium-carbon tool steel used for making knives, hardened but untempered
30,000 volts DC and 5,000 volts AC at 120Hz over Regent Royal orthographic film.



urethane foam

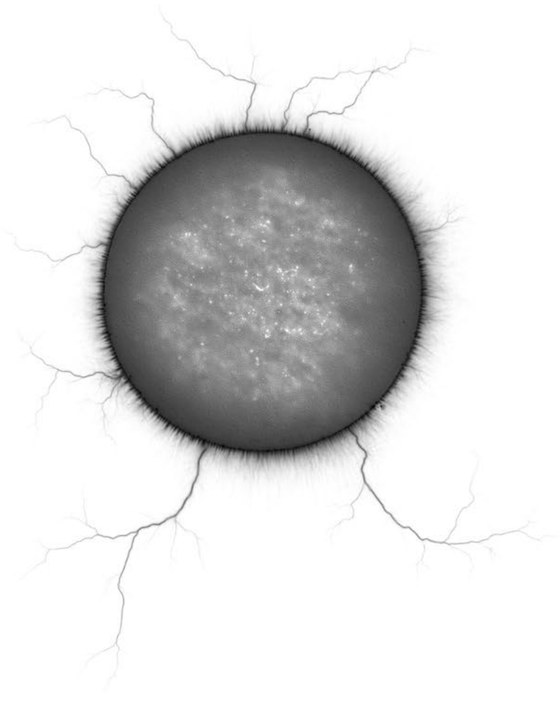


polyurethane “spray” foam from a pressurised disposable cannister, used to insulate a shipping container door,
is a truly awful material, the use of which should be avoided
15,000 volts AC at 150Hz over Arista orthographic film.

urethane rubber

urethane rubber poured from 2-part liquid, used for mould-making
8,000 volts Ac at 1500Hz over Arista orthographic film.

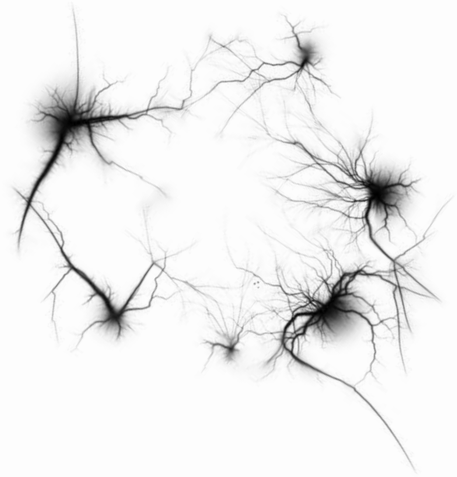
vellum



calf skin vellum purchased from St Petersburg, Russia, for the restoration of old books
12,000 volts AC at 250Hz over Rollei Ortho 25 film.

wax
(bees)

beeswax chewed out of tasty local honeycomb, for use in a simple wood polish

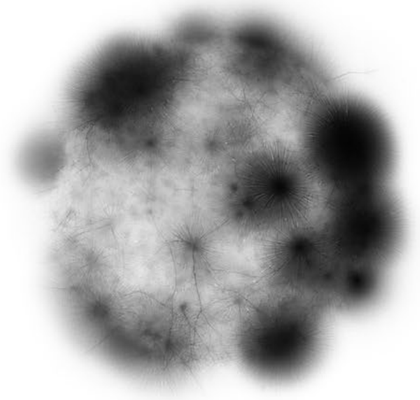


10,000 volts AC at 200Hz over Regent Royal orthographic film.

weathering steel

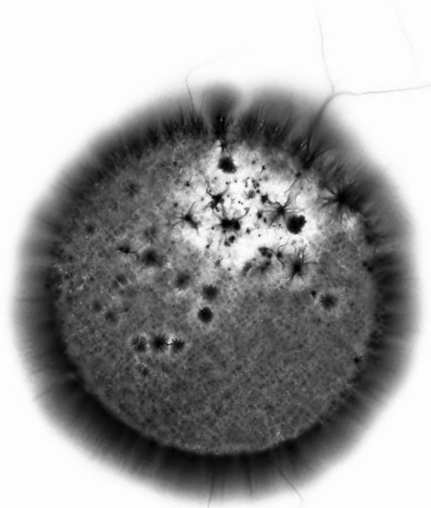
lyten weathering steel from sculptor Robin, used in large heavy decorated doors on his workshop
30,000 volts DC and 5,000 volts AC at 250Hz over Regent Royal orthographic film.

wool felt



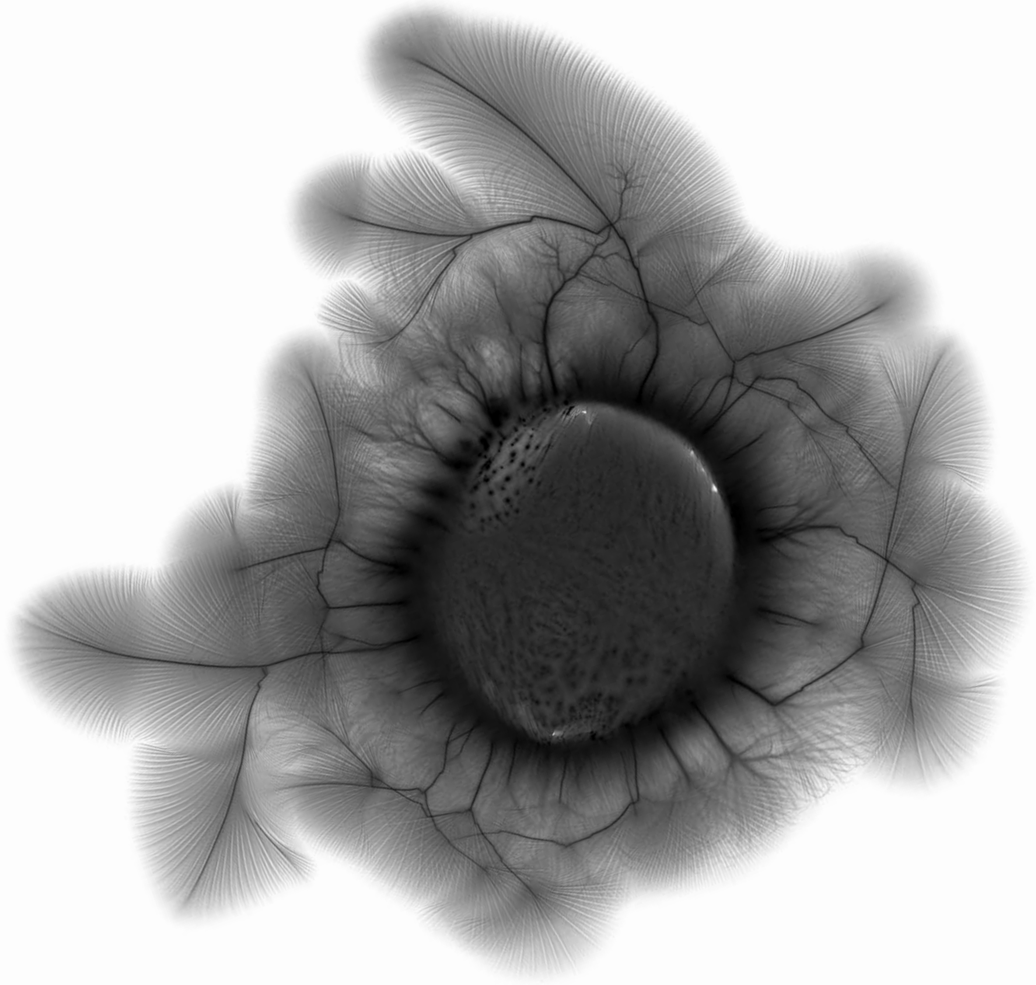
wool felt manufactured in Germany, previously used for restoring key padding in an old piano
10,000 volts AC at 120Hz over Avitone orthographic film.

wool
(woven fabric)



woven wool crepe fabric used for sewing a pair of wonderfully comfortable pants on my old singer treadle machine
15,000 volts AC at 250Hz on Avitone orthographic film.

zinc



zinc sourced from a scientific element seller, melted and poured into a mould
20,000 volts AC at 20Hz over Kodak Tri-X panchromatic film.

"These atoms are the alphabet of the universe
and their order determines the verses they make: the sky, the sea,
the rivers, the sun, the crops, the trees, and the living beasts.
They are not all the same, but they share in common many
fundamentals, the differences being in how they combine.
My verses and the world's are alike in this - the order,
position, and disposition change, and the world is changed."
- Lucretius, *The Nature of Things*, 1st Century BC.

material notes

Acrylic is a modern plastic (polymethyl methacrylate) that is everywhere in our daily lives, first produced in the early 1930's. This fluorescent acrylic was from my grandfather, who used the material to make stable and accurate master guides for 3-dimensional engraving of steel tools for die casting, on his German pantograph. The disc was cut from a larger piece - a 5:1 scale guide made for a 1970's Westinghouse fridge badge, to be carefully engraved into a steel die, later used for pressing softer metals into badges. Acrylic is used for a variety of purposes, being easily manufactured and formed, into transparent windows and numerous small consumer parts, being especially useful where exposed to the elements, with its high environmental stability (relative for a plastic).

Aluminium is a crap material, but has its uses. It is lightweight, stiff, and fairly soft. It is most often used alloyed with other metals, to increase its strength while still maintaining a low weight. It is often used in situations where light weight and high strength need to be balanced, such as in aeronautical applications, or in circumstances where it is cost effective, due to it being very inexpensive. It is the third most abundant element on our planet after oxygen and silicon, but is rarely found pure, due to is reactive nature, occurring rather as ores in various minerals such as bauxite (its primary commercial source). Its refinement from ores requires less heat and energy than many other metals, and this is reflected in its end cost. The metal was first separated in 1824, though its history is deeply bound with that of *alum*, a natural compound of aluminium, used for textiles dyeing many century BC. Its name comes from the Latin *alumen*, meaning "bitter salt", referring to the initial compound alum, and its taste.

Bone is the rigid organ forming animal skeletons, often collected from slaughtered livestock. This sample was prepared from the hind leg of a cow that was likely grown in the highly cramped conditions of modern farming, and sold as a dog bone by a local butcher. Bone is composed mostly of a calcium salt bound with collagen (thus combining compressive and tensile strength), structured in a matrix that gives it light weight, flexibility, and durability, with directional properties from its organic growth. I wear a mask while working it - the dust feels slightly greasy and gross, though it was boiled, bleached, and thoroughly dried. Maybe it is just me being a vegetarian and a little weird about it....
Its use as a material is prehistoric, such as with bone tools, which were widespread due to the ease of finding and working the material. It has also been used as decorative material in carving, as reliquaries and memento moris, boiled for glues, and burnt to make char for filtration and pigments. It has always had a strong connection with the afterlife, perhaps due to the internal hidden nature of bones, and their lasting permanence in decomposition when compared to the rest of the body. Bone is a potent symbol, aligning itself somewhere along the continuum between the positive proactive forces of life, and the ultimate power of death and time. It also holds connotations of ancestry, and of basic foundations.

> "In seed time learn, in harvest teach, in winter enjoy.
> Drive your cart and your plow over the bones of the dead..."
> -William Blake, *The Marriage of Heaven and Hell*, 1793

Brass is a golden coloured alloy of copper and zinc (often with other minor metals alloyed in). It is easily worked cold, and casts well. Its history is tied up with that of zinc, and it seems that major production and use first occurred in India during 2nd millennium BC, where zinc was distilled in a similar way to mercury, to be used for the manufacture of brass. It is often used mechanically for low friction applications such as gears and valves. It has minor bactericidal properties, being used for food containers through history. It also has a long tradition of use in ceremonial ware, likely due to its ability to be easily formed and take on a lustrous golden shine that captivates the eye.

> "Brass shines as fair to the ignorant as gold to the goldsmiths."
> - Queen Elizabeth I, 1581

Brick (modern) is mostly sand and clay, fired over 1000°C in blocks to create a durable building material.

> "...well, the wolf huffed and puffed but he could not blow down that brick house...."
> - Joseph Jacobs, *English Fairy Tales*, 1890.

Brick (old, hand-made) contains a greater number of impurities and has a lower strength and durability due to its unevenly mixed composition. It is, however, beautiful, and there is the obvious touch of a hand upon it, in its composition and final form. Various local clays are mixed in this brick, each containing various iron oxides and other trace minerals that naturally colour the clays. This brick was collected in Southern

Tasmania by Beatrice, where it was part of a demolished building on the coast.

Bronze is an alloy of copper, with 5-15% tin, creating a metal that is strong and durable, and hard enough to use for cutting edges when worked cold. Its ability to be cast into intricate shapes lends its use to detailed decorative items as well. Its surface takes on a range of beautifully coloured patinas in reaction to the environment, most notably the typical green verdigris. Sources of tin were often located far from those of copper, and thus the production of bronze necessitated trade across cultures. The Bronze age began around 4th millennium BC, spreading across India, Europe and China, encouraging other important cultural, technological and intellectual exchanges alongside the trade required for its manufacture. It has been used for coins, weapons, musical instruments, in low-friction mechanics, and for sculpture.

Canvas is a heavy weight plain weave fabric made of cotton, also made historically of hemp and linen. It has been used for sails, tents, upholstery, and stretched as an artist's painting surface.

Carbon fibre composite is a material composed of two very different substances - strands of carbon filament twisted into thread and woven into fabric, and a matrix of epoxy resin (or one of many other different polymer matrices giving alternate qualities). The materials interact to create a stiff, durable and exceedingly lightweight composite that has found favour in many high-end applications. It is also a good electrical conductor, as can be seen in the spark discharge imaging. While it is a very high strength material, it ultimately fails in a brittle manner, requiring a completely different design process to metals for instance - using algorithmically calculated impact attenuators in complex force simulations to control and direct fractures in forms under load. The material has a high chemical resistance, and is used in many electronic or motive applications, due to the heat conductive properties of carbon. It is used in aircraft, satellites, civil engineering projects, automobiles and sporting goods. A sure sign of its techno-allure to the general masses is the proliferation of tacky fake carbon-fibre decals and decorative panels.

Cardboard is a loosely defined paper product, most often made from wood pulp, and used mainly for packaging. Its first commercial use was during the early 1800's for various packaging tasks, while it was popularised by cardboard cereal boxes made by the Kellogg company in the early 1900's. While its main application is in packaging, it is also used for such things as postcards, book covers, and picture frames. This sample was cut from packaging that arrived from overseas, containing a spellbinding book by French philosopher Michel Serres.

Cast iron is a high carbon iron alloy that is known widely for cookware. It is a somewhat brittle metal that is however easy to machine, and has a mild resistance to corrosion. One of its greatest qualities is its low melting point (due to relatively large amounts of carbon), which enables it to be easily cast. Cast iron is produced as a by-product during copper production, and many copper ores are bound with iron ores, and this may have lead to its early discovery and use - via the widespread refining of copper. It use dates back to China during the 5th century BC, where it has been found as farm equipment and weapons. It is a dirty material to work, somewhat soft when the outer carbon-rich skin is worked past, difficult to join in any way except cold connections, but excellent when conceived in full cast components. It is used for large pipes, automotive parts, machine stands, and various other engineering applications.
In the alchemical tradition, iron is ruled by Mars, and has strong connections to the element of earth. It brings connotations of blood, and of fire, passion, and war. Nowadays cast iron has closer connections with the more peaceful flames of the home hearth, and of cooktops.

Celerytop pine (phyllocladus asplenifolius) is a tree endemic to Tasmania, commonly found in wet forest areas. There are many branch inclusions, and the timber is often highly featured. It is an excellent material, well behaved, and able to hold fine sections under stress. It has a beautiful subtle floral / menthol fragrance. It is quite durable and was often used for cladding of houses before it became more difficult to obtain. This wood was milled by one of the local millers in my suburb, and used to clad my outhouse.
Celerytop pine, and all other woods, are complex biological materials. In their growth, trees build their body mass by aligning molecules into specific arrangements that are reactive to stress and gravity.

> "In the living tree, the structure allows for growth and repair. There are many things to be learned from biological materials, but the most universal is that biology builds its materials at many structural levels, and rarely makes a distinction between the material and the organism."
>
> - Christopher Hall, *Materials*, 2014.

Cement varies greatly in its quality, depending on its type, composition, its source, and processing. This is a common portland cement, made by the energy-intensive process of heating limestone and clay to over 1400˚C to create solid "clinker", which is ground with gypsum to create a final product. This sample has fine sand mixed in, and would be classified as a mortar rather than cement - cement being the pure binder, rarely used on its own. It is used to make concrete - one of the most common construction materials of our age - through the addition of aggregates such as sand and coarse gravel. Various types of cement have been in use for centuries, such as volcanic ash and lime mixtures used by the Romans, as used in the magnificent Pantheon of Rome, the immense dome of which is made without any reinforcement.

Charcoal is the lightweight black material left after heating organic materials in the absence of oxygen. This sample was made from celery top pine sealed in a steel box in my ceramic kiln. It has been used for industrial and domestic heating since ancient times, and also in the production of explosives, pigments, and filters. Its use as a filter and purifier is made possible through its large internal surface area, which adsorbs certain contaminants, especially volatile organics. There is something beautiful and pure about charcoal, especially high fired charcoal like this - it has a crystalline quality, and feels as if it has moved beyond death, of the organic matter which it once was, and has become something truly other - strange and peaceful.

clay (unfired) is mostly silicate minerals arranged in a microscopic sheet-like structure that lets the material slip around at a molecular level, hence its squidgy plasticity. It also contains water at the molecular level (even when "dry", but not when fired at high heat), further accentuating its plastic nature. This clay was dug from the sides of the creek that borders my property, which is on Pottery Road, so named for the pottery works that was its main building at one point. It was dug out, the stones and sticks removed, then thoroughly dried, crumbled to dust, removing any further stones or sticks in the process. The dry clay dust was then slaked with water to soak it to a delicious slip, the remaining sand removed through settling, and other organic impurities floating to the surface, or caught with fingers. This slip was laid out on canvas and dried to a consistency that was workable, and finally kneaded to make a uniform clay for use.

> "Clay is ubiquitous. If you gathered it all up and spread it evenly over the surface of the earth like peanut butter, you would create a mud layer a mile in thickness. Certainly, there are places in the world where there is no clay - deserts, some mountains ranges - but in most areas of the world, it is readily available, often plentiful."
>
> - Suzanne Staubach, *Clay*, 2005

concrete is one of the most commonly used building materials in the developed world. It is made up of coarse gravel or stone aggregates and sand, held together by a cement binder that sets hard and strong. It can be further strengthened by pre-formed reinforcement such as steel bar or basalt composite mesh, or, by adding short fibres of polymer or steel into the mix. It is high in compressive strength, but relatively weak in tension, which is why it is most often reinforced in some way. In use it has often been referred to as "liquid stone", and one of its most characteristic features is its ability to take on almost any shape, provided that the formwork used to hold it while it sets can be made to support its heavy fluid weight as it hardens. Its strength is legendary, and "concrete" is often used in language as a metaphor for something that is solid and unchangeable, or something fundamental - a basic framework or bedrock.

copper is a pure metal that is pinky-orange in colour - *copper*-coloured, in fact. It is highly conductive of heat and electricity, and is relatively soft until worked cold, when it begins to harden and become brittle. It was one of the first metals to be used in prehistory, due to it being one of the few elemental metals to occur commonly as native ore, ready for use without refining or processing. It is used as a constituent of many alloys, such as bronze, brass, and monel, where it forms one of the main components. It is an indispensable part of our modern technological society, in the cabling of the electrical infrastructure through which most electricity is delivered, as well as in supply transformer coils, and in electrical motors windings and the like. The coils of one of the step transformers used in these discharge images was hand-wound using copper wire as thin as a hair, around a laminated steel core, all connected up through yet more copper wire. It is an integral part of the success of modern electrical power use, industrially and domestically. Average global use of copper stands at around 11kg per capita per year, and it is a finite resource which is often extracted from environmentally devastating large open-cut mines.

> "Over the entire 20th century about 170,000,000 tons of copper were produced and converted into manufactured goods in North America, of which about 60 percent remains in use, and 40 percent has been discarded, much into landfill. This discarded total is about 50 times the annual consumption of new copper in North America."
>
> - Christopher Hall, *Materials*, 2014

cork is the bark layer of the cork oak, the production of which is centred in Portugal. The main properties of cork are its elasticity and impermeability, which are the reason it is used to seal bottles and as a gasket

material. It is lighter than water, insulative with regards to heat and electricity, and is, surprisingly, fire retardant. It is used for many applications, notably for wine bottle corks, floats, gasket seals, and flooring tiles, and is often reconstituted into slabs from smaller offcut bits, for cheaper applications.

corrugated cardboard is a fibre based (mainly wood pulp) material made of 3 or more layers of standard cardboard, the internal layer(s) rippled and laminated between flat outer sheets, to create structural strength and cushioning. It was first produced in large quantities in New York in the 1870's, and is used as a shipping material - a great many of our goods have been transported within it at some point.

damascus steel (as is commonly known and shown here) is formed by forging together layers of different steels, usually high carbon and low carbon, to make a material that is hard and takes a fine edge, but is also resistant to fracture and shattering. The true nature of historic "damscus steel" in under contention and may refer to wootz steel, a specific alloy which has hard iron carbides in suspension, from its slow cooling at a high soaked heat. There is a lot of mythology around the name. It could be named after the capital of Syria where it was first sold, or after Damask pattern-woven fabrics made around that time. Its process is labour-intensive and damascus steel was a very expensive material. Its creation involves laying up several alternating sheets of steel, and forging them under high heat to bond them, beating this out thin and refolding it over itself many times, to create thousands of complimentary layers of steel within one blank. The blank is often coated in clay slip to prevent rapid oxidation and loss of carbon, with various materials added to the slip, such as rice husks or straw, adding traces of silica and carbon in the process. its creation was a closely held secret in history, but is nowadays manufactured by hand and small industry as a luxury material, and its typical use for weapons and blades has shifted to kitchen knives for fancy cooks like me.

dolomite is a sedimentary rock found around the world that is composed mainly of a calcium-magnesium-carbonate mineral of the same name. It is of medium hardness, has several cleavage planes, and a fine crystalline structure that can be seen upon close inspection. Dolomite rock is often used for road base and other aggregates due to its large deposits and easy sourcing.

ebony is a dense, dark, and waxy hardwood from various species of endangered trees mainly growing in wet African lowlands . Many species are extremely slow growing (2cms per year) and have been harvested to the point of near extinction. It is often illegally obtained from protected parks by poachers who are willing to risk the work, as it is valued so highly, because we demand the wood for our clarinets and pianos. It is a beautiful material, hard, prone to splitting, but able to take a high finish, mostly used in musical instruments, and other decorative or fine woodworking. This ebony is from offcuts supplied to me after a call-out to all my maker friends, when I wanted to make a piece of ebony jewellery. I got more than I needed, as nobody was willing to make anything out of it, because of its bad ecological and moral connotations. It is an exhausted resource that is also a living organism part of a delicate biological community.

fibreglass (or glass-reinforced plastic) is a composite material of glass and plastic resin. The making of glass fibres dates back to the late 1870's, when it was woven into cloth, often with silk, into a durable and flame retardant industrial material. Glass-reinforced plastic developed after polyester resins were invented in the 1930's, using spun fibres of fine glass strands, mass produced, woven into a mesh, and laid up with liquid polyester resins, to set into strong, lightweight composite panels. The material is used in boats, planes, watertanks, surfboards and many other applications.

Firewood (eucalyptus globulus), otherwise known as Southern Blue Gum, is a beautiful tree that just happens to be in abundance on my property, also as dead, dry trees perfect for burning in a wood stove. It is one of the most widely cultivated of native Australian trees, and is the primary source of eucalyptus oil. Its pink to brown wood is dense, and sometimes used in coarse construction work.

> "6th. I had not as yet been able to procure any of the flowers of a new species of the eucalyptus... This tree, which is one of the tallest in nature, as it grows sometimes to the height of 150 feet, blossoms only near its summit... We were obliged to cut down one of these trees in order to obtain its blossoms. Being already in a slanting position, it was easily felled. As the sun shone very bright the sap was mounting in abundance, and as the tree was cut down it flowed very copiously from the lower part of the trunk. This beautiful tree, which belongs to the tribe of the myrtles, has a very smooth bark....The seed capsules are open at the top, and are generally divided into four partitions.... It is shaped like a button; on which account I have denominated this tree *eucalyptus globulus*."
>
> - Jacques Julien Houton de Labillardière, *Voyage in Search of La Pérouse*, 1798.

fur is the hide of certain mammals, skinned and preserved with the hairs intact. The oily outer hairs and thicker inner guard hairs create a warm insulative material held together by a layer of preserved skin, that has been used since prehistory for clothes and other purposes. Modern mass manufacture of clothing, exacerbated by luxury marketing of fur, has led to horrendous treatment of live animals used in its supply, which is now in decline from pressure by environmental and moral lobbying. This is another clear instance of materials being supplied to the end user without any clear understanding, or responsibility, for the methods of that material's procurement and processing. This fur was obtained from roadkill in Southern Tasmania, of the small marsupial pademelon, whose skittish behaviour on night-time roads leads to many of them dead through car accident. It was prepared simply using alcohol and controlled drying, by local jeweller Nataša.

glass is one of the most influential materials manufactured by humankind. From its modern use in optic fibres, light bulbs, glass insulation, microscopes and eye-glasses, car windows and sky-scraper facades, to its ancient use in small decorative elements, glass has been put to a broad range of uses. It is defined as being somewhere between a liquid and a solid (because of its internal amorphous structure), but to our immediate senses, glass is known for its brittle nature, and the dangerous sharp shards its fracture produces. It can be tempered and hardened through controlled cooling, and mineral additions can alter its qualities for specific purposes. It comes in sheet, rod, strand, fabric, and loose strand wool. It is typically made from heating sand (silicon dioxide), lime, and soda, and then rapidly cooling, to stop it from crystallising, resulting in the clear, brittle material without internal atomic order, that we know as glass.

Gold (aurum) has been sought after throughout all history, and valued above all other materials. It is soft, inert, easily worked, does not tarnish, and is one of the few metals that can be found naturally occurring. However, it is largely "useless" for many purposes due to its softness, but rather, it is desirable - in jewellery, coins, wealth, and ornament. Clearly we are not driven simply by need and necessity, and gold embodies these more abstract desires. It is essence, soul, and all we hope for. Or it can be simple greed. In many cultures gold has been used as an exuberant form of decoration and adornment. It seems that many of us now prefer to look away such beauty in vaults, and count its financial value on computer screens in stock markets. What does this say about our world and where we are heading?
In the alchemical world, gold is the ultimate metal, the final expression of spirit - purified and fully realised. It is represented by the sun in astrology, the giver of life and light and warmth.

> "Sol gold is, and
> Luna silver we declare,
> Mars yron,
> Mercurie is quyksilver,
> Saturnus leed,
> and Jupiter is tyn,
> And Venus coper,
> by my fathers kyn."
>
> - Geoffrey Chaucer, *The Canterbury Tales*, 1476.

graphite (plumbago) is a crystalline form of carbon, naturally occurring, identical in composition to diamond, but different in atomic structure. Graphite has a structure of hexagon atoms arranged in sheets, giving it its soft and slippery nature. Diamond forms 3-dimensional frameworks, which in contrast make it extremely hard. Graphite is very soft, and cleaves apart in layers easily, but is highly resistant to heat and chemical attack. It also has interesting electrical properties, and is used as a resistive conductor in various applications, such as electrical components and motor brushes. Synthetic graphite such as this sample, is often used as a solid lubricant in industry due to its slippery nature, and also in high heat applications, such as melting crucibles and furnace parts.

hair (human) forms out of follicles on our skin, and is composed primarily of keratin cells, alive at the root, but dead along the strand. This hair was taken from my own head, after cutting off a particularly bad pony, and needled and massaged and felted into shape. Hair is commonly used for making wigs, and sometimes for making dolls or keepsakes. It has slightly eerie connotations, being a part of the body that people identify closely with, until it is cut off. It is associated with individual strength and virility, and there are many tales and spells involving the use of hair for control or subjugation of another.

> "If you weave the seven locks of my head with the web and fasten it tight with the pin, then I shall become weak and be like any other man."
>
> - Samson, *The Book of Judges*, 6th Century BC.

horn (water buffalo) is a keratin based organic, that grows around the bony protrusions of animal skulls, and is permanent, in contrast to antlers, which are shed. As a material it varies greatly, often being strong and

durable, yet soft and pliable. It is not particularly stable near heat or water. Horn has been used throughout history for tools, musical instruments, handles, buttons, and diverse decorative purposes.

huon pine is wood from the conifer endemic to the Western rainforests of Tasmania. It is oldest living tree in Australia (up to 3000 years) and grows very slowly (2mm per year in diameter). The wood is very finely grained, soft and buttery, with a sweet floral smell, and is exceedingly durable, even submerged, due to the presence of methyl eugenol oil, which gives it its fragrance, and has preservative qualities. It has an extensive history as a timber in early Tasmania, when it was more plentiful than it is now. Most trees are now in protected reserves. This piece is from local woodworker Conrad, who used it in ship building. It is expensive and highly prized, and its use now is mostly limited to boatbuilding and high end furniture.

jet is a soft stone that is the product of wood, fossilised and compressed in water. It is mostly carbon, with various impurities, and is defined as a form of lignite brown coal. Queen Victoria I popularised jet, in remembrance of Prince Albert, when it was the only gemstone allowed in court, and it is now synonymous with mourning jewellery. It is also used for small figurines. Working jet is a curious thing - it smells of the death of the planet - shedding fine black petroleum-smelling powder, which ignites easily, as does solid jet. It is a soft stone, without defined internal structure, and fractures easily, but takes a fine polish. It feels like a material that has gone through putrefaction and continued on to become something that is somehow a pure absence of life. Quite mysterious. It has a long history in folklore and superstition.

> "...experience shows that if water in which it [jet] has been washed is strained and given with some scrapings of the stone to a virgin, after drinking it she retains it and does not urinate; but if she is not a virgin, she urinates at once. And this is the way virginity should be tested."
>
> - Albertus Magnus, *The Book of Minerals*, 13th Century.

kelp is a large aquatic algal seaweed growing in shallow waters near the coast. Many species are fast-growing and plentiful, and have been a food resource in many cultures. It is also processed for use as a thickening agent, and its ash has been used in soap and glass manufacture due to its high alkali content. It is used in Tasmania for traditional basketry, after being stripped and prepared, and was suggested by local indigenous artist Joshua. It is also being used extensively for making plant fertilizer.

Lead (plumbum) is a deep grey beauty of a metal, which is heavy, soft, and with a very low melting point. Over half the modern demand is for batteries. Traditionally it was used for many things, due to its ease of working - food ware and vases, roofing details, and famously, water plumbing pipe. This is of course worrying, as it can be stored in the body over long periods of exposure and creates adverse effects, notably on brain function. It is however easily worked, and procured, and has a long history of use.

> "Lead was being extracted from its ores during the sixth and even seventh Millenia BC. The smelting of lead thus probably predated the smelting of any other metal, copper included"
>
> - Jack Ogden, *Ancient Egyptian Materials and Technologies*, 2000.

Lead has strong ties with death - with its use as bullets, and in tomb stone decoration, not to mention its poisonous effect in the body. It is the heaviest "stable" element, having a very long half-life, being used for long-term scientific dating (in conjunction with isotopes of uranium of which many forms of lead are the final decay products). Lead is considered by alchemy to be the oldest, basest and most impure of metals, and is represented by the planet Saturn. Lead forms a conceptual limit or boundary as a material, and can refer to long ages of time, especially of the distant past.

leather (chrome tanned) is the skin of various animals (most commonly bovine), that is removed from the carcass, degreased, its hair removed, and chemically tanned to prevent hardening and decomposition. Chrome tanning began in the mid 1800's and uses chrome salts to replace the water molecules in the collagen fibres that make up leather, thus preserving the skin and turning it into leather. Chrome tanned leather is soft, water resistant, and comes in fabulous colours like this orange. It is used in clothing, bags, books, furniture coverings, and various other applications.

leather (vegetable tanned) is an older chemical form of preserved animal skin, and differs from chrome tanned leather in being more effected by its environment and use, due to the natural tannins used in its processing, The tannin molecules come from various vegetable sources (tree barks mainly), creating a leather that responds in colour and handle to its use, absorbing water if untreated, although being potentially very durable, given appropriate care. It is used for saddlery, belts, shoe soles, luggage and as pulley belts or seals in machinery.

lime render is a mix of lime and sand, sometimes with straw to increase structure and bulk out the material. In the past, hair has been used to create a stronger structure and prevent cracking. It is used architecturally to cover walls internally and externally, and "breathes", allowing moisture to pass, while being resistant to the ingress of water by rain. It is fragile and friable at such small scales as this sample, but is durable and healthy as a building material, finding great favour as a healthy (although labour-intensive) building material. This piece was supplied by local building designer Lukasz, who used it to seal the straw-bale walls on his home.

linen is from the long fibres of the flax plant, spun and woven to form durable, lustrous cloth. It is an ancient material, perhaps the oldest of fabrics, with records of established industry 4,000 years ago in Egypt. It has a stiff feel that softens with use, breathes well, and is highly absorbent of water. It is slightly brittle and not very elastic, hence it creases easily, and eventually cracks with repeated folding. It is used for clothing, and the term "linen" is also synonymous with bedsheets, towels and napkins - which were tradtionally made of linen.

Magnet is a mysterious material that creates a strong magnetic field around it. This is a neodymium magnet, and while all materials exhibit magnetic qualities, they are usually too weak to be noticed by the senses. Magnetism can occur from a material being worked in one direction, and through natural formation, but this alloy of neodymium, iron and boron (plated with nickel) has been manufactured specifically to create a strong magnetic field. The magnetism is created by soaking the alloy in a strong magnetic field at elevated temperatures. This aligns the spin of the electron orbits (if you like the classic atomic model of reality), and creates a material that is electromagnetically aligned one way, and thus, magnetic.
Naturally occurring magnetic stone has been recorded as being first "discovered" in the first century by a shepherd in Greece (sometimes cited as being India, which does seem quite a different place).

> "The magnetic stone received its name "magnes" from the person who was the first to discover it, upon Ida. Magnes, it is said, made this discovery, when, upon taking his herds to pasture, he found that the nails of his shoes and the iron ferrel of his staff adhered to the ground."
>
> - Pliny the Elder, *The Natural History*, 79AD

Magnets are used for all manner of purposes in modern life, from electronic and electromechanical components, industrial holding devices, and for fridge magnets. The thing that really annoys me is when friends come around and can't resist playing with my super-magnets that I make stuff with - they pinch their fingers, break the magnets, and seem to disappear off into a world entirely of their own. At least all the broken pieces stick together. Magnetism is compelling and mysterious, and brings wonder to the senses....

marble is a metamorphic rock formed by heat and pressure to limestone. Its slight sparkle is due to the calcite crystals that form from this metamorphism. It is easily procured, and there are large deposits around the world, and a long history of mining and use. It is often used crushed, as aggregate, but also in slabs and chunks for flooring, sculpture, benchtops, and building facades. The colours vary greatly, and this sample is a white carrara marble, mined in Italy. Marble is a relatively soft stone, and ca be worked with chisels, as the stereotypical sculptor may be imagined, or wet with diamond blades and fine paper, as was done here.

mdf (medium density fibreboard) is a cheap and nasty material situated somewhere between wood and cardboard. It is made by bonding pulp wood fibres into sheets under heat and pressure with chemical binders, notably urea formaldehyde, hence its bad health reputation. It is used for a great variety of crappy building and furniture applications. To be avoided, if possible.

Mercury (hydragyrum) is a silvery metal that is liquid at temperatures above -38.9°C. It was first observed solid on the intensely cold Christmas day of 1759 in St Petersburg by Mikhail Vasil'evich Lomonosov, and was previously not considered a metal. Mercury has an undeniable fascination to the senses, with its heavy, reflective, liquid nature. It is used in many electrical applications, including vapour lighting and switches, as well as thermometers and other scientific equipment. It is the only metal to retain its ancient alchemical name.

> "Under his Roman name of Mercury, Hermes is the prime god of the alchemists who hoped to transform base matter into refined, spiritual gold. Mercury is "quick silver", the spirit that existed in matter."
>
> - Gisela Labouvie-Vief, *Psyche and Eros*, 1994

Meteorite ore varies in its nature depending on the individual meteorite fall. This Meteorite is from Gibeon, Africa, which fell in prehistoric times and was estimated to be 26 tons. It is mostly iron and nickel, with traces of other elements, and has a distinctive octahedrite structure. This structure only forms through extraordinary slow cooling - this piece of meteorite solidified very slowly a phenomenal 4,000,000,000 years ago, while the Earth itself is aged at only 4,500,000,000 years old. This makes these crystalline lattices by far the oldest existing structures any of us will ever directly encounter in our lives. Crazy amounts of time....
Meteorite was sometimes crafted into daggers and ornaments in the ancient world, such as King Tutankhamun's iron dagger. Before the smelting of iron was developed, meteoric ore was the only naturally

occurring form of iron (besides extremely rare telluric iron in Greenland), and it was significantly harder than any other metal known to early cultures. It would have been very precious and mysterious.

> "When the stars threw down their spears
> And water'd heaven with their tears:
> Did he smile his work to see?
> Did he who made the Lamb make thee?"
>
> - William Blake, *The Tyger*, 1794

Meteoric ore is an exceptional material that I was always eager to work with. The first time I did so, in a dark studio one evening, I watched the sawdust fall from my saw, twinkling in the light, and realised, quite tragically, that I was making stardust. It is a gorgeous material, incredibly potent, insanely old, though it often has many flaws and cracks, making it difficult, and sometimes impossible, to work properly. I now feel quite reluctant to use it, as it is a very finite resource, and after buying a small whole meteorite fragment that cost me a fortune, I have decided to keep it intact, and simply bask in its presence.

neoprene rubber is a general purpose synthetic rubber that is a polymer of chloroprene. It is flexible over a wide temperature range and resistant to chemical attack. It was first produced in 1930, and has largely replaced natural rubber, produced from the sap of the rubber tree. It is used for seals, hoses, electrical insulation, vibration dampers, pulley belts and a vast range of other purposes.

oak is a dense hard timber from several tree species of the same name, native across the northern hemisphere. It is a very durable wood due to its high tannin content, and has a long history of use for building work, tool handles, furniture, boat-making, and wine barrels, among other applications. This timber was from a tree felled and milled in the backyard of retired engineer and wood-dabbler Ted.

paper (canson ingres) is a modern acid-free paper, manufactured of wood pulp and cotton, and sized with gelatin. This particular paper is used by artists for drawing. The history of paper in general is a vast and convoluted topic, which many sources date to 1st Century BC China. With the invention of woodblock printing 600 years later, the basic notion of the printed newspaper was set. The effect of printed paper books and manuscripts on the dissemination of learning and thought is hard to fully appreciate, as it is such an integral part of our knowledge culture. Paper is a very important material that has had a tremendous impact. Of course paper has many other uses, from wrapping goods and foodstuffs, banknotes, photographs, legal documents and love letters to name a few. This piece was supplied by artist and drawing lecturer Ben, who uses it in machine-mediated drawing expoeriments.

paper (cotton rag) is a handmade paper entirely made from cotton fibres. It is less directional than the canson paper, due to it being made by hand in a mould and deckle, rather than machine produced en masse. This paper is extremely absorbent, and intended primarily for use with watercolour pigments.

Perspex, a brandname for polymethyl methacrylate (PMMA), is a strong, tough, and lightweight plastic most notably used as glass replacement (along with polycarbonate) in certain circumstances.

> "...the largest single window in the world, an observation window at California's Monterrey Bay Aquarium, is made of one big piece of PMMA which is 16.6 m long, 5.5 m high, and 33 cm thick."
>
> - *Polymer Science Learning Centre Information Booklet*, 2008.

Perspex transmits up to 92% of visible light (3 mm thickness), and gives a reflection of about 4% from each of its surfaces. It displays the unusual property of keeping a beam of light reflected within its surfaces, and is frequently made into optical fibres. It was discovered in early 1930's in England. To produce 1 kg of perspex, about 2 kg of petroleum is needed, and it is not easily recycled. It is considered a group 7 plastic among recycled plastics and is not collected for recycling in most places.

pigment has been used throughout the ages to colour our world, from ground earthen ochres on cave walls, plant roots used to dye fabrics, crushed insect bodies to colour our food, to synthetic mineral colourants in modern plastics. A pigment could loosely be defined as an intensely coloured substance used to change the colour of other materials. This pigment is a cobalt blue, synthetically created, very stable, and bound in a gum arabic medium intended for watercolour painting. This colour is the favourite sky base of children's book illustrator Owen.

plaster is nowadays commonly made of gypsum heated to remove its molecular water, and then powdered, ready for mixing with water to set solid into whatever form is desired. The resulting dry plaster is clear white in colour, solid and stable, but soft and fairly brittle, allowing for final forming and finishing work. It is used for walls (often sandwiched between paper layers as in preformed Gyprock sheeting), decorative architraving, sculpture, mould-making, and medical bone casts.

plastic (unknown kind) is a modern material that surrounds us at all times. This unknown kind of thermoset plastic is an unused drink token from a Berlin night club Postbahnhof, that I found years later in my jacket pocket. I like this unused pink drink token so much, because its a great pink, and the feel of plastic in your hand is kind of like being sober in a Berlin nightclub - its weird. The shape of this token became the template for all the other material samples collected here, and they were all formed to match.

plywood is a manufactured wood product of layers of wooden veneers or "plies" that are stacked and bonded together at alternating grain directions, forming a stable flat sheet resistant to warping, shrinkage, and splitting, and with greater stiffness than the natural timber used in its manufacture. Its history dates back to the 1860's in France. Various grades of veneers and glues alter the qualities, maximising compressive and tensive stresses, having greater environmental durability, or showing decorative outer face surfaces. The sample here is from local small boat builder Sam, who used it in a small skiff.

polyethylene (high density) is an easily recycled plastic composed mainly of ethylene molecules. It is strong and lightweight, naturally opaque, resistant to many chemicals, and able to withstand autoclave sterilising. It is one of the most commonly used plastics that is extruded, moulded, and blown into an enormous variety of products, including conduit and pipes, food containers, chairs, bags, geomembranes, and storage boxes. This sample is from contemporary jeweller Mark, who once fused milk containers together to create chunks of plastic to create jewellery out of, before he retired very early.

polypropylene is a rigid thermoplastic with a relatively high melting point, also known for its high fatigue resistance. Discovered in the 1950's, it is now the second-most widely used plastic (after polyethylene), coming into everyday use for products such as automotive bumpers and batteries, kitchen cutting boards, hinge parts, packaging, medical tools, textiles, rugs, and food containers. This sample was cut from the base of a broken electric kettle.

polystyrene is a cheap recyclable polymer of the styrene molecule, that is naturally transparent, hard and stiff. It is often formed as an expanded closed-cell foam (EPS), as here, created through blowing carbon dioxide gas, creating a material that is lightweight and thermally insulative, but with low melting point and solvent resistance. As an expanded foam it is commonly used for food containers, building insulation, and cushioning for packaging. It is easily recycled, but not undertaken in some areas, such as the small remote southern island of Australia, Tasmania.

porcelain is a high fired ceramic of fine composition, made from various clay minerals including kaolin. It is vitreous and glass-like when fired around 1300°C, tough, translucent, electrically insulative, and very white in comparison to other ceramics. Its use dates back at least 2000 years to China. It is commonly used for food plates and cups, laboratory equipment, toilet bowls, and electrical insulators.

Radiata Pine is a cheap soft wood that is one of the most widely grown timber species in the world, with global plantations of 3.7 million hectares. Despite this, it is a threatened species in its natural habitat of California. It is used for wood pulp, building construction, furniture, laminated wood, and crates. The bark is often used as garden mulch. It is the most commonly used timber in Australia.

> "Porta general purpose Dressed All Round (DAR) is made from standard and better radiata pine that may include imperfections such as knots and resin pockets. Suitable for indoor use, it is easy to work with and has excellent staining properties.
> Softwood; Easy to work with; Stain or paint; Indoor use; Suitable in wet areas"
>
> - Bunnings website, 2019

reed grass (lomandra), or *sagg* as it is commonly known, is a prolific plant on the property where I live in Tasmania, and all across Australia. This sample was very simply stripped, dried, and soaked, then woven by hand. Such processes, carried out with much greater refinement, were common practices for indigenous basketry work in Tasmania. The lower stem was also used as a food source, the seeds ground for flour, and the root crushed as medicine for treating insect stings.

reinforced concrete consists of cement and aggregate, with reinforcing rod, fibre or mesh. The reinforcing adds tensile strength to the concrete, which is weak in this respect, but very strong compressively - effectively creating a composite material optimised for various methods of loading. Commonly the reinforcement is steel bar, as here, which is mostly protected from rust through being encapsulated in the concrete. It eventually often fails through corrosion of the steel however, swelling and busting open the concrete around it. It is one of the most common architectural materials, used for footings and foundations, entire units and skyscrapers, bridges and large watertanks.. Recent alternative reinforcing materials are

becoming more common, such as plastic fibres spread through the mix, or basalt composite bar and mesh, which do no corrode, are non-magnetic, and provide a longer-lasting structural material.

rock maple is timber from the sugar maple tree, native to North America and Canada. It is a hard and dense wood that is well behaved, if harsh on tools. It is very hard-wearing and ideal for flooring, as well as being used for furniture, musical instruments, and interior joinery. It is the only timber besides Celerytop pine that I have found stable enough for making fine wooden kinetic jewellery work.

sailcloth is made from a variety of natural and synthetic fibres, from cotton and linen, to nylons, polyesters and high performance textiles like kevlar. Cotton, such as this sample, was used mainly from the 19th century until the late 20th, replaced by synthetic fibres due to cotton's poor resistance to rot, and its high water absorption rate. It is now more often used for upholstery and heavy luggage.

shell (scallop) is the naturally occurring outer case of a sea mollusc, found in plentiful numbers across the globe. The shell is primarily calcium carbonate, and has been used as an ingredient for plastering and paving, and is now being used for a range of exotic purposes, such as heated and powdered as an anti-microbial agent, or for the extraction of strontium in contaminated water. I used this scallop shell to cut ribbons of kelp while on the South-west coast of Tasmania, and it is likely it has been used similarly in such a simple way, many times before. The scallop shell also has rich symbolic meaning - it is the traditional emblem of St James the Great, and has been linked to Celtic rituals of the setting sun, while shells in general are connected to the feminine principle, nurturing, and containment.

silicon rubber is a flexible elastomer that is chemically resistant and holds its properties in a wide range of temperatures. It is a good electrical insulator. It is easy to manufacture to shape and comes in many forms - sheet, block, 2-part liquid, or as a peroxide-cured adhesive tube from Bunnings. It is found in a wide range of applications, from seals in industrial machinery, electrical and vibrational insulators, as a mould-making material, for food cooking implements, sportwear, and orthodontics. This silicon was sourced as sheet from the wonder store Tokyu Hands, in Japan.

silk is a continuous fiber extracted from the cocoons of certain moth larvae, and has been in use since ancient times, sometime over 8,500 years ago. It is collected mainly through killing the larvae of silkworms fed on mulberry leaves, and spooling the thread from the unbroken cocoon, to be spun into thread and woven into textiles. A traditional Japanese kimono will use the silk of 5000 silk worms. Silk is a strong material, composed of protein, with a natural sheen due to its triangular cross-section. It is a poor conductor of electricity. Silk is used in clothing, parachutes, in surgical sutures, and a host of other applications.

> "The most widely raised type of silkworm, the larva of *Bombyx mori*, no longer exists anywhere in a natural state. The legs of the larvae have degenerated, and the adults do not fly."
>
> - John Kershaw, *The Story of Silk*, 2017.

silver (argentum) is the most reflective and electrically conductive material known. It has a long history of use, due to its easy working, its shininess when polished, and perhaps also its relative scarcity. Silver is a big industry in Australia and much of it comes from galena ore mined beneath the ground, later separated from the predominant lead in the refining process (shipped across the globe to do so). It is also sometimes found natively, alloyed with gold, with which it has many similar material qualities, as well as mythical associations. It is used in coinage, jewellery and tableware, as well as in photography, electronics, high-end mirrors, as an anti-microbioal, and in various chemical processes.
In alchemical knowledge, silver is associated with the moon, and its self-reflective and intuitive natures. It is a particularly responsive metal, and ideal for research into the esoteric aspects of matter. One early pioneer of this kind of work, Elizabeth Kolisko, researched the reaction of silver nitrate to the phases of the moon, over many years, through developed paper, published in the book *Das Silber und der Mond*, in 1929.

> "The moon, like to a silver bow new bent in heaven...."
>
> - William Shakespeare, *Midsummer Nights Dream*, 1595.

Slate is a fine low-grade soft-ish metamorphic rock that comes in many different colours and grades. It is used for roofing and flooring, due to the way it cleaves easily into thin planar sheets. Slate is stable mechanically, as well as thermally and chemically, being used in the past for laboratory tables, and more recently for billiard tables. The common term "a blank slate" refers to its ancient use for writing tablets, with chalk pencils. It is a good electrical insulator, as evidenced by its shallow spark discharge image.

Stainless steel refers to a range of alloys of iron, usually with chrome and nickel, that resist rusting due to the quick formation of a benign oxide layer. Stainless steel is hard, tough, corrosion-resistant, non-magnetic (though if cold-worked this can change, and the 400 series alloys are magnetic), and is generally very well behaved, except when it comes to heat, where its behaviour can be problematic due to its low thermal conductivity. It is difficult to form, though somehow quite obedient and predictable. It is very demanding on hands and tools, but rewards hard work with a strong finished product that can be long-lasting and shiny. Modern forms of stainless steel are historically recognised as being invented in 1913, though corrosion resistant high chromium steels were patented as early as 1872.
Stainless steel is used for food utensils, sinks, surgical implements and implants, in the chemical industry, as a construction material, for water tanks and in a broad range of other applications. This disc of 316 alloy was lathed from a bar used for making jewellery, and slowly sanded by hand. It is one of the most suitable metals for making kinetic ball race rings, and other fine turned, welded and fabricated work.

Tantalum is a beautifully heavy metal, coloured the deep grey of thunderclouds, hard but malleable, rare and expensive, with a very high melting point and low reactivity. It is my favourite metal, alongside pure gold, due to its density, its stubborn difficulty of working, and its darkness, which lends it a lush brooding character. It is used in electronic components, surgical implants, my handmade jewellery, and in exotic alloys for reactors, turbine blades and rocket nozzles. Discovered in 1802 (though not separated purely until 1903), it was named after Tantalus, son of Zeus, whose torment may have been seen to have parallels with the metals highly unreactive nature, and possibly to the plight of fabricators trying to make anything out of it....

> "Aye, and I saw Tantalus in violent torment, standing in a pool, and the water came nigh unto his chin. He seemed as one athirst, but could not take and drink; for as often as that old man stooped down, eager to drink, so often would the water be swallowed up and vanish away, and at his feet the black earth would appear, for some god made all dry. And trees, high and leafy, let stream their fruits above his head, pears, and pomegranates, and apple trees with their bright fruit, and sweet figs, and luxuriant olives. But as often as that old man would reach out toward these, to clutch them with his hands, the wind would toss them to the shadowy clouds."
>
> - Homer, *The Odyssey*, 8th century BC.

terracotta is a type of fired clay, meaning "baked earth" in Italian, and first referring to a porous reddish ceramic from one local area. It now means any ceramic that is reddish (due mainly to iron content), porous, often heavily grogged, and low fired. Terracotta is commonly left unglazed. It is a brittle material, and all forming is done before firing, except perhaps for ocassional cutting with a diamond blade. It is used for roofing tiles, plant pots, water pipes, sculpture, and simple cookware.

tin (stannum) is a a soft shiny crystalline metal that melts at low temperatures. It was first used with copper, in the historically important alloy bronze, and was traded across cultures extensively. It is produced mainly from the ore cassiterite and refined by reduction under heat. Its original name stannum refers to the early misconception (pre 4th Century AD Europe), that it was an alloy of silver and lead. It is a soft metal, easy to cast, and when bent creates an intriguing crackling cry, as its microstructure is stretched and broken. It is used as a protective layer over steel, notably in "tins" of baked beans, in alloys with other metals such as bronze or pewter, in the electronics and glass-making industry, and in soft solders, of which around half of the worlds supply is used for. As one of the ancient world's 7 known metals, it has important alchemical associations, and is allied with the planet Jupiter.

titanium is a strong, lightweight, chemically inert, and high-temperature metal that has technological connotations of jet fighters and rockets. It is relatively modern, being isolated as an element in 1910, and only coming into any real use in the 1950's. As a metal it is most often alloyed with small amounts of other elements, this sample being alloyed with aluminium and vanadium (grade 5) to improve its strength and workability. As such an alloy it machines smoothly, and can be worked well in general, albeit with difficulty, and special tooling such as carbide bits. It is not a very good conductor of electricity, or of heat, which often causes overheating of tools while working, in a similar fashion to stainless steels, but worse. Welding is difficult, as it reacts strongly with oxygen and nitrogen, requiring fiddly gas shielding.
It is a very common material in its ore form, such as rutile or titanite, but requires considerable energy to refine, due to its high melting point and sensitivity to atmospheric gases when molten. The metal is used in the aerospace industry, high end engineering, luxury sporting goods, medical tools and implants, the chemical industry, for making super-lightweight kinetic ball jewellery, and a host of other applications. Most of the titanium produced is not metallic, but in the form of titanium dioxide - a whitening agent and pigment used in paint, food, and cosmetics. It is also common as titanium nitride for tool coatings.

tool steel is a generic name for a variety of steels that are composed of iron, with 0.5-1.5% carbon, making them incredibly hard when properly treated. Other alloys are often added to increase hardness, wearability,

workability, and corrosion resistance. This sample is an O1 oil-hardening tool steel, that can be hardened and tempered to make a sharp and durable blade. It is a somewhat difficult material to work, but can be sufficiently formed to meet most applications. It is hard, often gummy to work cold, though easily forged, but difficult to join. Through the process of "hardening" - heating at high temperatures and rapidly cooling - it becomes very hard, due to iron carbides being trapped in its structure. Subsequent "tempering" - a more gentle heating to relieve intermolecular stresses - turns this very hard but brittle steel, into something tougher and more durable.

The initial industrial manufacture and subsequent scientific understanding of making carbon steel, gave rise to the main thrust of material science. This approach redefined chemistry during the 17th Century, altering the general landscape of scientific understanding. No other metal alloy has received as much intense investigation as that of iron and carbon, and created a meeting of the crafts, manufacturing, and scientific understanding. Now, steel is still one of the most important materials of our modern world, being in use in virtually every aspect of manufacturing. It is globally mined, refined and distributed.

> "For iron and steel, the global in-use stock is about 2.2 tons per capita... at least 10 tons in the USA but only 1.5 tons in China."
>
> - Christopher Hall, *Materials*, 2014.

Steel is ruled by Mars in the alchemical tradition, with its connotations of fire, the smithy god Vulcan, and of passion and strength. It is associated with earthly endeavours, and proactive, masculine undertakings.

urethane foam is part of a large group of urethane polymers, with a specific aerating liquid that creates an expanding closed cell foam when exposed to the atmosphere. It is lightweight, waterproof and highly insulative, used for gap filling, insulation, condensation control, and form-fit packaging. It is a particularly nasty substance while it forms, and one I hope never to use again..

urethane rubber is a modern elastomer developed in the late 1930's. Urethane rubbers can be formulated to cover a wide range of properties from extreme flexibility, to harder solids that can survive extreme pressures. This rubber sample was formed from a 2-part liquid, is quite flexible, and intended specifically for casting concrete parts, which is how the cement sample was formed. Urethane rubbers are used for many soft and hard applications, including industrial belts, concrete moulds, suspension, condoms and skateboard wheels.

vellum is calf skin (sheep skin is technically parchment) in thin sheet form prepared for writing or printing. It is seldom used today, and mostly for restoration work. It is prepared by cleaning flesh and hair away from calf skin, which is stretched on a frame to be scraped with a curved blade, in between being dried and wetted several times, so that tension is introduced into the skin and it is thinned. Pumice is used for final smoothing, and the surface chalked to better accept ink. It was used for books and manuscripts of all kinds in history, but is now limited to important religious texts, or high-end legal documents such as the US Constitution, as it is considered more durable and stable than paper.

Wax from bees has been in use for a long time. The earliest evidence of beekeeping is from pictographic wall panels within the Sun temple of Niuserra, Egypt, in the fifth Dynasty (25-24th Century BC). Being readily available and easily formed, it has been used as a setting agent, binder, and sealant.

> "Beeswax is produced by the female worker honeybee. The liquid wax is secreted from glands under the abdomen and hardens into plates. These in turn are removed by the hind legs of the bee, transferred to the fore legs and then placed in the mouth, chewed, and finally applied to the combs."
>
> - Eva Crane, *A Book of Honey*, 1980.

weathering steel is a low carbon high strength alloy that contains small amounts of other elements, mostly copper and nickel, to form a dense, stable, non-porous oxide layer that protects from further oxidation. It has a very characteristic rusty look, orange when dry, deep red brown when wet, and has found favour with modern architecture, for its gutsy, natural aesthetic. Its main appeal is its low maintenance - the oxide layer means it does not need to be painted or maintained. It was developed in the late 1920's but was initially only used for earth-moving equipment and othe rindustrial applications. In manufacture it works similarly to other alloys, and can be welded and joined similarly to other steels. It is used in architectural facades, bridges, shipping container construction, and large sculptural works exposed to the elements.

wool felt is produced by matting and condensing the fibres of sheep wool. It is considered to be the oldest known textile, as it is a very basic technique, with surviving samples dating back to 6,500 BC in Turkey. It can be made by hand, assisted with needle, ran through simple rollers or sheets, stamped by foot, or produced at industrial scale with large machinery. The process relies upon the minute barbs of the softened fibres to interlock and hold against each other, matting together to form a solid mass, which is compressed and worked to the desired density. It can be re-formed through the application of heat and moisture. Felt is used for many applications, such as industrial seals, packing cushioning, acoustic insulation, hats, polishing abrasive wheels, or pad stops under piano keys.

wool (woven) is the fibre of sheep spun into fine yarn, and woven into fabric. Wool can also refer to other animal fibres, such as alpaca fleece, goat cashmere or rabbit angora. As an animal protein fibre it behaves very differently to the cellulose based plant fibres of cotton and linen. Wool is crimped along its length, and slightly elastic, which makes the woven fabric very insulative, and as wool can absorb one third of its weight in moisture, it is an ideal regulator of heat and moisture. Woven wool is used for clothing, blankets, upholstery, and soft home furnishings.

The process of manufacture for woven wool is a long one, from the shearing and cleaning of the fleece, carding and spinning of the fibre through worsted or woollen processes, dyeing to colour, and weaving of yarns on a loom. Weaving of wool was popular in Egypt around 2000 BC, simple looms being developed much earlier, mainly for flax, around 5000 BC. The technological developments of the loom, particularly around the late 1780's with the power loom, created one of the largest shifts in labour practice at the time. A factory of skilled weavers were replaced with faster and cheaper machinery that could be run by one or two poorly paid children. In many places such as Scotland, violent riots were known to end with dead workers, as they rebelled against their livelihood slipping away through early industrial mechanisation. Materials and manufacturing have always been closely linked with the livelihood, and with a sense of meaning, for individual workers.

zinc is a soft shiny metal with a low melting point and a high resistance to corrosion. It is brittle at normal temperatures, and is not easily worked. It is most often used as a protective layer over steel, or in alloys with other metals such as brass, but rarely in its pure form. It is well known for die-cast toys, where it is alloyed with a small amount of aluminium to form a cheap metal that is easily formed into cars, planes and fancy little space rockets. Zinc is mined from ore that is often blasted and collected underground, crushed and separated by a chemically assisted flotation of the sulphide, which is refined through various applications of heat, acid baths, and electrolysis. It has been important throughout history as an alloying element, and much like tin, was not known to be a separate metal, until much later after being in use with brass. It was the alchemists of the East intent on discovering the esoteric mysteries of the universe, rather than commercial manufacturing interests, that first separated zinc as a metal in its own right.

> "The production of zinc probably began on a laboratory scale by the iatro-chemists in India in the latter part of the first millennium BCE and beginning of the first millennium CE... In both India and in China a striking feature of the production of zinc was the rise of a real chemical industry based on scientific laboratory practice, long before such developments began in Europe."
>
> - Paul T Craddock, *Brass, Zinc and the Beginnings of Chemical Industry*, 2018.

Zinc extends the early interests of the alchemists and their seven planets and metals, through contemporary alchemical associations of zinc with Uranus - a modern planet for a modern metal (in the Western world, at least). There are associations of renewal and progressivity, as well as the general traits of Uranus' ruling sign, Aquarius.

process notes

These images are created on various large format photographic film emulsions. High voltage electricity is made to move through a material sample, and exits the sample, discharging a unique spark signature as it does so. These discharges expose the film, through photons that are thrown off the ionising air just above the paper. This is a camera-less procedure.
The electricity is created through several generators that have been made specifically for the purpose. The simplest is a DC pulse unit which consists of a bank of batteries at 500 volts, a tuning capacitor of between 1 and 30uF, and a step-up coil (autotransformer) similar to that used for spark ignition in an engine. This creates a damped resonant pulse, closer to a quickly decaying AC signal than pure DC pulse, of up to 60,000 volts. One of the more complex generators consists of a modified solid-state tesla coil oscillator controlled by a simple 555 timer switch in the range of milliseconds, connected to a parallel set of larger step-up coils. This allows for adjustment of duration, power, and oscillation frequency in the range of 0.1Hz to 1.5MHz (used mostly between 20Hz and 10kHz). The ability to "tune" the high voltage electricity to match the characteristics of various materials is vital for such difficult materials as plastic.
Metals conduct electricity easily, their atomic lattice shuffling electrons around with the greatest of ease. Other materials like carbon are conductive, with some resistance, which is sometimes used to make resistors in varying values. Materials such as plastics can be used as capacitors, being able to variously contain electricity, having characteristics that change with frequency in certain circuits. All materials have a capacitive nature to some degree, as well as varying resistive, inductive and even magnetic natures - electricity is messy in the real world. Everything reacts electrically, in complex ways, feeding back into a circuit to change the signal, reflecting electrical fields out into the surrounding area, and changing over time, or through temperature and humidity. It is much more complex than a simple current passing along a wire. Many insulative materials like wood or plastic can be made to conduct a high frequency signal - part of their capacitative nature or ability to soak up electrons. The charge is "passed", or shunted along in small steps - the high frequency signal vibrating within their electrically over-soaked structure. This is all assuming you follow the standard model of reality with electrons orbiting around atom nucleii, which in my lazy brain, I most often do. The complexities extend as one takes into account the effect of electrical fields as they expand outwards from the movement of any charge, impacting upon and reacting to nearby flows, and feeding back in damped reactive loops of effect. Such interactions can be seen in some of the discharge images as subtle transverse tendencies where minor spark arcs cross stronger lines perpendicularly. As all the images are exposed on 8x10 large format film, the details can be quite complex, overwhelming, and totally beautiful.

The basic physical setup consists of a large copper plate (600 x 600mm, 3mm thick) which is in some situations is connected to ground. Otherwise, it is connected to one side of the circuit - usually one side of the step-up coil. The photographic film is placed on top of the copper plate, the subject on top of the film, and a connection is made to the top surface of the subject - usually with a copper or graphite electrode - connecting to the other side of the step-up coil. In terms of conventionally assigned current, positive connections to the subject will produce a longer, cleaner spark, while positive at the copper plate will produce a less vigorous but more subtle, feathered discharge. This of course is only when dealing with predominantly DC circuits.
With a simple DC battery based circuit, small 12V batteries are connected in series to create 150-600 volts, and a small value resistor placed in front of a decent highly rated switch, a high voltage bipolar capacitor in the range of 1-40uF, and a step-up transformer - most simply an old spark ignition coil (autotransformer) from a car ignition. The switch operates the connection to the capacitor. When switched on, the capacitor stores charge, and when switched off, it drops it, and this radical change in voltage and movement of charge induces a field in the step-up transformer, which creates a sympathetic high voltage spike (and decaying resonant peak determined by the circuit) in the output coil - this is the spark discharge output.
The capacitor and the coil of the step-transformer create a tuned circuit, which is also effected by the complex interactions with the material sample. I am no good with formulas (or many other rational considerations, really) so ended up fudging around with various values (especially the capacitor values) to get an intuitive grip on it all. It must be remembered that each component is not as simple as it seems - such as capacitors, which have small resistive and inductive natures also, and as such, vary tremendously in effect across the same value. With capacitors, the speed of discharge is very important in this circuit, leading me to trialing large electrolytic motor-start capacitors, connecting banks of parallel polypropylene capacitors, and experimenting with bulky foil and glass plate setups similar to early tesla coils.
The AC circuit is a very different beast which has a very different effect. It is mains powered, consisting of a solid state tesla coil oscillator circuit from RM Cybernetics in the UK, set by a timed switch (simple breadboarded 555 timer circuit running in steps from 5ms to 5 seconds), and a parallel pair of step-up coils. The output of this setup reaches nowhere near the sheer grunt of the DC setup, which has 60,000 volts with 50uF of fast capacitors and a large hand-wound step-up coil, but the ability to tune the AC to resonate within the materials allows for a far greater level of subtlety, especially whenever materials are not very conductive, such as dry woods and plastics.

A word of extreme caution also - whenever doing this work, I always have one hand placed behind my back, as the kick from the large capacitors stepped up in voltage across my chest and heart would be fatal. One hand behind my back!

All of the photographic emulsion development is quite ordinary darkroom work, 80% of it orthographic, allowing the use of a red light during work, which helps greatly with safety when dealing with these high voltages. The panchromatic films were stand developed using Rodinal, because the high accutance edge contrast works well for the sparks, and I am lazy and don't like to agitate the film. This body of images were unfortunately made in a metalworking workshop, converted to a darkroom space at night, with all the dust and grit playing havoc with exposures, and necessitating some photoshop editing time after scanning. There was also the issue of this workshop being off-grid, running solar in mid winter, in South-West Tasmania, on a 350 acre bush block populated with tall gums. Electricity can become very precious. All the water used was collected by bucket from a creek bordering my property, the film washed with a crazy set of aquarium pumps in staggered recirculating trays, and dried on an ad-hoc clothes line next to a wood fire stove. Nightly temps of -4ºC meant the fire needed to be going a while before developing, so the chemicals would be up to temperature. But the elemental beauty of the place, the deep night darkness, the clarity of the air, and the screech of Tassie devils somewhere up the hill, all resonated perfectly with the abstract purity of the task, delving deep into the heart of matter with vibrating pulses of high voltage electricity. Lots of fun.

"We want a principle, a system, an integration, and we want elements, atoms, numbers.
We want them, and we make them. A single God, and identifiable individuals....
The arithmetic of whole numbers remains a secret foundation of our understanding;
we're all Pythagorians."

- Michel Serres, *Genesis*, 1982.