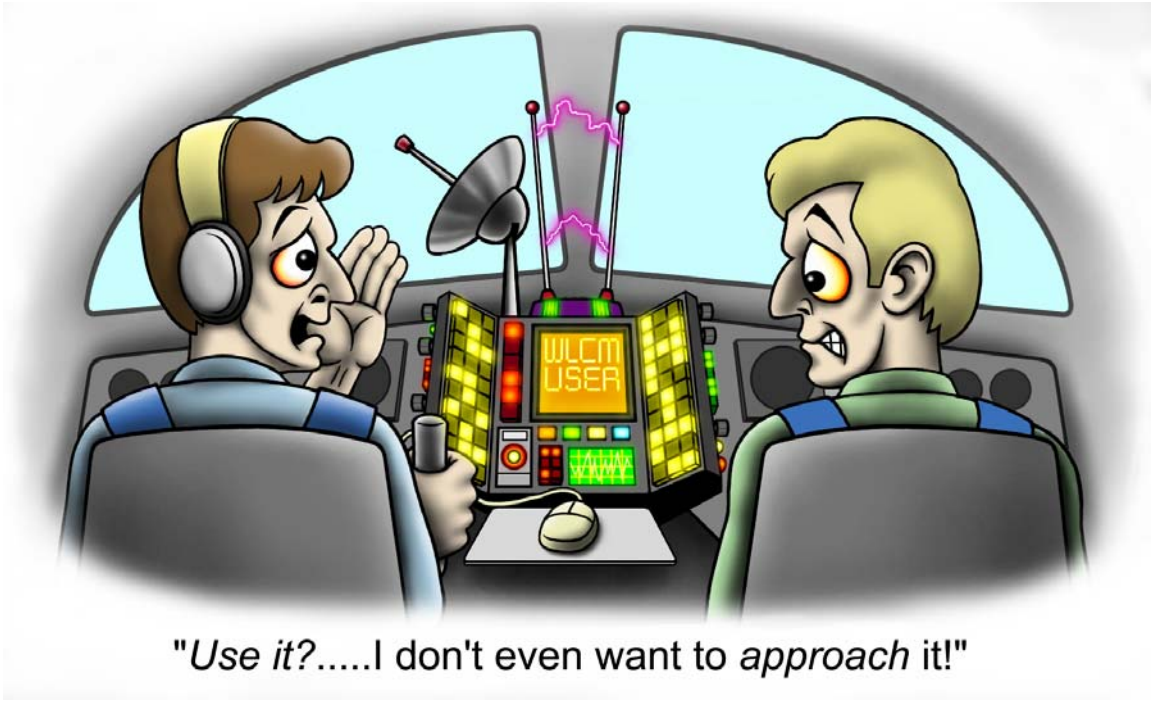
The User-Hostile Interface



"*Use it?*.....I don't even want to *approach* it!"

Written By: Walter Shawlee 2
(Avionics News)

Illustrations: Larry Stewart

The User-Hostile Interface **by: Walter Shawlee 2**

Recently, while enjoying some sushi with one of my friends here, we were talking about how systems work from the user's viewpoint. Maybe you talk about women, football and fast cars, but we both have deep technical and philosophical backgrounds, so we talk about world fiscal trends, technology and the great test gear we scored on ebay. Eavesdroppers are no doubt utterly mystified by our discussions. He looks after the radio and computer networking gear for all the law enforcement in our city, and is pretty much one of the smartest people I know.

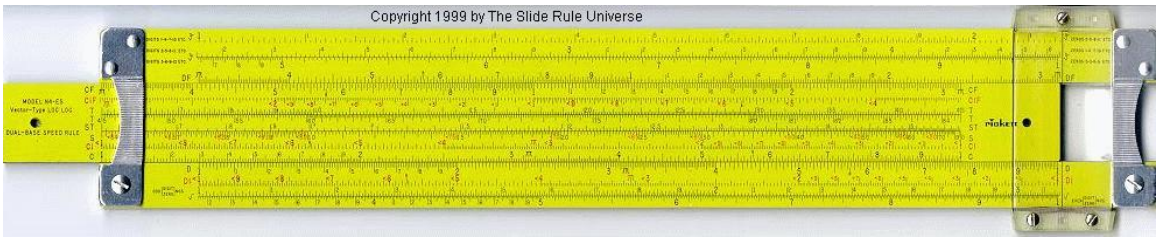
He made a comment that really made me stop and think, which was that neither he nor the pilot could figure out how to run the GPS/Comm radio installed in one of their helicopters. It's been in the ship for about 3 years, but has been used only in the most basic way. The pilot has 20+ years flight experience, and he has about the same in electronics and communications, yet neither of them could make the radio do something simple the pilot wanted to do, and which supposedly the radio could easily do. They had to dig out the manual, and both spent an hour in the cockpit before they got it to work. Not really the perfect situation in a high stress flight environment, but it illustrates some of the biggest problems lurking in our industry.

Having warmed to the subject, and knowing how many years I have spent in the avionics world, he then went on to flambé me for another 15 minutes about all the other radio gear in that ship that was just as bad, and in fact had less operational functionality than they had previously, and as a bonus was much harder for the pilots to use. I am happy to report that I designed none of it that he was unhappy with (and thus am fortunately blameless in this one, single case), but I couldn't help sympathizing with every word he said. The general state of all electronics interfaces today can best be described as ghastly, bordering on dysfunctional.

How did we get to this unhappy spot? Actually, it was almost inevitable, since we produce engineers with literally zero background in the arts, human factors, philosophy, psychology or sociology, and then turn them loose woefully ill equipped to make all the things we require in everyday life from mops to cell phones, and they are mainly miserable failures. Not from a sales perspective perhaps, but from the user's viewpoint, it is usually a selection of the least awful. Much like politics, as it happens.

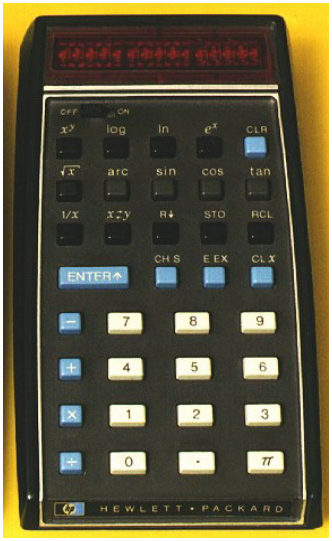
This wrong-headed trend started appearing publicly way back in the early 60's even before electronics was so all-pervasive, at a company called Pickett, that made slide rules. It was suggested to them that rather than use arcane and cryptic slide rule scale names like A, C, K, and CIF, that they use X^2, X, X^3 and 1/piX on the rule body, which people could at least puzzle out, and from there, grasp intuitively how the rule worked. A high school student also designed and offered to them a brilliant multi-decade scale that solved the problem of "placing the decimal point", and allowed a gigantic dynamic range of 20 decades, perfect for electronics and engineering. The reply from the company president at

that time was that anybody smart enough to use a slide rule could figure it out without those things, so it was all unnecessary. European and Asian makers went on to extensively mark their rules to be "self-documenting", but American makers resisted with few exceptions right up until the very end, when the debut of the HP-35 calculator made slide rules a memory in 1972. Everybody couldn't wait to get something "easier to use". Interestingly, many slide rules languish today in drawers because nobody can figure out how to operate them (so I guess it wasn't really ***that*** obvious), although they are painfully simple. If you happen to need to know this information, you can look here for detailed instructions: http://www.sphere.bc.ca/test/howto.html and here: http://www.sphere.bc.ca/test/2learning.html



Pickett N4ES, courtesy of the Slide Rule Universe
http://www.sphere.bc.ca/test/sruniverse.html

Ahh, the calculator. While many makers like Wang and Freiden already made obvious and easy to use (but expensive) 30 pound desktop models with normal looking keys like x, +, - and =, Hewlett Packard (hp) would leap into the market with a tiny and miraculous hand-held, pocket sized HP-35 and alter modern history forever. It is hard to truly appreciate the genius of this landmark design, but it is literally the birthplace of modern microprocessor applications, and the first truly personal computer. There was just one tiny flaw in it, which Michael Malone (the author of ***Bill and Dave***, the best study of hp and its founders), described this way: *"It was as if Alexander Graham Bell had invented the telephone, and then demanded that people only speak Hittite when they used it."* And in one swift stroke, the User-Hostile Interface was fully entrenched.



HP-35, courtesy of Museum of HP Calculators

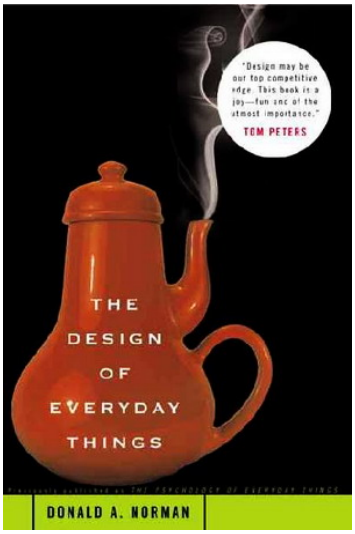
http://www.hpmuseum.org/

The HP-35 used RPN, or *reverse polish notation* to enter commands, a technique known and understood by exactly no one, and which had no "=" key. In a further assault on intelligibility, pressing the **arc** key would invert trig functions, as a kind of hidden shift key. To add to the nightmare, later models would add both dedicated function and multi-colored shift keys to change functions and get more use out of every single key switch. It was at this exact moment that the biggest engineering mistake in human history would emerge and sink its fangs into everybody: ***it doesn't matter if people understand it or it's obvious, they will just learn to use it.***

No, actually they won't. The HP style calculators were a big hit in the engineering world (that should have set off alarm bells everywhere, but it didn't), but largely impenetrable to everybody else. They sold almost 10,000 a month right out of the gate (10 times hp's own estimate), but Texas Instruments and the Japanese, Taiwanese and Chinese would go on to sell untold 100's of millions of them to everybody else with normal keystrokes and an equal key, and RPN would eventually disappear to relief of many. Unfortunately, the damage was already done. The pattern of the cryptic and hard to figure out tool (and where *proof of understanding* was your techno-merit badge, just like Unix) was now set in the minds of engineers, and they would fall back on this exact lesson endlessly through the software and computer age. Lets face it, just what was somebody thinking when they decided to click on a screen icon marked START to shut down a computer?

This concept of pushing a badly flawed but "technically better" design would prove to be the pattern for decades of development, generating a great deal of commerce, but very little user happiness. It's no wonder that people have sometimes gone berserk over the simplest things from Apple, since they at least have devoted some significant energy to ease of use, actual utility and beauty in design. There's clearly no RPN spoken there.

What actually makes a good design or product? For this, I have to refer you to a wonderful book called ***"The Psychology of Everyday Things"*** which was later re-titled ***"The Design of Everyday Things"*** by Donald A. Norman. His understanding of the design process is so profound, I think you owe it to yourself to read this book, rather than take any edited summary from me. I used to give copies of this to all the designers and engineers at NAT so they would really understand that there is a way of thinking about the design that includes the end user and what they want to do as critical elements. As I put on the wall in R&D: ***a good design should delight the customer, and depress the competition.*** I still believe that simple rule is the foundation of all good product development, and you are welcome to steal it.



The Design of Everyday Things, by Donald A Norman
http://www.amazon.com/Design-Everyday-Things-Donald-Norman/dp/0465067107/ref=pd_bbs_sr_2?ie=UTF8&s=books&qid=1206831568&sr=8-2

At the end of the day, ***it's always the work that is important, never the tool***. Toolmakers keep trying to change that situation by insisting you learn their arcane, tribal voodoo technique to do the simplest things, but really it's a huge misallocation of energy and resources. The work, the function you need to do, is ***everything.*** The ideal tool to do that work is literally invisible and inherently understandable. Now, what do you own you can say that about?

We are in a bad state when the frustration with everyday items has become all-pervasive, and we seem unable to devote any energy to making good products, but only to making new ones. I can't ever remember any problems with my old touch tone phone (or a dial one either, and I hate to date myself that badly), but I can barely understand most people talking on a cell phone, and the cliché of the cell phone not working when it's important is now so common that we just take it for granted. It's a good thing you can now download music on them, since they seem somewhat ineffective as actual phones.

It's interesting to trace back these problems and see how they crept into everyday life, but it's really not so wonderful to face them in the cockpit. Here's where things get serious in a big hurry, and far away from help. Many modern and not so modern avionics products have casually started out on the wrong path, and then made a permanent home there.

Oddly, the first mis-steps were colors. We all accept, and the FAA likes to insist, on certain colors for certain tasks. Red is a warning, amber is a caution, green indicates normal operating condition, blue or white for messages. Yet, general aviation comm radios used amber gas discharge displays for frequency displays, and FM tactical radio controls used red LED displays. Transmit condition was indicated by a green light, yet that is a caution, and receive was indicated by an amber light, yet that is a normal state. The mixed messages were considerable, and the rationale was varied, but usually something to do with the choices being "technically better". Hmm, that sounds familiar.

Need some color assistance? See the Nasa/Ames Color Reference:
http://colorusage.arc.nasa.gov/cockpit_1.php

As cockpit devices became more complex, displays and panels were loaded with more data and legends, often abbreviated because of technical or space issues. Thus the pilot's world suddenly became laced with ICS, VOL, LVL, XTRK, SCN, SQ, TX, MN, CTCSS, GD, TRK and BRG. These terms were not only often unfamiliar to pilots when fully spelled out, but moved directly to incomprehensible when the vowels were removed. Sadly, no magic decoder rings were issued to flight crews, but they remain hopeful it might yet happen in the future.

Radio systems shifted from just required AM Comm radios and Nav Aids to FM Tactical radios, GPS, MLS, TCAS, electronic flight bags and a host of other complex items to make the pilot "safer", more efficient and better equipped to deal with his flight tasks. Each had its own design and appearance, and its special tricks to make it operate, a huge memory and operating problem for the user. Regrettably, no radio training for flight crews ever materialized along with these items. The extent of actually available learning materials generally was a short "operator's guide" that promptly disappeared on delivery, and some cryptic information added to the flight manual supplement that often failed completely to explain the system, but addressed only FAA flight safety issues.

Since cockpit panel space is small, the multi-tasking of controls has set in with a vengeance, so that there is no body memory a pilot can employ, where " I always turn this to select the frequency". No, now that one control enters all kinds of data, depending on the mode of the unit, defeating a power memory tool for instinctive operation. Many functions are conducted by key press operations with legends that change constantly (soft keys). As a result, the pilot has to watch carefully what he is doing, rather then just flip a familiar switch to activate some operation. And of course, every unit in the panel has a different "obvious" technique; so running the whole avionics panel is now a virtual Mensa entrance exam.

How are pilots expected to truly learn this equipment? What about fleet operations, where many pilots have to use different machines and different systems on a regular basis? And more correctly, why should a two-inch thick manual ***even be required*** to run a radio? How can it be that a computer and display is stuffed into the panel, but no thought is given to having the equipment ***teach*** the user directly with ***help and tour functions***?

Well, it appears the old Pickett attitude of "anybody smart enough to use it can figure it out" is still with us. Norman discusses this problem in detail in his books with his concept of "knowledge in the head", which explains that many objects simply cannot be operated without extensive preparation and study, because the design is so badly flawed that it does not lead the user to do the right thing. Thus are endless mistakes, accidents and "No Fault Found" service occurrences swiftly generated in the cockpit to the distress of everyone.

Now enter graphical GPS and a host of new adjunct navigation services including digital pictorial navigation with terrain, ADS-B, WAAS and all kinds of flight planning tools. The problem here is that many of these systems are really computer-based products, sitting in a cockpit container. The software-driven computer workspace has its deep flaws, from nested menus to counter-intuitive operations, and generally relies on significant graphical user interaction with a mouse or other device to navigate functions and make selections, something not really possible in the cockpit unless we plan to add a small card table there for the mouse to sit on.

What kinds of control operations are really possible for a pilot? If we are talking about a helicopter pilot, the answer is frequently ***none***, as both hands are always busy, if we are discussing a fixed wing (non-military) pilot he can ***usually free up one hand and look to the side to see the radio gear***. He can push something if it's large and not too close to something else (although not reliably, as turbulence and vibration can make single key press operations very erratic), and he can turn something, which can be a potentiometer or a rotary switch/encoder. The pilot can also move the position of a toggle or lever through 2 or 3 positions, or push a slider or linear control. Don't forget that this all has to work in flight with gloves on, too.

Literally all cockpit interfaces come down to just these four basic movements (a few devious designers have single controls you can both turn and push for added confusion), and all system results flow from them. The bigger issue of how the pilot is actually going to do this movement, or whether or not he has enough time and attention to do whatever is required, is largely ignored by equipment makers. Pilots simply do not have two free hands, and unlimited time and attention to operate any radio device, no matter how critical it may be. Equipment makers really need to get this problem under control, or start supplying a ride-along navigator/technician to go with each unit. The pilot does not want to lose his concentration and situational awareness just to run a radio.

Several years ago, I was at a trade show, and a new GPS/Comm box was on display for people to try out. Being a confirmed equipment fan, I had to try this out for myself. It looked very nice, but nobody standing there could make it work, and in fact, several times, we got the unit locked up, and had to power it down to escape from strange situations where we just couldn't make it function any further. I happily deferred to some senior pilots (since this unit was making me look like a total idiot), who also could not make it run, and after about 20 frustrating minutes, that entire group left to be replaced by another group who also had trouble.

This is a major storm warning. No person I have ever spoken to said they ***liked*** nested drop down menus and tedious step interfaces to do what they see as the obvious thing. It is usually creeping "featurism" that brings on this visual control clutter. But it is really worth knowing that most people use only a very small subset of functions for any product, from a cell phone, microwave, to a laptop or Nav Aid, and for them, the rest is actually a problem, kind of an intellectual field of land mines they have to navigate to do simple but important tasks. As they forget how things work, they use a progressively smaller ands smaller group of functions.

It is important to understand that these design errors relentlessly translate into huge support costs over the life of avionics systems, consuming thousands of man-hours in chasing and troubleshooting non-existent problems. They also trigger many operational problems, some very serious, where communication or navigation simply does not function as needed in critical situations. These costs and loss of functionality are not trivial, and severely stress everyone involved, plus they inevitably lead to a loss of confidence in the support service and equipment itself. As we move into a deeper and deeper reliance on complex systems for flow control and safe flight, the stakes for good design get much higher and more important.

I spent many years running avionics services for fleet operators, and there are a few things I can share with you that may prove useful. First, most pilots will never admit they have made a mistake with a radio; it always "didn't work". And second, they will often say they understand something when they do not. This is reality, so you need to adapt your support strategy around it. Pilots prefer to study and experiment in private, and the best thing you can do is to give them truly useful (and highly visual) operating information, and a way to run the gear by themselves, and let them reach their own understanding. Finally, all the things and terms we take for granted, from modulation to sideband mean exactly nothing to pilots. We might as well be speaking Urdu to them. They are not technicians, and do not pretend to be. The huge mistake everyone keeps making is to treat them and speak to them as if they were.

Many years ago, I realized these operational problems would just not go away, and wrote a small booklet called "The FM Radio Guide". This was meant to explain to customers the underlying concepts behind the complicated world of tactical radio, and we gave away thousands of copies to anybody that wanted them. No doubt many went to users of other radio gear, but that was OK, I liked the irony of that. The guide had two very important results, it greatly reduced our nuisance system problems from users, and it made them feel much more confident about what they were doing, improving their experience and happiness with our gear. Mind you, almost 20 years ago, we had ***already*** put a "Help" button on our control systems, and had the units wake up asking if the user wanted a tour of the operation. If we could do it then with a simple text display, it can certainly be done today on almost any system. Those control systems even had "context-sensitive help" for all the detailed data entries.

Design is an art, and engineering is a science. Good product development requires both, and in the right sequence. Design is the operational concept and the interaction with the user, engineering is calculating the size of the required heatsink and laying out the circuit boards. These are very different fields of study, and only rarely can people do both well. The product has to move back and forth between these two disciplines until a workable system emerges.

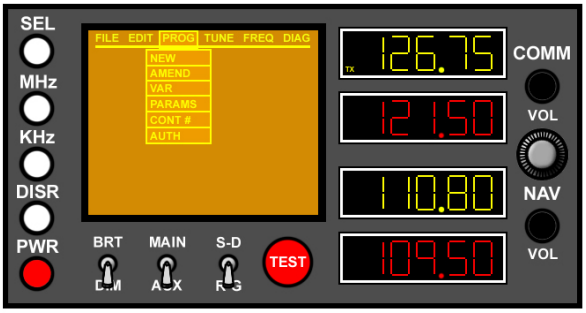
Design problems creep in mainly because of an elemental error in who should steer the primary design concept. The avionics world is cluttered with engineering people with flight experience, and they inevitably drive the process with a technology focus. Sadly,

they are the worst possible people to do so. They know too much about the systems, and as a result, are totally unable to understand or even credit the problems new users will encounter in learning or operating it. Customers and willing co-workers who do not really understand all the concepts are the ideal source of test guidance here, and if that fails, I suggest using your receptionist. If he or she can't figure it out, it is almost certainly doomed in the real world of users. I can verify from personal experience that this final test actually works very well. When somebody who has never seen it before can just sit down and make it work, you have the right recipe.

To really improve things, there are some simple strategies that work. Be sure colors are appropriate, and legends are fully understandable. Never abbreviate unless it is impossible to do otherwise, and be sure the word you use is really the correct one. If possible, also remote any high use functions out to the collective or yoke so that it is not necessary for the pilot to let go of everything to run the system. Make the system serve as its own manual, so that any user can figure it out ***without*** a manual. Make functions clear, obvious and easily understood. Data entry has to be clean and simple, without any multiple operation steps. If you absolutely must add a host of secondary functions, make it possible to shut them off, or disappear from sight when not wanted. Consider a layered approach to operation, with high use operations on top, and strong physical mapping to controls. Watch out for pushbutton inputs, these are hard to carry out in flight. If the control is a selector, consider rotary encoders instead and a feedback beep for stepping through operations. When writing the manual for a system, be sure you explain everything clearly, including the underlying science, and be generous with illustrations. And finally, let others who do not know the system try and run it, and don't let the design escape into the world until they can do it with no prompting from you.

We can always do better, our challenge is not to become lost in the technology and forget that ***functionality always comes first***, and it's ***only the user that defines what is satisfactory***. Those are really the most important messages.

Hard to Understand Clearly



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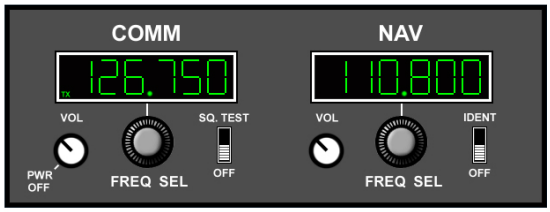

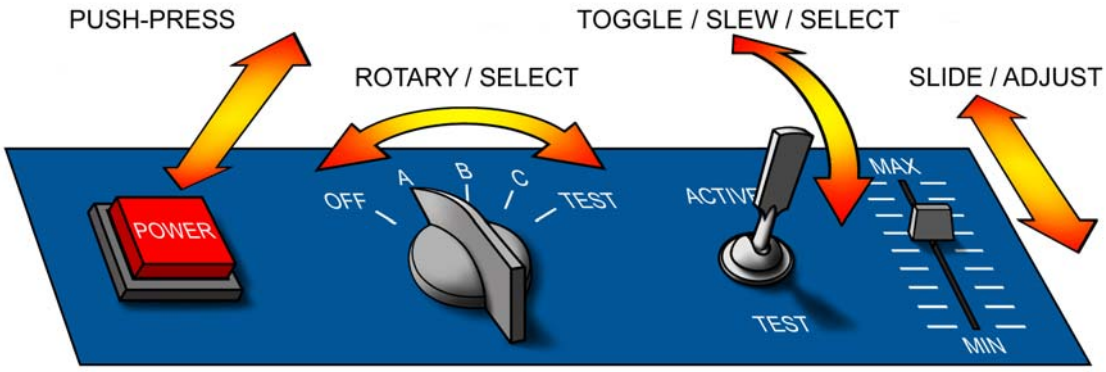

TYPES OF CONTROL MOTION

Control Motion Summary

Motion:	Push/Press	Rotate	Toggle	Slide
Best For:	Simple momentary or latching function.	Source/Data selection or level adjustment	Important single function or selection	Level adjustment.
Problems:	Vibration can cause multiple entry on momentary switches even if de-bounced. Momentary selection switches very hard to operate blind.	Expensive, often have to pass through unwanted steps. Knobs are often too small for a good grip or proper resolution.	Hard to move or select if tightly spaced.	Very hard to seal unless lever operated, which is expensive.
Key Features:	Momentary switches are very inexpensive.	Positive feel, easy to operate without looking.	Positive feel, easy to operate without looking.	Easy to operate without looking.