Touchscreen Expert Witness:

"How much is there to know about tablets and touchscreens, anyway?"

By Jean Renard Ward

"So, touchscreens and tablets are simple -- right?
You just touch, and it gets the location.

… How complicated could that be?"

To tell the truth, one reason I find these technologies so interesting is that they are ***not*** so simple. Or perhaps I should say, there is not just ***one*** thing you need to know a lot about, you have to know a lot about a ***lot*** of things.

Here is a quick illustration :

> To get a feel for how much technical material there is, you might try a very narrow search on Google about touchscreens and tablets [1].

Most of the smartphones and tablet computers of the last 10 to 15 years use capacitive touch sensors (though there are **many** other kinds of touchscreen and tablet technologies).

So let's start there.

In this experiment with a Google search,

- We put aside all questions of the technologies for *using* touchscreens and tablets. We don't worry about touchscreen gestures, user interfaces, handwriting recognition, haptics, 3D sensing, and so forth -- we only ask about the hardware.
- We look only at patents.
  We are ignoring the huge body of engineering journals, research articles, technical publications, and the like about touchscreens and tablets.:
- We do a narrow search on patent references on patents.google.com.
  We don't include what is in "Google Scholar", and we don't include all the other things that a regular Google search would find.
- We limit ourselves only to the U.S. patent office.
  We are excluding the European, Chinese, and Japanese patent offices etc., although most capacitive touchscreens today are engineered and manufactured in Asia.
- We limit to only a single one of the relevant patent categories -- G06F3/044 ("Digitisers, e.g. for touch screens or touch pads, characterised by the transducing

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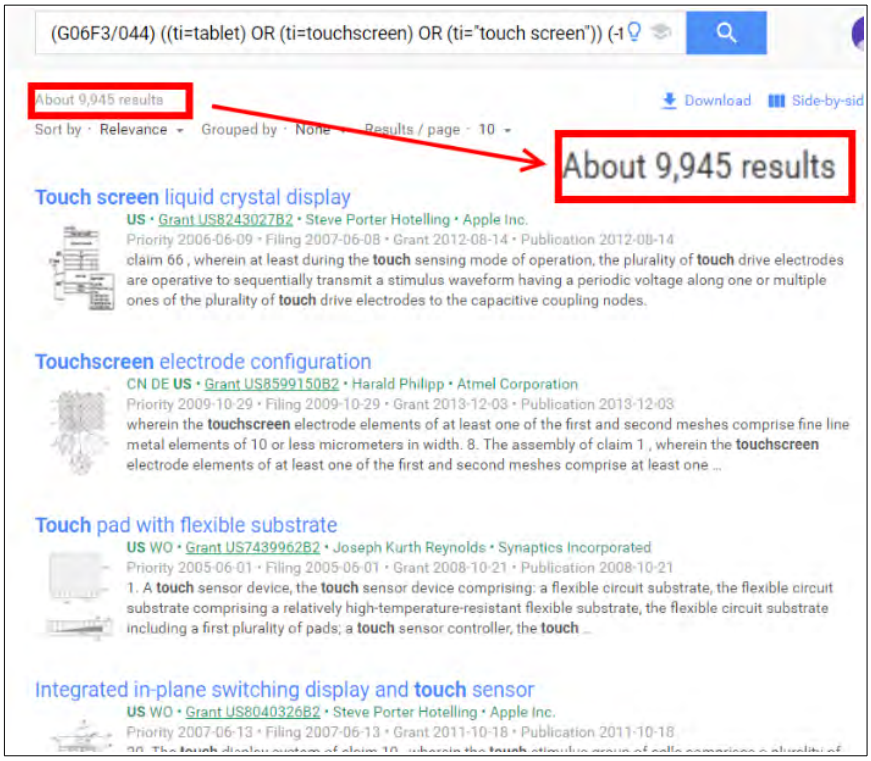
1 (You could also perhaps do this another way, such as go and find all the Wikipedia pages that mention "touchscreen" or "tablet", but that might take much longer to do.)

means by capacitive means") – thus ignoring what would turn up if we didn't exclude additional patent categories; and

- We further limit only to the time period from 2005 to 2015.
  So we also ignore all the earlier work on capacitive touchscreens, even though multi-touch touchscreens have been around at least since 1985, general capacitive touchscreens at least since the 1960's, touchscreens in general from the 1930's, and the first touch tablets (the "telautograph") were patented in the late 19th century.
- We specify in the search that we only want references with "touchscreen", "tablet" or "touch screen" explicity in the title.
  So we not specifying any of the many other terms used for these inventions, such as "telautograph", "touch-sensitive panel", "electrographic sensor", "writing pad", etc., and not including other patents (such as for "contact sensors") that specifically say how they can be used to make touchscreens and tablets.

When I did this a while back, Google Patent Search returned approximately 10,000 matches.

When I tried some other searches – such as looking only for resistive touchscreens, or only for electromagnetic tablets – I again got a **lot** of matches.



"So, that's nice. But could you be a bit more specific?"

On a project not too long ago concerning touchscreens, I was asked to summarize, "as briefly as practical" what a "Person of Ordinary Skill In The Art of touchscreens" would know about touchscreens.

"POSITA" is a legal term. I am not a lawyer[2], but a POSITA is a hypothetical person of ordinary skill in a particular technical art – in this example, a younger engineer a couple of years out of college, working on touchscreens. The questions is what a POSITA would know and understand how to do if they had full access to any

2 (I think that, by law, I am required to say that. But since I am not a lawyer, I don't know for sure.)

technical library in the world. I had worked with many POSITAs[3] on touchscreens and tablets over the years, so I had a fair idea.

Note that a POSITA would know about more than one way to build a touchscreen. This was relevant, because the teachings for one kind of touchscreen could be relevant for a different kind. For example, a POSITA would know tricks on how to use a correction table to fix inaccuracies in an electronic tablet with a stylus, so a POSITA would also know and understand how to use similar tricks for finger-touch touchscreens and other kinds of tablets.

The result was a section of approximately 60 pages in a longer report, supported by well over a hundred numbered citations to references in a separate appendix[4].

Here is the outline of what was in that section, but greatly shortened:

1. Touchscreens and Touchpanels Were A Well Known Art

a) Touchscreens were ubiquitous
   - Even non-technical users knew about them, going back to the 1960's, so a POSITA would know about all those kinds of touchscreens.

b) Touchscreens were common devices, widely supported
   - The iPhone was introduced in 2007, the PalmPad PDAs in the 1990's, Point-of-sale terminals and information kiosks in the 1980s: A POSITA would know about all of them.

c) Resistive layers
   - Layers and strips of (transparent) resistive material had been used in touchscreens starting at least in the 1970's, and even back in the 1930's for writing tablets.
   - "Resistive" was also a relative term, so a POSITA would know that the same material, perhaps laid on a bit more heavily, made a good (transparent) conductor when you needed to have transparent "wires" in a touchscreen.

d) X and Y traces/conductors in an array or matrix, single touch
   - Touchscreens and tablets using an X/Y grid of wires or conductors were known at least since the 1960's.

e) Capacitive sensing for touchscreens and tablets
   - Used at least since the 1960's for input on radar screens.

f) Multi-touch touchscreens
   - Already invented in 1985. Apple's iPhone touchscreen was based on technology Apple bought, that dated to the late 1990's.
   - (But there were also other multi-touch tablets in the 1970's, less well known.)

g) Acoustic touch sensing
   - Sound waves sent sideways through glass: When you touch, it causes a reflection of the sound, picked up SONAR-style by transducers at the edges.
   - Sound waves sent through the air from a stylus/pen, picked up by microphones at the sides and triangulated to get the position.

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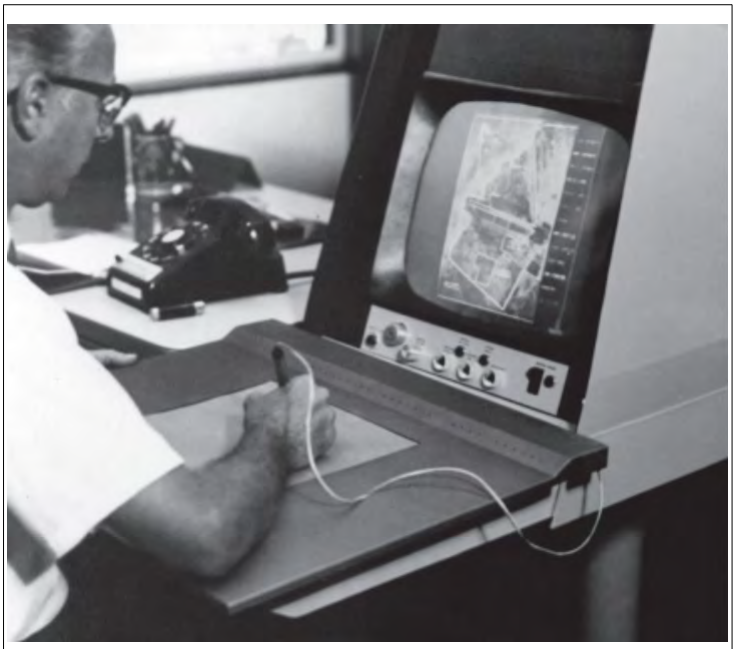
3 (Minus the technical libraries, of course.)

4(You can find them among the references in the on-line bibliography at http://www.ruetersward.com)

h) Electromagnetic sensing
   - A POSITA would know about all the different tablet designs using electromagnetic sensing, going at least back to the RAND tablet in the 1960's.



The RAND tablet (notice the size)

i) Touch sensing using reflected or interrupted light
   - Light would shine sideways through glass, or from underneath. Where you touch causes a reflection. That is picked up optically.

j) Camera/vision touch sensing
   - A video camera watches your hands, and notes where the tips of your fingers are. A POSITA would know about things like parallax correction, which could also be needed for a writing tablet when the stylus or pen is held at an angle.

k) Force sensing with triangulation
   - You press on the glass of a display with your finger: force sensors at the corners triangulate the leverage to compute where you are pressing.

l) Force sensors in a grid
   - You have an X/Y grid of small force sensors. They pick up where you are pressing: if your finger straddles two sensors, the location is in the middle.

Of course, to engineer anything, such as a touchscreen or a tablet, you have to know engineering for the components and circuits you use in the design, too.. This particular report was about certain ways to manufacture <u>transparent</u> touchscreens (not just tablets and touchpads, and not just capacitive touchscreens), so a POSITA[5] would also know about all the engineering techniques, tricks, trade-offs, and gotcha's for things like the following:

2. General Background of a POSITA:

a) A basic understanding of electrical circuits and principles
   - Our POSITA would also be a circuit designer, and know a lot about resistive components, capacitors, amplifiers, signal processing, digital circuits, etc.

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5 (Remember that POSITA is a hypothetical person, not a real person.
They have "ordinary skill in the art", but they also have really, *really* good library access!)

b) Optical Transparency
   - A POSITA would know about the standard ways of measuring transparency, how to take into account how much light you need to see through, how clearly you can see, the thickness of a "mostly" transparent materials, etc.

c) Haze, Transmissivity and Related Engineering Factors Affecting Transparency
   - There is an entire technological discipline about trading off transmissivity (how much light gets through), haze (blurry reflection of light), glare (sharp reflection of light), different wavelengths of light, color distortion, etc.

d) Screen-door transparency was well-known.
   - You can see through the mesh of a screen door fairly well, even though the wires are not transparent. This is used to make “transparent” layers and shielding. If the wires are not too wide, and don't block too much of the light, the transparency is pretty good. Many transparent materials in touchscreens are actually just such a fine mesh.

e) Manipulating resistances of a conductive/resistive layer
   - There are many ways to make an electrical layer more conductive or more resistive: change the thickness, change the width of the wires in a "mesh", change the metal or chemical composition, change the directions of the wires slightly, drill a lot of holes in it so there is less metal, etc.

f) Review and tutorial references teaching general engineering concerns of touchscreens/touchpanels.
   - If you have access to any technical library in the world, there are many different textbooks, engineering tutorials, and specialized reference books that talk about touchscreens and tablets, and how to engineer some of them[6]. A POSITA would know about these, and understand what they said..

g) Accuracy and resolution.
   - You need a touchscreen or tablet to be accurate "enough", and to let a user point to "small" things. Just <u>how</u> accurate , <u>how</u> small you need, depends on what you are doing. All the different touchscreen and tablet technologies have different problems, and people have worked out many different ways to overcome or get around them.

h) Related art of particular relevance
   - There are other things that are related enough to touchscreens, that a POSITA would know about them, also. They would teach things you could apply to touchscreen problems.
   - This includes fingerprint scanners, "simple" proximity and touch sensors (such as for "no press" elevator buttons), how to make thin transparent metal films for shielding the front of a radar screen, touch-sensor "skins" for robots, etc. The US Patent Office frequently mentions patents for other things like these when they are reviewing new patent applications for touchscreens.

i) Fabrication techniques known in the art
   - This particular project had to do with how to manufacture a transparent resistive /conductive touchscreen layer, so all the techniques used to manufacture touchscreens before were relevant -- fine wire meshes with

6 (Even if you know <u>everything</u>, it never hurts to have someone show you how to use the things you know.)

"screen-door" transparency, vacuum-deposition of metals on a glass substrate[7], micro-etching, conductive polymers, micro-stamping, thick/thin-film resistors, photolithographic printing of circuit patterns, to mention a few.

j) Interference and shielding
   - Any electronic component may need to be shielded from interference from other components nearby. Our POSITA would know about all the materials used in touchscreens, displays, television screens, and the like to shield against both electromagnetic and capacitively-coupled interference.

k) Alternatives to ITO/ATO and the like
   - Our POSITA would know about all the different materials used to make transparent circuits and touchscreens. ITO (indium tin oxide) was one of them: our POSITA would also know about alternatives people had developed: other metal and metal-oxide compounds, carbon-fiber and silver-wire films, conductive plastic polymers, micropatterned circuits, etc.

l) Techniques to reduce the need for transparent layers
   - Since our POSITA knows about touchscreens and transparency, our POSITA would know that having multiple layers of transparent stuff combined, results in less transparency (like how multi-layer bulletproof glass is noticeably "darker" than single-layer regular glass. So our POSITA would know all the tricks for manufacturing with fewer layers.

Engineering, among other things, is about figuring out the best choices and combinations from several things, none of which are prefect[8]: you need to know how something breaks, before you can figure out the best way to make it stronger. So:

3. A POSITA Would Have Been Aware of Various Shortcomings Of Common Touch Screen Technologies

a) Failure and defect modes: breaks, cracking, etc.
   - Our POSITA would know what causes cracks in thin conductive films and in wires, and the ways they can affect a touchscreen. So our POSITA would also know all tricks people had worked out for making them break less, or for making a touchscreen where the breaks don't hurt as much.

b) Optical uniformity: "non-blotchiness"
   - Our POSITA would know that even if something is 90% transparent, but the 10% is in blotches of different colors, this causes extra problems when people try to look through it. Our POSITA would know know all the problems of "blotchiness", and all the different tricks for making different things be less "blotchy".

c) Non-linearities in Touchscreens
   - "Non-linearity" just means that things are not even, which throws things off. Layers, films, sheets of glass can have variations in thickness. In a window pane, this make things look slightly curvy. In a touch screen, it means if you draw a straight line, the computer sees a line with odd wiggles. Our POSITA

7 (This is how aircraft windows were made "self-defrosting" in the 1940's – which I think is an interesting factoid.)

8 (This is not a typo: this is using a bit of humor to emphasize a point.)

would know about techniques (in hardware, software, and firmware) for addressing these problems.

d) Large-format/Large-dimension touchscreens and panels
   - Large touchscreens and tablets -- say two or three feet across -- are hard to build, and hard to use. One problem is that it can just take a lot longer for electronics to check across the whole thing for where you might be touching, so you have to write or draw more slowly. A POSITA would know all about these problems, for all kinds of touchscreens and tablets, and how people had solved them before.

Anyway, that was the gist.

Conclusion: ... How much is there to know? **A lot**!

In our two examples, we only talked about capacitive touchscreens, and only about manufacturing a transparent capacitive touchscreen. If we just expanded things a little bit, to include (say) "resistive touchscreens", or "remediation techniques for timing errors in tablets", or "algorithms for multi-touch gestures", or "pattern analysis for signature verification"[9], or any of a number of things that come up with touchscreens and tablets, the list of Things To Know can get **much** bigger.

So there is a lot more to know about touchscreens and tablets than you might at first think!

So, with so much that had been done before, just what is really new about touchscreens and tablets today? Or more particularly, what things could be novel enough to be patentable?

As patent practitioners know, it all depends on exactly what a patent's claims say, and how that compares with the details of prior art. A qualified expert witness on touchscreens and tablets, and their long history, may be helpful in understanding the claims and knowing what the prior art might be helpful.

About the Author: *Jean Renard Ward is highly experienced, MIT-educated expert witness in patent litigation. Mr. Ward's areas of design and development expertise include multi-touch/touchscreen and tablet hardware, capacitive touch and proximity sensors, styli/electronic pens, haptics; gestures, user interfaces (UIs), touchscreen graphics, and accessibility user interfaces (blind/visually-impaired); digital rights management (DRM), digital encryption and authentication (PKI), and malware detection; programming/coding (C/C++/Java, other systems), source-code analysis and reverse-engineering, and firmware. Clients include Google, Samsung, Ericsson, Lenovo, Motorola, Nokia, and Lucent Technologies. Mr. Ward has been Granted multiple US patents. He received his degree in Computer Science and Electrical Engineering Degree from M.I.T.* ***Mr. Ward can be contacted at Rueters-Ward Services; Phone: (617) 600-4095; Cell: (781) 267-0156; Email:*** *jrward@alum.mit.edu* ***Website:*** *www.ruetersward.com*

9 (All of which are "real things" people know about for touchscreens and tablets.)