Creative Surveying Tools and Gadgets

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ABSTRACT

Surveyors have always been 'problem solvers' and when it comes to creative solutions, they are second to none. For example, do you need a tool to simultaneously measure the level, alignment and orientation of a tail-end drive pulley? There is nothing available commercially? Ask a surveyor and, hey presto, the problem is solved. In the 1957 classic by Nino Culotta, he describes Australians with the observation that "they're a weird mob". If he had got his first job in Australia with surveyors and not bricklayers, he might have said "they're a creative mob". This paper provides a not-so-scientific look at some innovative, interesting and downright strange tools and gadgets invented by surveyors to solve problems that came their way.

KEYWORDS: *Problem solving, innovation, surveying, gadgets.*

1 INTRODUCTION

In the 1957 classic by Nino Culotta, he describes Australians with the observation that "they're a weird mob" (Culotta, 1957). If he had got his first job in Australia with surveyors and not bricklayers, he might have said "they're a creative mob".

A number of years ago I transferred to Newcastle to work on the Kooragang Island Coal Loader Expansion Project. I was fortunate to work with and learn from two surveyors who had been involved in engineering and construction surveying for their whole careers. John and Stan were great surveyors and had that certain 'knack' for problem solving. Their customised hand-made tools, their creativity and their passion for their work was the inspiration behind many of the 'gadgets' described in this paper as well as a realisation that with a bit of lateral thinking we can solve almost anything that comes our way. Thanks, John and Stan.

This paper outlines a series of tools, gadgets and ideas and their application in surveying. It is not a scientific paper and not all the items are unique, but it is hoped you find them interesting and inspiring (and fun). To quote Albert Einstein: "Creativity is intelligence having fun".

Commercially there is a huge array of specialised tools available for surveyors. The ones I have had the opportunity to use are well made, precise and typically do a great job. And they often cost a fortune! The hand-made survey tools and gadgets described in this paper are not in the price league of commercially available tools, although they are often as well made and almost universally fit for purpose. The following scenarios look at the use of hand-made surveying tools and gadgets and where applicable comparisons are drawn to commercially available tools.

2 SURVEYING RAILS (PART A)

2.1 Scenario

Rails are not just for trains. In workshops and factories, cranes and other plant use rails and the alignment, spacing and level or grade of the rails is critical. As an example, Figure 1 shows the Leica GRP1000 (Leica Geosystems, 2017a) in use. It is practical and precise, but very expensive. Perhaps a less expensive and simpler solution would be a block of wood?

Figure 1: Leica GRP1000.

2.2 Solution

Not having a budget large enough to purchase a Leica GRP1000, an inexpensive but accurate solution was required. The tool involved three pieces of wood, two prisms and one hour of construction (Figure 2). After a small amount of calibration it was put to use and performed flawlessly.

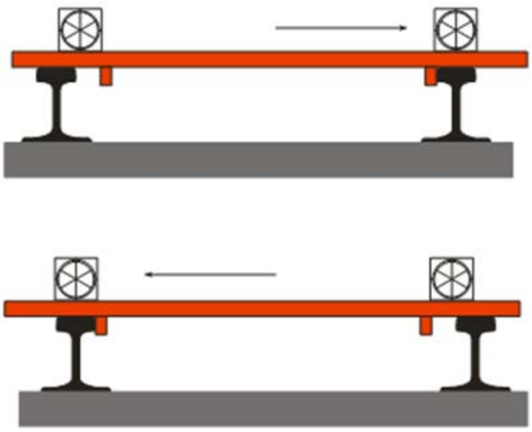

Figure 2: Rail tool.

2.3 Application

The device was placed hard up against the inside running edge of one rail and observations were taken. The rail was then pushed against the inside of the other rail and another measurement taken. Then the tool was pushed along the rail (with an attached broom handle – not shown in Figure 2) and the observations repeated.

3 SURVEYING RAILS (PART B)

3.1 Scenario

Another type of rail survey was the survey of a section of rail (about 200 m) on a mine site where we needed to find a quick and accurate way to find the centre and elevation of the rails without the hassle of physically measuring and marking up the rails every time (and all the bending over that would be involved!).

3.2 Solution

A surveyor in our team on site designed a very simple attachment for the end of a sighting pole and we had a fitter and machinist make up the attachment in a matter of an hour or so (Figures 3 & 4). The attachment was simply a small plate of steel with two vertical rods placed equidistantly about the centre and a 5/8" bolt welded in the centre (to attach it to the sighting pole). The attachment was placed on the rail and rotated until the vertical rods touched each side, automatically centring the tool.

Figure 3: Rail tool on sighting pole.

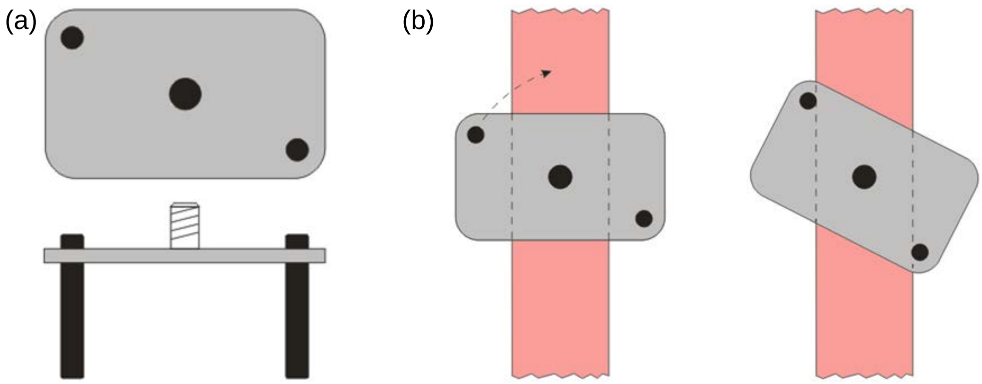

Figure 4: (a) Plan and evaluation view, and (b) rotate and self-centre.

3.3 Application

After checking the tool against observations made by measuring and marking up a section of rail and finding no errors, we proceeded to measure the 200 m of rails quickly and efficiently without any issues.

4 HIDDEN POINT (FROGS)

4.1 Scenario

Inside workshops and factories, points are often not easy to observe directly using traditional targets and sighting poles. Often the point is only accessible at an angle due to obstructions. In the scenario depicted in Figure 5, the surveyor needed to observe point A but other machinery obstructed the line of sight. Leica Geosystems (2017b) and Trimble equipment have routines that allow you to measure ‘hidden points’, but long before these routines were in use the ‘frog’ was invented. The frog was used for measuring points that were not readily accessible and was simplicity itself.

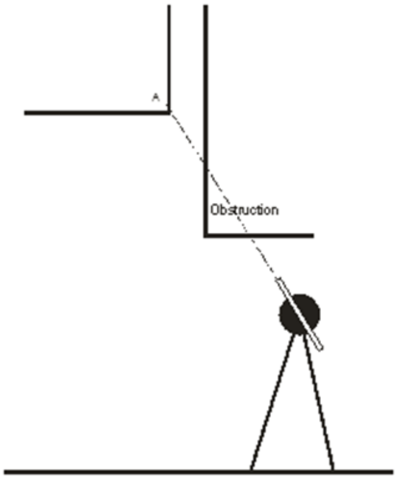

Figure 5: Obstructed observation.

4.2 Solution

The ‘frog’ was a rigid aluminium bar with reflective targets spaced at intervals along the face. The frog could be angled into confined spaces and held steady (typically braced) against the point to be observed. The surveyor would measure to two (preferably more) targets and record the coordinates of each target (Figure 6). The data was post-processed in a spreadsheet to calculate the hidden point’s coordinates.

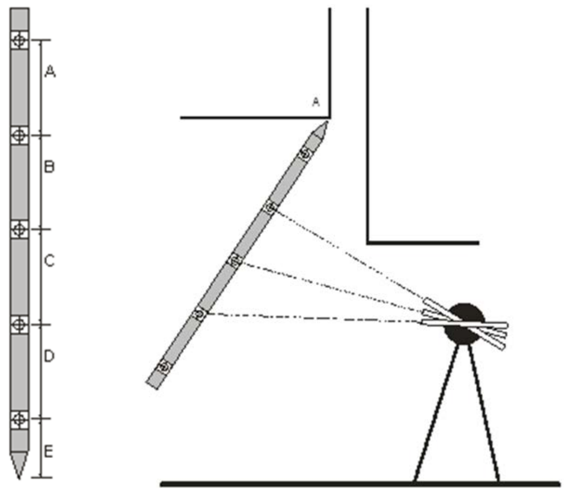

Figure 6: The ‘frog’ and its use.

4.3 Application

The frog was used for any situation where the point to be measured was inaccessible, but with the introduction of reflectorless Electronic Distance Measuring (EDM) technology the need for the frog became less and less.

5 HOLE CENTRES

5.1 Scenario

Often there is a need to observe the centre of bolt holes, typically at the base of a flange or tower. There are commercially available ‘hemi-spheres’, which are placed in the holes and give you a defined point to place a mini prism on (Figure 7). The hemi-spheres come in a number of different sizes (depending on the size of the hole) and are relatively straightforward to use, but a set can cost hundreds of dollars and they are very easy to misplace.

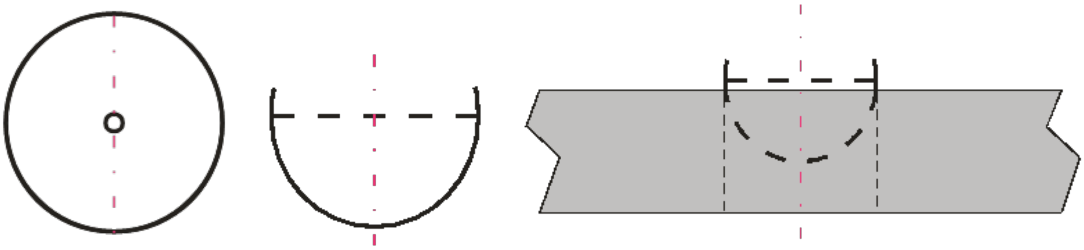

Figure 7: Plan view, side view, and hemi-sphere centred in bolt hole.

5.2 Solution

The solution was inspired by a simple kid’s spinning ‘top’. The ‘centre top’ was self-centring and by being fabricated with the angle at the point at 90º, it meant that the offset from the point of the centre top to the point of contact with the bolt hole was equal to the radius of the hole. A single observation gave the 3D coordinates of the centre of the hole at the top of the flange. The spindle of the centre top was machined to take a standard black Leica mini prism and internally threaded to also take orange Leica mini prisms (Figure 8).

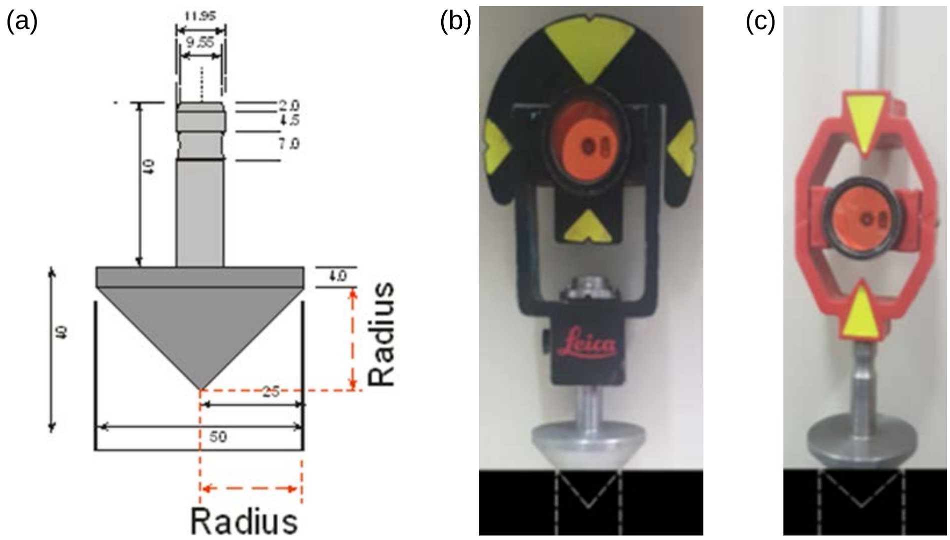

Figure 8: (a) ‘Centre top’ design, and holding (b) a black Leica mini prism and (c) an orange Leica mini prism.

5.3 Application

The obvious use for this gadget was for surveying bolt holes and holes in flanges. However, I have also found it a really useful way to take observations to galvanised iron pipes and as such it works brilliantly – not a bad $50 investment.

6 BOLTS

6.1 Scenario

A project that I worked on in the Pilbara involved the setting out and cast-in bolts for stackers and reclaimers on an iron ore site. There were nearly a thousand bolts to be set out in 3D (by another survey firm) prior to concreting the bolts in and then the same bolts had to be checked by us. Traditionally the centre of the bolts had to be marked so a mini prism could be used to observe the marks. This is tedious work and involves a lot of kneeling and bending (and my old bones were not really happy with this idea).

The process was facilitated to some extent by using a centre-finder to mark up the bolts (Figure 9). A centre-finder is a great tool to have and works well to find the centre of bolts or round rods. Marking up each bolt is slow, although the centre-finder makes it easier, but there had to be a better way. An alternative would be to use tools like the commercially available PQR nuts (PQR, 2017), but these still require you to screw the PQR nut onto each bolt in turn (Figure 10).

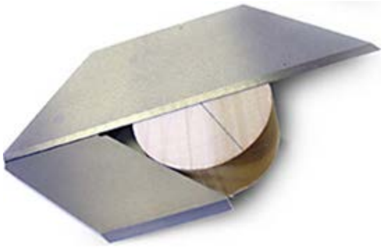

Figure 9: Centre-finder in use.

Figure 10: PQR nuts.

6.2 Solution

Given that the bolts were all the same size (that made it easier), I had fabricated an aluminium cap that fitted over the bolt and attached to a standard Leica (orange) mini prism. This 'bolt-cap' worked perfectly, so well in fact that the survey firm who was installing the bolts asked for one to be made for them too (Figure 11).

The bolt-cap was so successful that it was estimated to have saved thousands of dollars and hours of effort. There was no marking up required on the bolts and no kneeling or significant bending involved. The bolt-cap was very stable on the bolt and a real pleasure to use. It was so efficient in terms of time, cost and ergonomics that it was nominated for a Rio Tinto productivity award.

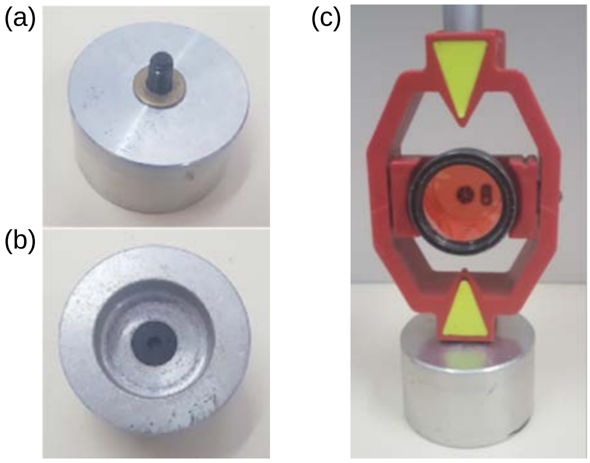

Figure 11: Bolt-cap (a) top view, (b) underside view, and (c) attached to an orange Leica mini prism.

6.3 Application

The bolt-cap was in one size and therefore only of limited use for other situations, but the concept was simple and could easily be reproduced. The time and effort saved certainly justified the $100 spent on the bolt-caps.

7 POINTERS AND REFLECTIVE TARGETS

7.1 Scenario

Often there is a need to identify a point to be surveyed. The pointer is one of the simplest yet arguably the most useful of tools I used on a number of construction sites.

7.2 Solution

The solution was to attach reflective stickers to whatever was at hand. The most useful was simply a 150 mm steel ruler with a reflective target attached (Figure 12). This can be used to point directly onto a point to be surveyed. It had the added advantage of doubling as a ruler!

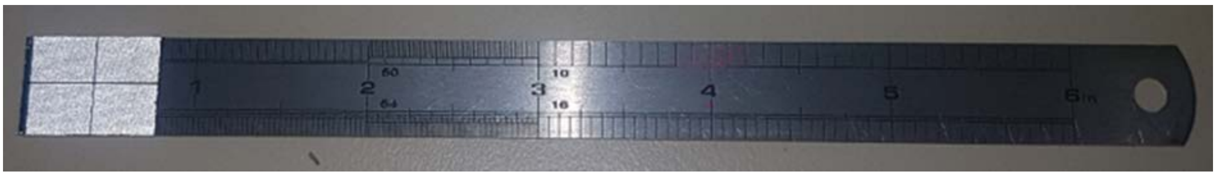

Figure 12: Reflective target on ruler.

However, sometimes the mark is not always that easy to point to and I was shown a neat target made out of a piece of plastic and a reflective sticker (Figure 13). This target is placed directly over the point to be observed and read directly. The small hole in the centre allows the target to be aligned easily to a point.

Figure 13: Reflective sticker on plastic.

7.3 Application

Just about anything, anywhere, anytime.

8 PULLEY MEASUREMENTS

8.1 Scenario

While working in Newcastle, I undertook a considerable amount of engineering work involving aligning conveyor belts, drive and tail pulleys. Measuring pulleys to determine alignment, squareness and level can be a difficult task and there is not one single method for undertaking this task. What we looked for was a simple yet robust solution that would work whatever the situation.

8.2 Solution

What we came up with was a combination of Leica Reference Line and Hidden Point routines and a roller tool (Figure 14a). I have not tried the Trimble tool but I assume that it works in a similar fashion. The tool gave the position relative to the centreline of the conveyor, squareness to the centreline and level of the roller axis simultaneously.

The tool is placed against the roller hub (Figure 14b) and oriented in any angle to allow for a clear observation of the three targets at A, B and C. The targets were available to be observed straight on (right-angled targets) or the tool could be turned through 180° and observed side on (reflective targets).

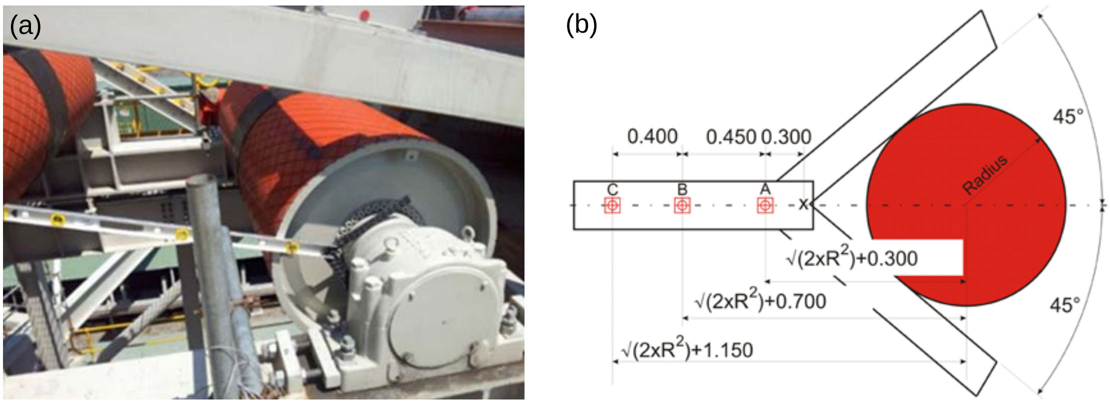

Figure 14: (a) Roller tool in use, and (b) roller tool schematic.

The procedure is as follows:
1. Measure the radius of the roller hub (actually, measuring the diameter or circumference and calculate the radius is easier). As the angle of the 'arms' is 90°, the distance from the centre of the roller is calculated to be $\sqrt{(2R^2)}$ and therefore the distances from the centre of the roller to A, B and C are calculated as shown in Figure 14b.
2. The next step is to use the Hidden Point option in the instrument to calculate the coordinates of the centre of the roller on that side of the roller. Note that observations to any two points give a solution, but observations to three points provide a check on the observations.
3. Repeat the process for the other side of the roller.

The subsequent calculation includes the following:
1. The level (or height) of the roller, i.e. difference in RLs.
2. Using the Reference Line, you can calculate the chainages either side of the roller to determine the squareness of the roller to the centreline of the conveyor.
3. The average chainage is the position of the roller and can be compared to the design position of the centre of the roller.

8.3 Application

The roller tool worked brilliantly, giving the flexibility needed in some situations where direct observations of the roller would be problematic. The advantage of the roller tool was that it could be attached to the roller and then rotated until it was in a position where all three targets were visible to the instrument. The targets did not need to be at any particular orientation (e.g. horizontal or vertical) for a solution to be determined. Given site restrictions and access issues, having a tool that could be oriented in any direction was a real bonus.

9 PIPE SURVEY

9.1 Scenario

An interesting challenge arose involving the survey of a series of 200 mm to 460 mm cast iron pipes within a factory. The location, orientation and alignment of the pipes had to be determined accurately so that a new set of pipes could be fabricated to align with the old.

9.2 Solution

The solution involved modifying a commercially available device called a 'flange wizard'. The magnetic centring heads are designed to establish and mark a centre point on a pipe or tank (Figure 15). The flange wizard was modified in order to take a black Leica prism (Figure 16), providing a simple solution that solved an interesting problem.

9.3 Application

Although designed to survey pipes, the tool can be used for a number of applications where rounded objects need to be surveyed.

Figure 15: Commercially available flange wizard (Flange Wizard, 2017).

Figure 16: Modified flange wizard.

10 MINI BIPOD

10.1 Scenario

The mini bipod is perhaps the most useful tool I use on a daily basis (by the way, I did not invent it). Often I need to observe a drill hole, nail or State Survey Mark (SSM) without setting up a full tripod and target, but want something more accurate and semi-permanent than a mini prism so you can re-observe if required.

10.2 Solution

The mini bipod shown in Figure 17 was fabricated by a local welding service and utilises a standard Leica-like round prism and mini pole (or mini pole plus extension pole). It is simple, inexpensive ($90-$120 for a set) and extremely quick to set up.

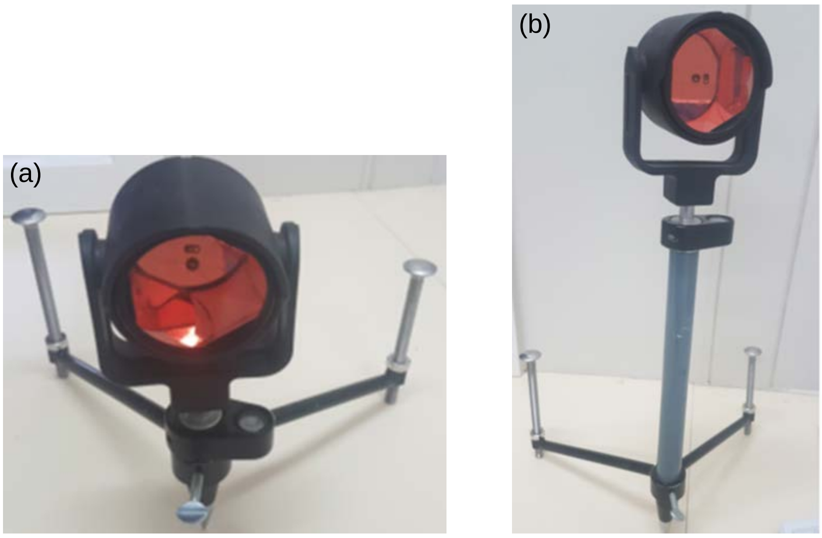

Figure 17: (a) Mini prism on mini bipod, and (b) setup including an extension pole.

10.3 Application

The mini bipod is used anywhere a quick and simple targeting system is required that gives extremely accurate results. The added advantage is that with a quick release of the mini bipod, I have a mini pole and prism at my disposal. As an interesting side note, recently I forgot to pick up a mini bipod set up on a construction site. It was sitting on a concrete slab in the middle of the site, still in position and still level three days later, a tribute to the stability of the mini bipod.

11 BLOCKS

11.1 Scenario

In engineering work, I often use simple scratch marks on concrete, or paint pen marks on columns or whatever surfaces are at hand. They are durable stations that do not obstruct anything. It is desired to have a quick and simple target that gives accurate results.

11.2 Solution

The ‘blocks’ as they are called are fabricated from 30 mm galvanised angle iron and 30 mm reflective targets. They could be placed on marks or stuck to columns with super-strong magnets (Figure 18). Cheap, incredibly easy to manufacture, accurate and durable, they are an essential addition to my field bag.

(a) (b) (c)

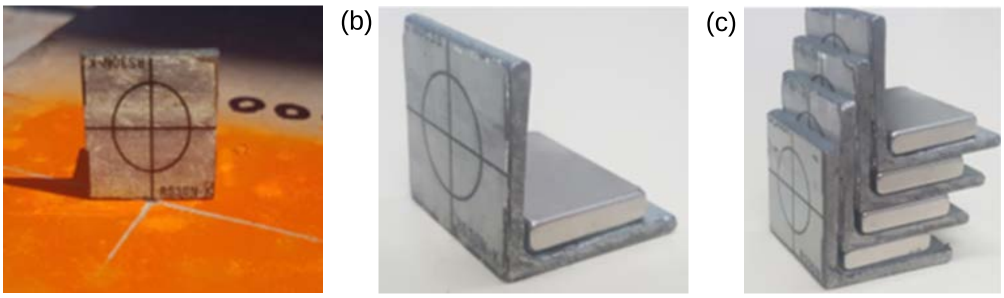

Figure 18: (a) Block set up on a scratch mark, (b) block with magnet, and (c) blocks and magnets.

11.3 Application

The blocks are simple targets for flat surfaces or steel columns. They are very quick to set up, inexpensive (less than $3 each) and very accurate. When working on construction sites, setting up a tripod and target can be an issue, so a block is a great solution.

12 CONCLUDING REMARKS

The tools described in this paper are not anything special – just simple, creative and inexpensive solutions to interesting problems. Most surveyors will have similar tools or experiences, and this paper salutes their creativity and imagination as much as John's, Stan's and mine.

Whether it is creating survey tools, solving challenging business problems or finding left-field solutions to problems in the field (often on the fly), surveyors are a creative mob and probably always have been. Who else would have thought of using the crinoline wire out their wife's skirt to make a surveyor's measuring wire (Culture Victoria, 2017)? Nino Culotta would have been proud, probably Albert Einstein too (Figure 19).

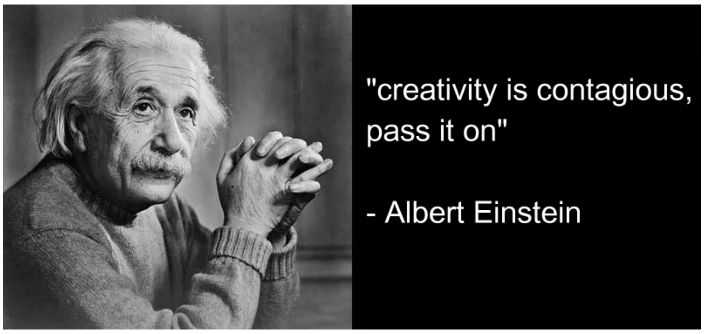

Figure 19: One of Albert Einstein's quotes on creativity.

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