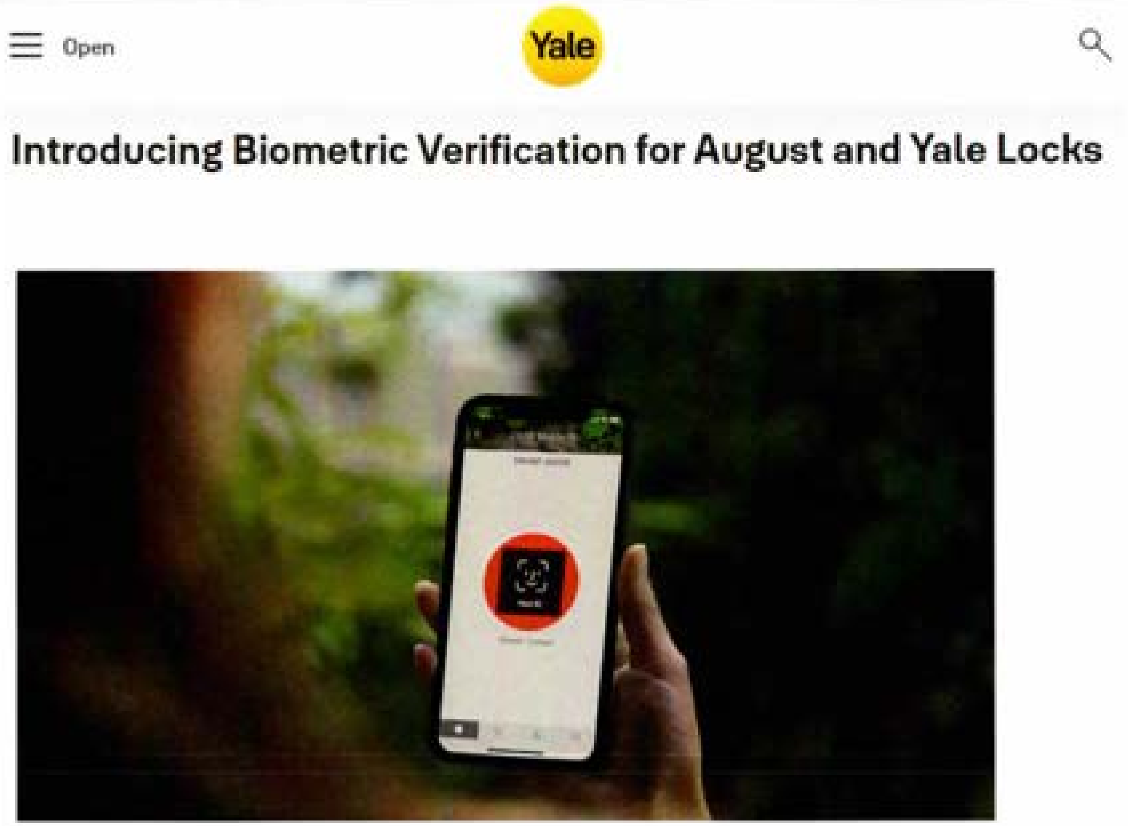
Exhibit I

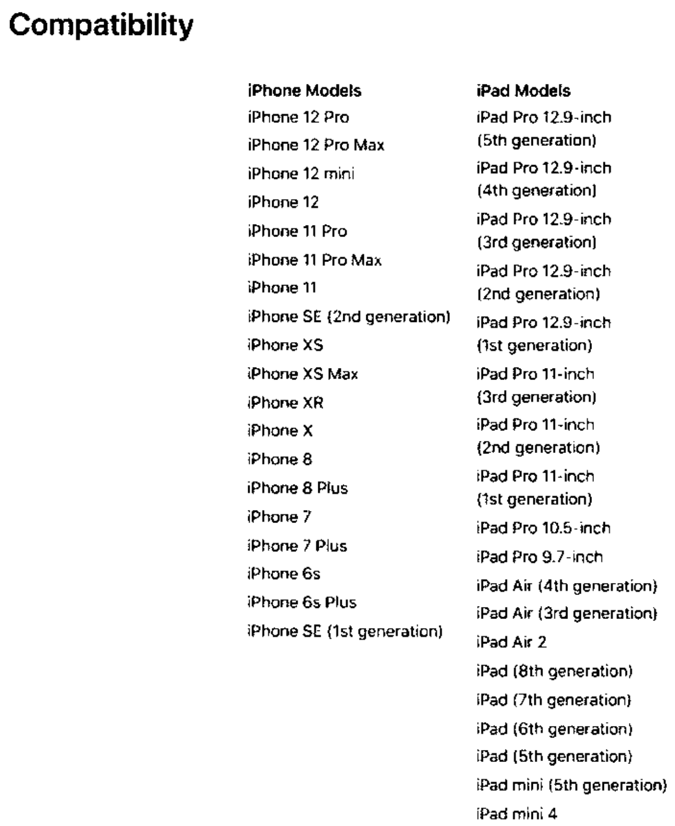
Claim Chart for U.S. Patent No. 9,665,705 ("the '705 Patent")

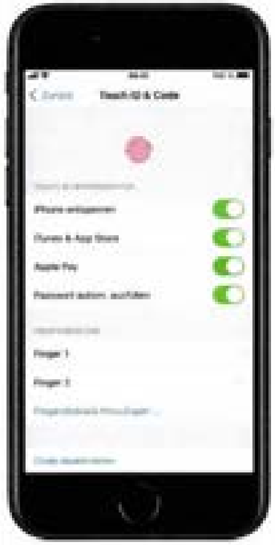
The Accused Instrumentalities include, but are not necessarily limited to, Apple iPhone and Apple iPad compatible with Yale Smart Locks, and any Apple product or device that is substantially or reasonably similar to the functionality set forth below. The Accused Instrumentalities infringe the claims of the '705 Patent, as described below, either directly under 35 U.S.C. § 271(a), or indirectly under 35 U.S.C. §§ 271(b)–(c). The Accused Instrumentalities infringe the claims of the '705 Patent literally and, to the extent not literally, under the doctrine of equivalents.

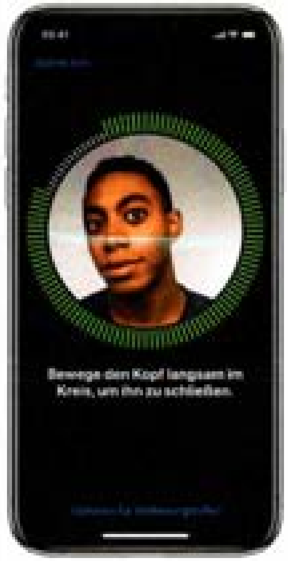
Claim 1	**Accused Instrumentalities**
1. A system for providing secure access to a controlled item, the system comprising:	***To the extent that the preamble is deemed to be a limitation, the Accused Instrumentalities are configured to use a system in accordance with this claim.*** More specifically, the controlled item is a locking mechanism of the door lock of the user's home. The Accused Instrumentalities are configured to provide secure access to the user's home via Yale Smart Locks when the user provides biometric signal to the Accused Instrumentalities via Touch ID or Face ID. "When the "Secure Remote Access" feature is turned on, the app will use your phone's built-in authentication tools to prompt fingerprint or facial recognition before you can unlock or lock your home remotely (note: if your phone does not have these features, it will prompt you to use your PIN code). This further ensures that your door is only operated by the right people at the time you intend for it." (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

Claim 1	Accused Instrumentalities
	 Open Yale Introducing Biometric Verification for August and Yale Locks (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

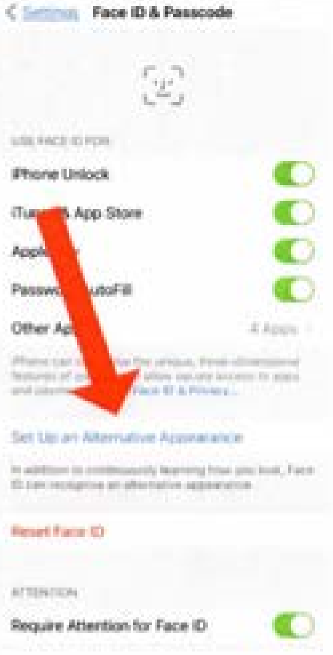
Claim 1	Accused Instrumentalities
	 (https://www.apple.com/shop/product/HPAR2ZM/A/yale-assure-lock-sl-touchscreen-deadbolt-black)

Claim 1	**Accused Instrumentalities**
	The Accused Instrumentalities compatible with Yale Smart Locks are shown below:  **Compatibility** **iPhone Models** iPhone 12 Pro iPhone 12 Pro Max iPhone 12 mini iPhone 12 iPhone 11 Pro iPhone 11 Pro Max iPhone 11 iPhone SE (2nd generation) iPhone XS iPhone XS Max iPhone XR iPhone X iPhone 8 iPhone 8 Plus iPhone 7 iPhone 7 Plus iPhone 6s iPhone 6s Plus iPhone SE (1st generation) **iPad Models** iPad Pro 12.9-inch (5th generation) iPad Pro 12.9-inch (4th generation) iPad Pro 12.9-inch (3rd generation) iPad Pro 12.9-inch (2nd generation) iPad Pro 12.9-inch (1st generation) iPad Pro 11-inch (3rd generation) iPad Pro 11-inch (2nd generation) iPad Pro 11-inch (1st generation) iPad Pro 10.5-inch iPad Pro 9.7-inch iPad Air (4th generation) iPad Air (3rd generation) iPad Air 2 iPad (8th generation) iPad (7th generation) iPad (6th generation) iPad (5th generation) iPad mini (5th generation) iPad mini 4 https://www.apple.com/shop/product/HPAR2ZM/A/yale-assure-lock-sl-touchscreen-deadbolt-black
1a. a memory comprising a database of biometric signatures;	***The Accused Instrumentalities include a memory comprising a database of biometric signatures.***

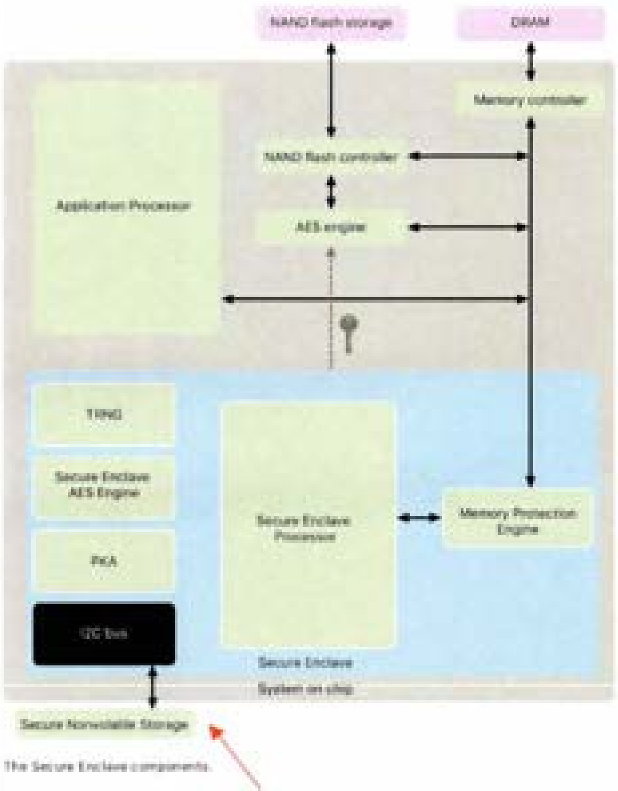
<u>Claim 1</u>	<u>Accused Instrumentalities</u>
	More specifically, the iPhone allows multiple biometric signatures to be entered into a database on the iPhone: **Touch ID** The iPhone allows the registration of multiple fingerprints:  Touch ID & Code iPhone entsperren iTunes & App Store Apple Pay Passwort autom. ausfüllen Finger 1 Finger 2 Fingerabdruck hinzufügen … Fig. from https://support.apple.com/en-us/HT201371 under Manage Touch ID Settings. In the second bullet, it literally says: "Register up to five fingerprints." "Touch ID can read multiple fingerprints, and it can read fingerprints in 360-degrees of orientation. It then creates a mathematical representation of your fingerprint and compares this to your enrolled fingerprint data to identify a match and unlock your device. "

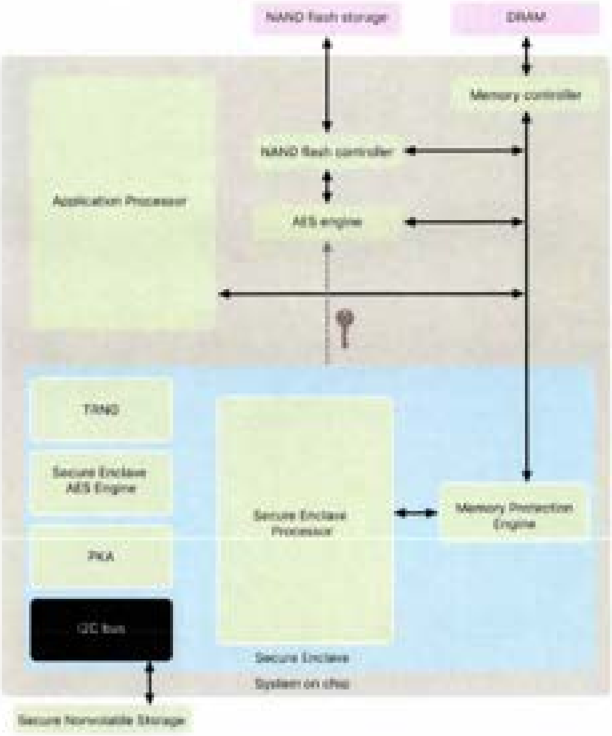
Claim 1	Accused Instrumentalities
	(https://support.apple.com/en-us/HT204587) "Touch ID can read multiple fingerprints and recognize fingerprints at any orientation of the finger. The system then creates a mathematical representation of your fingerprint and compares it to the registered fingerprint data to determine a match and unlock your device." (https://support.apple.com/en-us/HT204587) **Face ID** The iPhone allows the registration of multiple faces:  Bewege den Kopf langsam im Kreis, um ihn zu schließen. To register a face, the iPhone takes a series of pictures of the user in different poses while circling his head. This is revealed in detail in https://support.apple.com/en-us/HT208109 in the second section "Configure Face ID", there also the figure shown above.

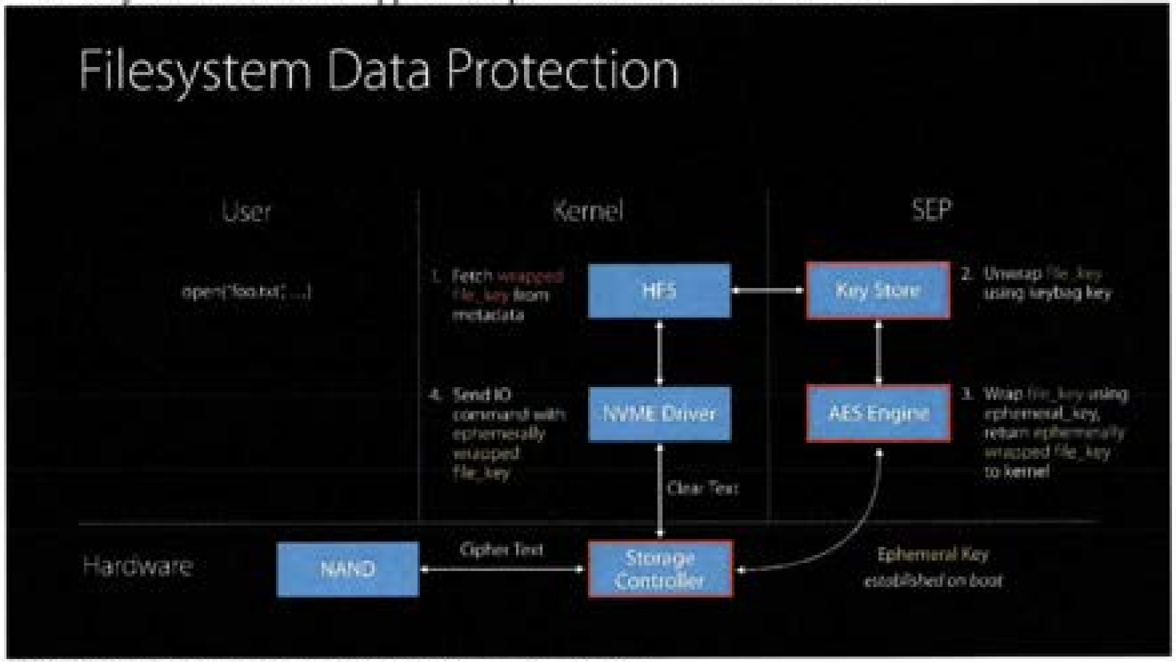
Claim 1	**Accused Instrumentalities**
	To register a second face, the iPhone offers a corresponding option in its settings. If the user selects the option "Set up an alternative appearance" as shown in the figure below (from How To Add A Second Face To Face ID - Macworld UK; https://www.macworld.co.uk/how-to/second-face-id-3803421/), a second face is registered by the iPhone in the same way as the first face. "Set up Face ID or add another face. • Select "Settings" > "Face ID & Code" > "Configure alternate appearance" if you want to configure another face to be recognized by Face ID." (https://support.apple.com/de-de/guide/iphone/iph6d162927a/ios)

Claim 1	Accused Instrumentalities
	 Settings Face ID & Passcode USE FACE ID FOR iPhone Unlock iTu App Store Appl Passwo utoFill Other Ap 4 Apps iPhone can r the unique, three-dimensional features of y allow secure access to apps and paym Face ID & Privacy... Set Up an Alternative Appearance In addition to continuously learning how you look, Face ID can recognise an alternative appearance. Reset Face ID ATTENTION Require Attention for Face ID The page How To Add A Second Face To Face ID - Macworld UK (https://www.macworld.co.uk/how-to/second-face-id-3803421/) literally states: "Face ID is a fast and secure way to unlock your iPhone or iPad Pro, but you may not know that you can actually set up more than one face to use the feature. This second face could belong to a loved one, enabling your partner or child to access your phone without requiring your smiling mug to unlock it. " To store the biometric signatures ("template data") from the received biometric signals, the iPhone has a System on Chip (SOC) called a Secure Enclave. A Secure Enclave Processor provides the Secure Enclave with computing power:

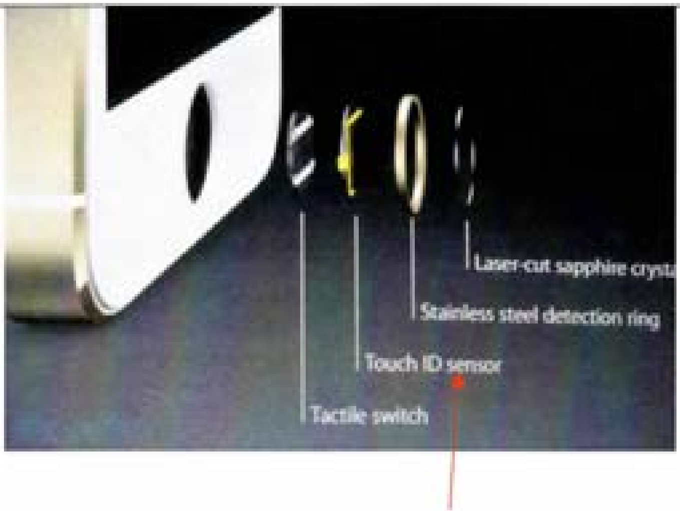
Claim 1	**Accused Instrumentalities**
	"The *Secure Enclave* is a system on chip (SoC) that is included on all recent iPhone, ... devices" (Ex. A, Apple Platform Security, at 7.) "The Secure Enclave is a dedicated secure subsystem integrated into Apple systems on chip (SoCs)." (*Id.*, at 9.) The Secure Enclave Processor provides the main computing power for the Secure Enclave." (*Id.*, at 10.) "During enrollment, the Secure Enclave processes, encrypts, and **stores** the corresponding Touch ID and Face ID template data." (*Id.*, at 19.) The Secure Enclave has access to a memory assigned to it and accessible only to it: **Secure nonvolatile storage** "The Secure Enclave is equipped with a dedicated secure nonvolatile storage device. The secure nonvolatile storage is connected to the Secure Enclave using a dedicated I2C bus, so that it can only be accessed by the Secure Enclave." (*Id.*, at 15.) This memory serves as a database for storing the biometric signatures: "The secure nonvolatile storage is used for all anti-replay services in the Secure Enclave. Anti-replay services on the Secure Enclave are used for revocation of data over events that mark anti-replay boundaries including, but not limited to, the following: • ... • Adding or removing a Touch ID fingerprint or Face ID face". (*Id.*, at 16.)

Claim 1	Accused Instrumentalities
	This database is shown in the figure from Apple Platform Secutiry reproduced below:  NAND flash storage DRAM Memory controller NAND flash controller Application Processor AES engine TRNG Secure Enclave AES Engine PKA I2C bus Secure Enclave Processor Memory Protection Engine Secure Enclave System on chip Secure Nonvolatile Storage The Secure Enclave components. Database 105 (Ex. A, Apple Platform Security, at 9.)

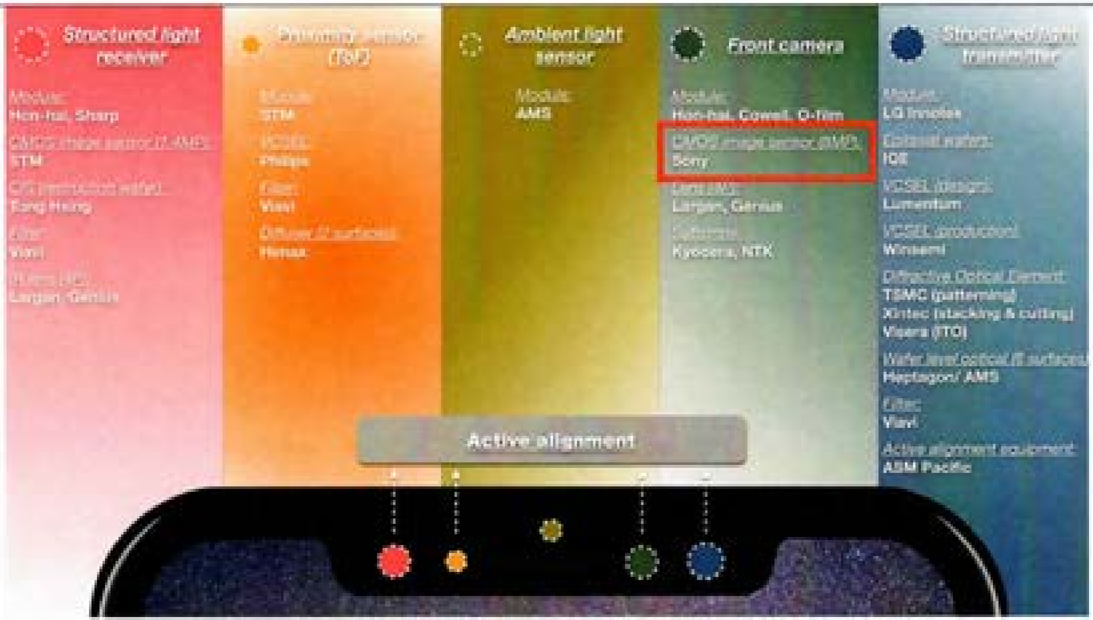
<u>**Claim 1**</u>	<u>**Accused Instrumentalities**</u>
1b. a transmitter sub-system comprising:	***As set forth in elements 1b1, 1b2, and 1b3 below, the Accused Instrumentalities include a transmitter sub-system.*** The iPhone's Secure Enclave is a transmitter sub-system. It sends ephemerally re-encrypted file keys to the application processor with its file system driver ("Application Processor file-system driver") to read the files in the NAND Flash Storage.  NAND flash storage DRAM Memory controller NAND flash controller Application Processor AES engine TRNG Secure Enclave AES Engine Secure Enclave Processor Memory Protection Engine PKA I2C bus Secure Enclave System on chip Secure Nonvolatile Storage The Secure Enclave components. (Ex. A, Apple Platform Security, at 9.)

Claim 1	**Accused Instrumentalities**
	"sepOS can then use the ephemeral wrapping key to wrap file keys **for use by the Application Processor file-system driver. When the file-system driver reads or writes a file, it sends the wrapped key to the AES Engine. "** (*Id.*, at 14.) "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. [...] When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and **sent back to the Application Processor."** (*Id.*, at 85.) The file system driver of the application processor is an NVME driver:  Filesystem Data Protection User Kernel SEP open("foo.txt", ...) 1. Fetch wrapped file_key from metadata HFS Key Store 2. Unwrap file_key using keybag key 4. Send IO command with ephemerally wrapped file_key NVME Driver AES Engine 3. Wrap file_key using ephemeral_key, return ephemerally wrapped file_key to kernel Clear Text Hardware NAND Cipher Text Storage Controller Ephemeral Key established on boot (Ex. B, Behind the Scenes with iOS Security, at 30.)

Claim 1	**Accused Instrumentalities**
1b1. a biometric sensor configured to receive a biometric signal;	***The Accused Instrumentalities include a biometric sensor configured to receive a biometric signal.*** More specifically, the iPhone has at least one biometric sensor for capturing a fingerprint or a face (Touch ID and/or Face ID), namely a Touch ID sensor and a camera system with image sensor, respectively. **Touch ID** "Apple devices with a Touch ID sensor can be unlocked using a fingerprint." (Ex. A, Apple Platform Security, at 19.) "Touch ID is the fingerprint sensing system that makes secure access to supported Apple devices faster and easier. This technology reads fingerprint data from any angle and learns more about a user's fingerprint over time, with the **sensor** continuing to expand the fingerprint map as additional overlapping nodes are identified with each use." (*Id.*) "When the fingerprint sensor detects the touch of a finger, it triggers the advanced imaging array to scan the finger and sends the scan to the Secure Enclave." (*Id.*) The biometric sensor for Touch ID is located below the home button: "The Home button is a stack of different materials, capped with a sapphire crystal lens. The surrounding stainless-steel ring works as a ground and detects the user's finger. This action activates a capacitive touch sensor installed underneath the cover: A CMOS chip with small capacitors." (https://appleinsider.com/inside/touch-id)

Claim 1	Accused Instrumentalities
	 Laser-cut sapphire cryst Stainless steel detection ring Touch ID sensor Tactile switch Biometric sensor 121 "Where is the Touch ID sensor located? The Touch ID sensor is located either in the home button or - on the iPad Air (4th generation) - in the top button. (https://support.apple.com/en-us/HT201371) The image sensor captures an 88-by-88-pixel, 500 PPI raster scan: "The 88-by-88-pixel, 500-ppi raster scan is temporarily stored in encrypted memory within the Secure Enclave while being vectorized for analysis, and then it's discarded. The analysis utilizes subdermal ridge flow angle mapping, which is a lossy process that discards minutia data that would be required to reconstruct the user's actual fingerprint. The resulting map of nodes is stored without any identity information in an encrypted format that can only be read by the Secure Enclave, and is never sent to Apple or backed up to iCloud or iTunes. "

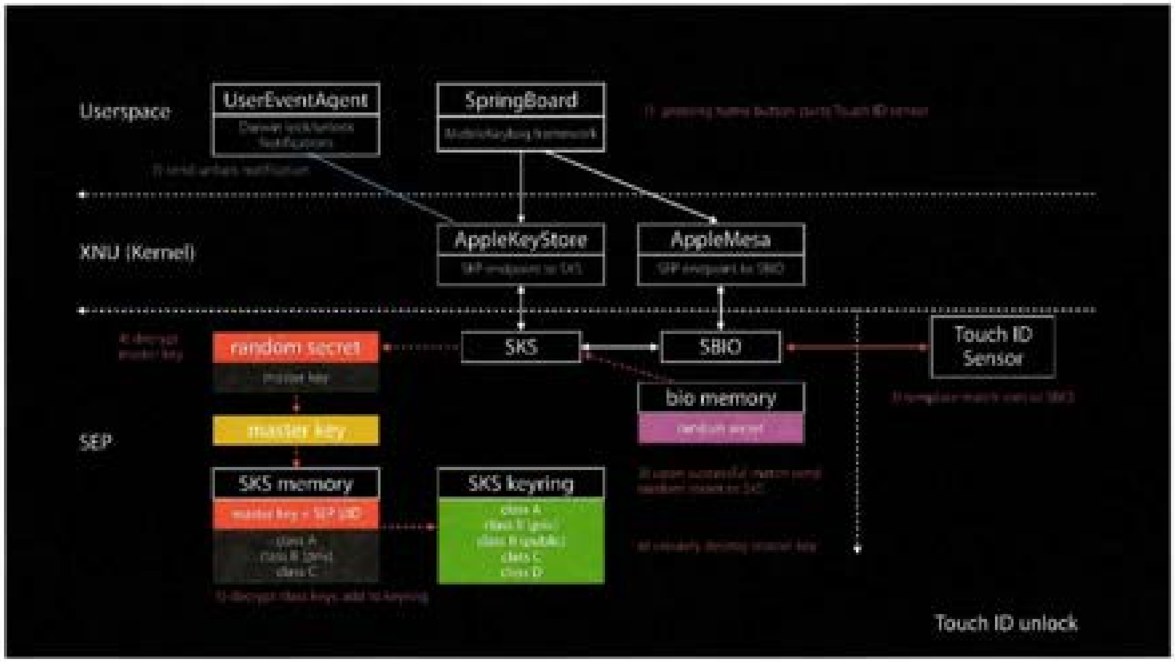
Claim 1	Accused Instrumentalities
	(Ex. C, iOS Security white paper, at 8.) **Face ID** The biometric sensor for facial biometrics is a camera system ("**TrueDepth** camera **system"**) with an image sensor. "With a simple glance, Face ID securely unlocks supported Apple devices. It provides intuitive and secure authentication enabled by the TrueDepth camera system, which uses advanced technologies to accurately map the geometry of a user's face. " (Ex. A, Apple Platform Security, at 20.) To receive a biometric signal, the camera system with image sensor reads over 30,000 infrared points to capture depth information along with a two-dimensional infrared image. "After the TrueDepth camera confirms the presence of an attentive face, it projects and **reads over 30,000 infrared dots to form a depth map of the face along with a 2D infrared image**. This data is used to **create a sequence of 2D images and depth maps**, which are digitally signed and sent to the Secure Enclave. To counter both digital and physical spoofs, the TrueDepth camera randomizes the sequence of 2D images and depth map captures, and projects a device-specific random pattern. A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (*Id.*) The camera system includes a biometric image sensor, namely a "CMOS image" sensor from Sony, to perform facial biometrics:

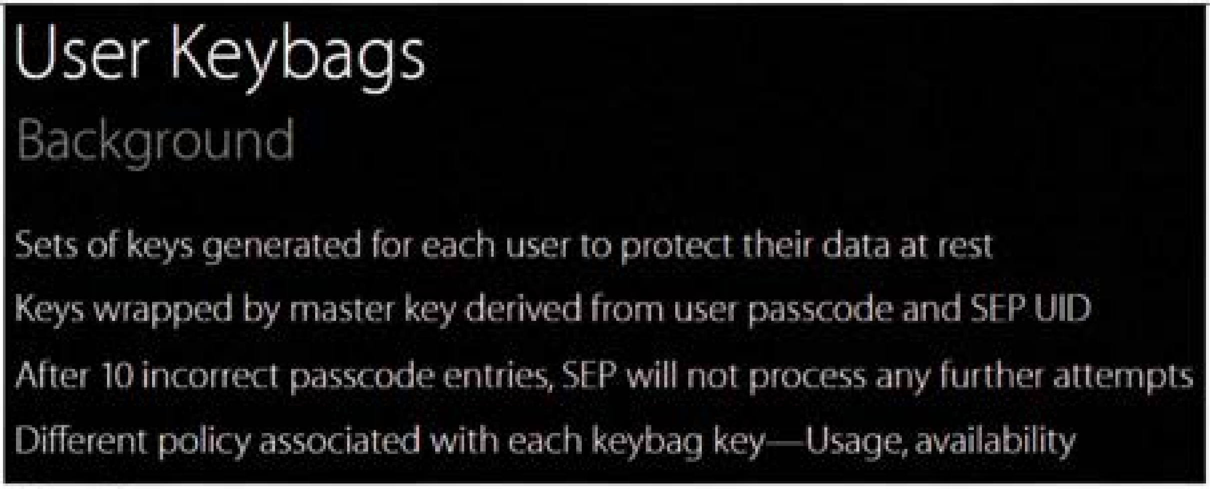
Claim 1	**Accused Instrumentalities**
	 Structured light receiver Module: Hon-hai, Sharp CMOS image sensor (1.4MP): STM CIS (wafer): Tong Hsing Filter: Viavi Lens (IR): Largan, Genius Proximity sensor (ToF) Module: STM VCSEL: Philips Filter: Viavi Diffuser (2 surfaces): Himax Ambient light sensor Module: AMS Front camera Module: Hon-hai, Cowell, O-film CMOS image sensor (7MP): Sony Lens (VIS): Largan, Genius Substrate: Kyocera, NTK Structured light transmitter Module: LG Innotek Epitaxial wafers: IQE VCSEL (design): Lumentum VCSEL (production): Winsemi Diffractive Optical Element: TSMC (patterning) Xintec (stacking & cutting) Visera (ITO) Wafer level optical (8 surfaces): Heptagon/ AMS Filter: Viavi Active alignment equipment: ASM Pacific Active alignment (https://appleinsider.com/articles/17/09/09/inner-workings-of-apples-face-id-camera-detailed-in-report)
1b2. a transmitter sub-system controller configured to match the biometric signal against members of the database of biometric signatures to thereby output an accessibility attribute; and	***The Accused Instrumentalities include a transmitter controller configured to emit a secure access signal conveying information dependent upon said accessibility attribute.*** More specifically, the iPhone's System on Chip (SOC), i.e. the Secure Enclave with its Secure Enclave Processor (SEP) or a Secure Neural Engine contained therein, is a means (103) to check a match of the biometric signal with elements of the biometric signature database. "The *Secure Enclave* is a system on chip (SoC) that is included on all recent iPhone, ... devices" (Ex. A, Apple Platform Security, at 7.)

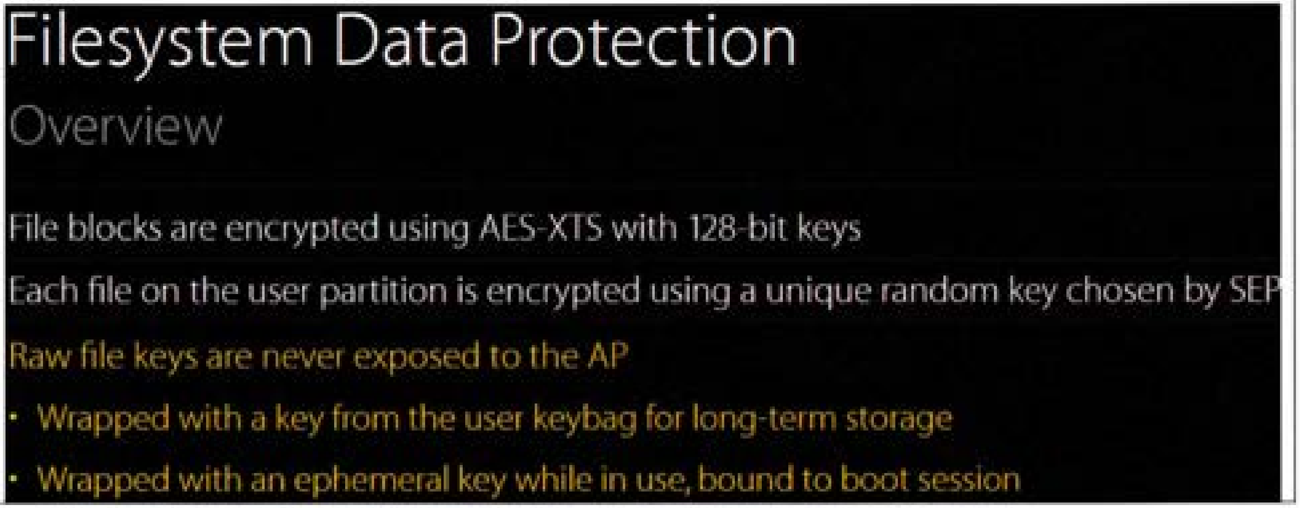
Claim 1	**Accused Instrumentalities**
	"During **matching**, the Secure Enclave **compares** incoming data from the biometric sensor against the stored templates **to determine whether to unlock the device** or respond that a match is valid (for Apple Pay, in-app, and other uses of Touch ID and Face ID). " (*Id.*, at 19.) The biometric signal received from the biometric sensor ("incoming data from the biometric sensor") is thus checked by the Secure Enclave and its SEP with the elements of the database of biometric signatures 105, i.e. the "stored templates", for the presence of a match. For Touch ID, the Secure Enclave match verification is performed as follows: "The Secure Enclave is responsible for processing fingerprint data from the Touch ID sensor, determining if there is a match against registered fingerprints, and then enabling access or purchases on behalf of the user ..." (Ex. C, iOS Security white paper, at 7.) "During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches...." (Ex. A, Apple Platform Security, at 19.) "Touch ID can read multiple fingerprints, and it can read fingerprints in 360-degrees of orientation. It then creates a mathematical representation of your fingerprint and compares this to your enrolled fingerprint data to identify a match and unlock your device. " (https://support.apple.com/en-us/HT204587) "Touch ID can read multiple fingerprints and recognize fingerprints at any orientation of the finger. The system then creates a mathematical representation of your fingerprint and compares it to the registered fingerprint data to determine a match and unlock your device." (https://support.apple.com/de-de/HT204587)

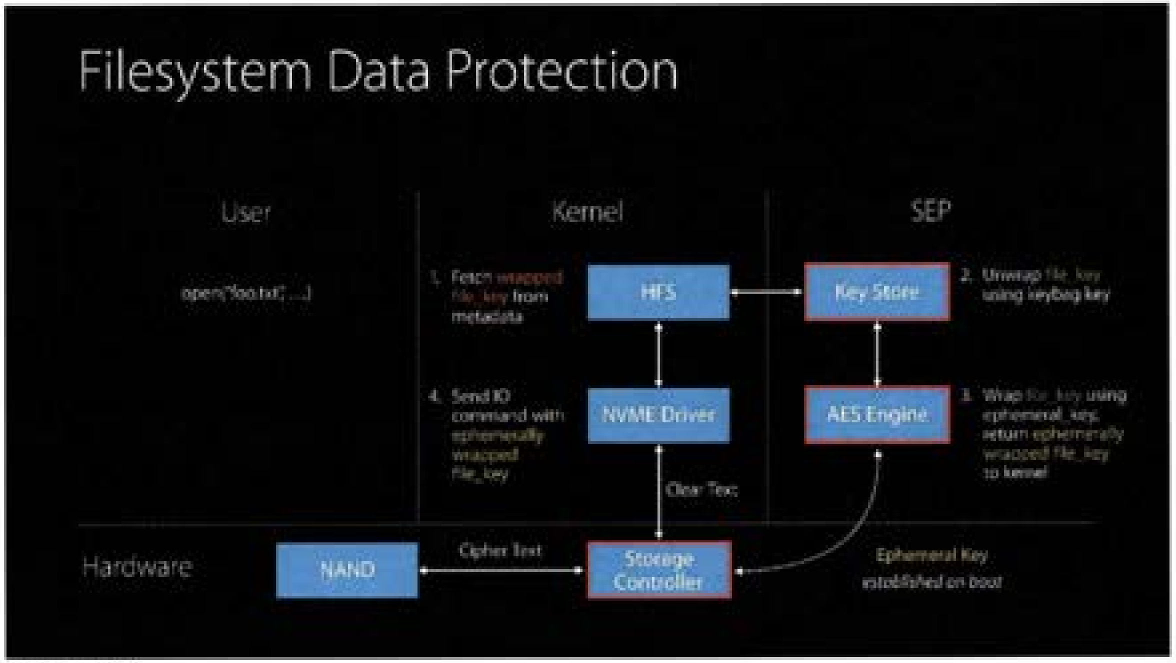
Claim 1	**Accused Instrumentalities**
	For **Face ID,** the Secure Enclave has a neural network protected by it, i.e., a Secure Neural Engine, which is used to verify the match: "Face ID uses neural networks for determining attention, **matching**, and antispoofing, so a user can unlock their phone with a glance." (Ex. A, Apple Platform Security, at 20.) "A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (*Id.*). "Facial matching security Facial matching is performed within the Secure Enclave using neural networks trained specifically for that purpose... Face ID data, including mathematical representations of a user's face, is encrypted and available only to the Secure Enclave. This data never leaves the device." (*Id.* at 23.) When the Secure Enclave, or more precisely the Touch ID or Face ID subsystem within the Secure Enclave, has determined that a match exists, an accessibility attribute is issued by the corresponding Touch ID or Face ID subsystem. This Touch ID or Face ID subsystem is also referred to as the SBIO. The accessibility attribute confirms that there is a match and that the iPhone is to be unlocked ("... determine whether to unlock the device ..."). This confirmation of the match is signaled by the SBIO by issuing a random secret to which only the Touch ID or Face ID subsystem within the Secure Enclave has access: "During matching, the Secure Enclave compares incoming data from the biometric sensor against the stored templates to determine whether to unlock the device [...]." (*Id.* at 19.)

Claim 1	**Accused Instrumentalities**
	"Uses for Touch ID and Face ID **Unlocking a device or user account** [...] **keys for the highest class of Data Protection-which** are **held in the Secure Enclave** [...]. With Touch ID or Face ID enabled, the keys aren't discarded when the device or account locks; instead, **they're wrapped with a key that's given to the Touch ID or Face ID subsystem inside the Secure Enclave**. When a user attempts to unlock the device or account, **if the device detects a successful match, it provides the key for unwrapping the Data Protection keys**, and the device or account is unlocked. This process provides additional protection by requiring cooperation between the Data Protection and Touch ID or Face ID subsystems to unlock the device." (*Id.* at 24.) "The class key is protected with the hardware UID and, for some classes, the user's passcode." (*Id.* at 85.) **"Complete Protection** *(NSFileProtectionComplete):* The class key is protected with a key derived from the user passcode or password and the device UID. Shortly after the user locks a device (10 seconds, if the Require Password setting is Immediately), the decrypted class key is discarded, **rendering all data in this class inaccessible until the user** enters the passcode again or **unlocks** (logs in to) **the device using Touch ID or Face ID."** (*Id.* at 86.) The Touch ID or Face ID subsystem within the Secure Enclave is the SBIO shown below. SBIO is an application that runs within the Secure Enclave on the SEP and is responsible for checking the match of biometric features. SBIO receives the corresponding biometric data from a biometric sensor, such as the Touch ID sensor. The random secret is stored in a memory ("bio memory") associated with the

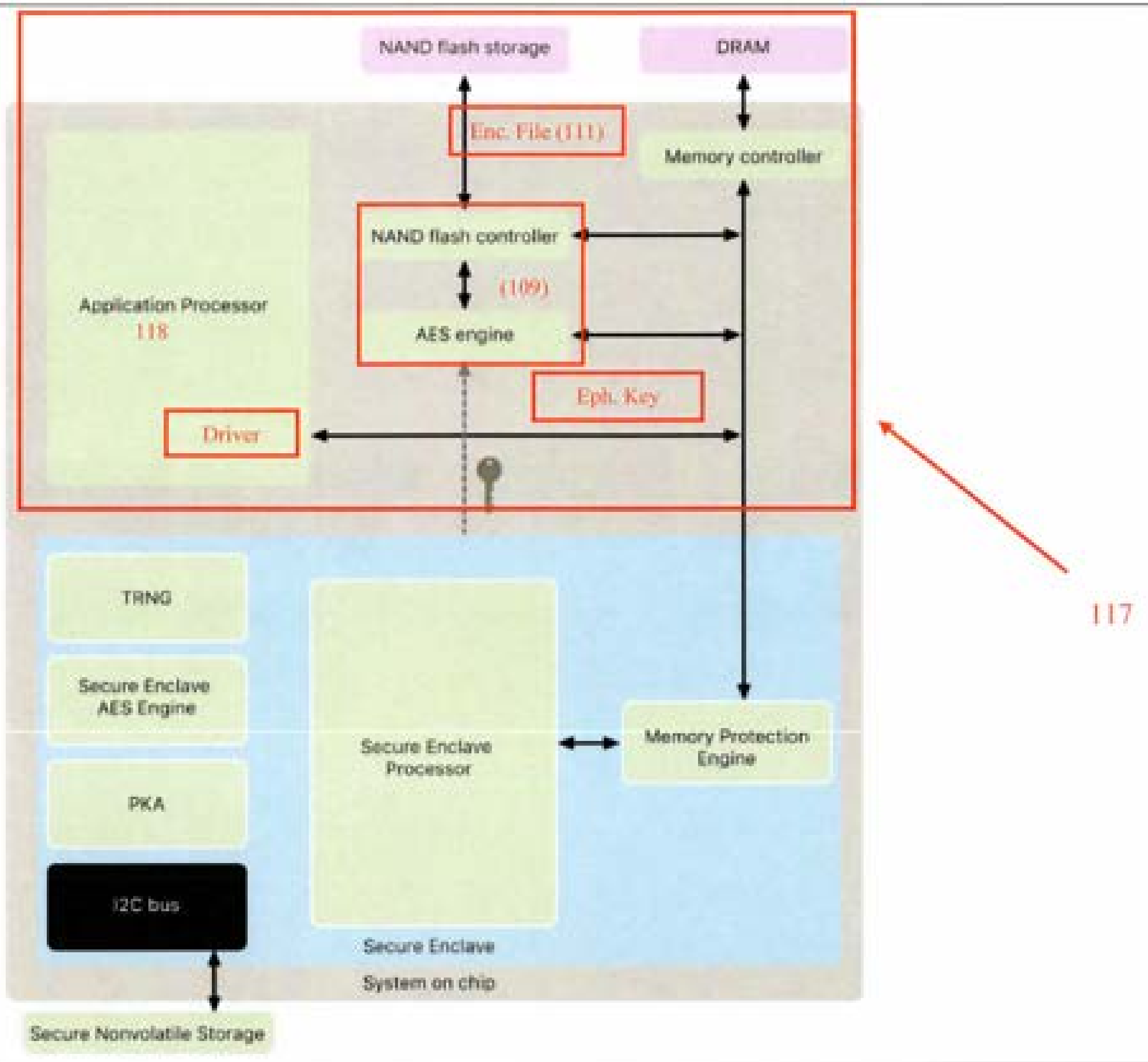
Claim 1	Accused Instrumentalities
	SBIO and is output from the bio memory upon match, see step 3 in the diagram below ("3) upon sucessful match send random secret to SKS"):  Userspace UserEventAgent Darwin lock/unlock Notifications SpringBoard MobileKeybag framework 1) pressing home button pings Touch ID sensor 6) send unlock notification XNU (Kernel) AppleKeyStore SEP endpoint to SKS AppleMesa SEP endpoint to SBIO 4) decrypt master key random secret master key SKS SBIO Touch ID Sensor bio memory random secret 2) template match sent to SBIO SEP master key SKS memory master key + SEP UID class A class B (priv) class C SKS keyring class A class B (priv) class B (public) class C class D 3) upon successful match send random secret to SKS 6) securely destroy master key 5) decrypt class keys, add to keyring Touch ID unlock (Ex. B, Behind the Scenes with iOS Security, at 34.) The class keys are encrypted with a master key:

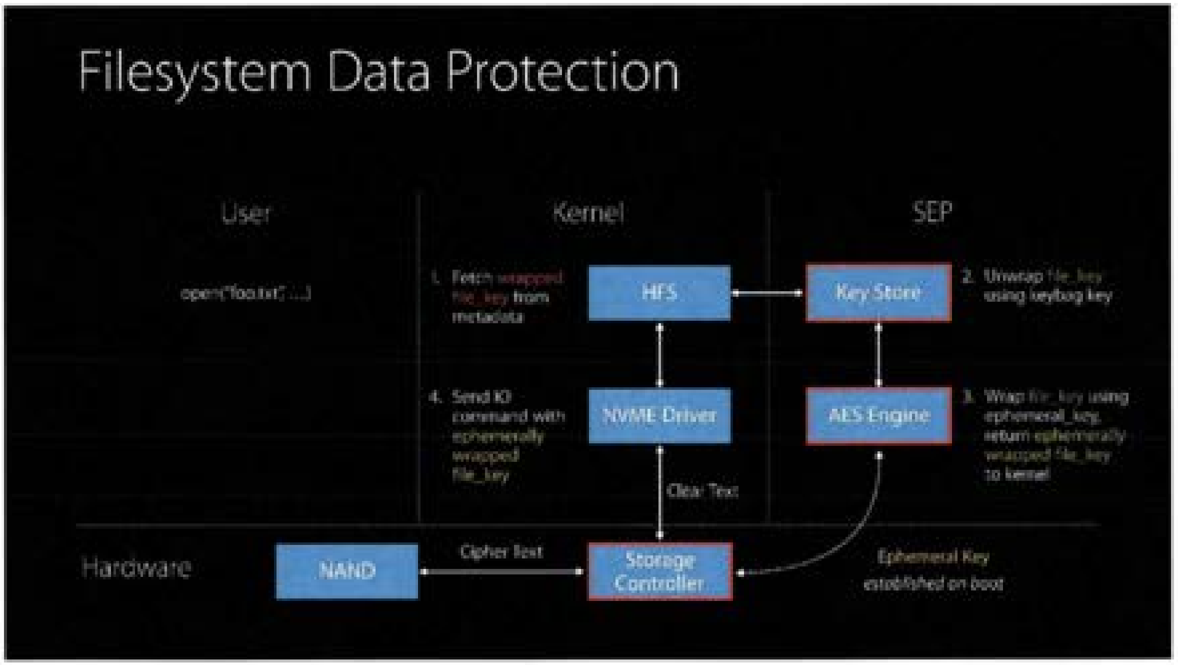
Claim 1	Accused Instrumentalities
	 User Keybags Background Sets of keys generated for each user to protect their data at rest Keys wrapped by master key derived from user passcode and SEP UID After 10 incorrect passcode entries, SEP will not process any further attempts Different policy associated with each keybag key—Usage, availability (*Id.*, at 25.) The random secret is issued to SKS. SKS is a Secure Key Service application which is located within the Secure Enclave on the SEP and is responsible for decrypting class keys. The random secret provided by SBIO is used to decrypt a master key ("4) decrypt master key"). The master key is concatenated with the UID of the SEP and thus class keys are decrypted and added to the SKS keyring ("5) decrypt class keys, add to keyring") for further use by the Secure Enclave. The decrypted class keys include, for example, the class key of class A.
1b3. a transmitter configured to emit a secure access signal conveying information dependent upon said accessibility attribute; and	***The Accused Instrumentalities include a transmitter configured to emit a secure access signal conveying information dependent upon said accessibility attribute.*** For example, the Secure Enclave emits a signal with ephemerally re-encrypted file keys: "sepOS can then use the ephemeral wrapping key to wrap file keys for use by the Application Processor file-system driver. When the file-system driver reads or writes a file, it sends the wrapped key to the AES Engine."

Claim 1	**Accused Instrumentalities**
	(Ex. A, Apple Platform Security, at 14.) "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. [...] When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and sent back to the Application Processor." (*Id.* at 85.) The signal with the ephemerally re-encrypted file keys is a secure signal because it comes from the Secure Enclave and thus from a secure environment. Furthermore, the signal is secure because the transmitted information is encrypted. The emitted file keys are encrypted with the ephemeral key: "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. At startup, the Secure Enclave negotiates an ephemeral key with the AES Engine. When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and sent back to the Application Processor." (*Id.*)  Filesystem Data Protection Overview File blocks are encrypted using AES-XTS with 128-bit keys Each file on the user partition is encrypted using a unique random key chosen by SEP Raw file keys are never exposed to the AP • Wrapped with a key from the user keybag for long-term storage • Wrapped with an ephemeral key while in use, bound to boot session

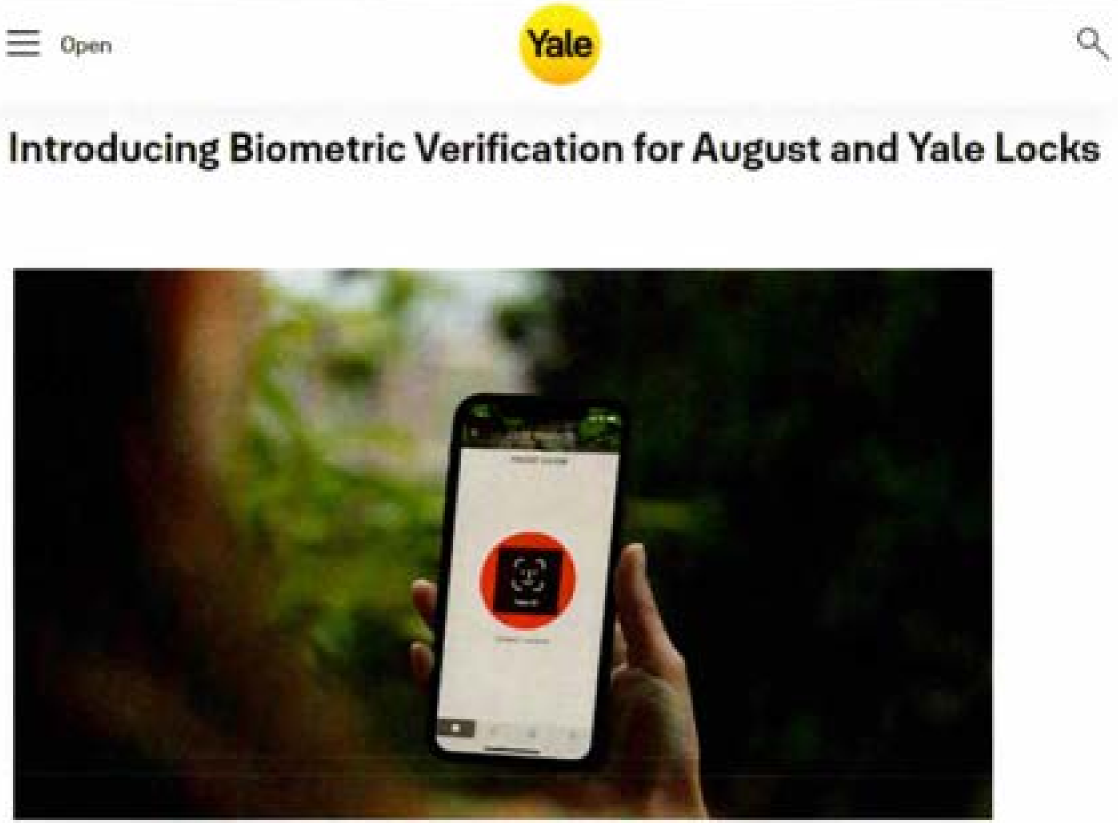
Claim 1	**Accused Instrumentalities**
	(Ex. B, Behind the Scenes with iOS Security, at 29.)  Filesystem Data Protection User Kernel SEP open("foo.txt", ...) 1. Fetch wrapped file_key from metadata HFS Key Store 2. Unwrap file_key using keybag key 4. Send IO command with ephemerally wrapped file_key NVME Driver AES Engine 3. Wrap file_key using ephemeral_key, return ephemerally wrapped file_key to kernel Clear Text Hardware NAND Cipher Text Storage Controller Ephemeral Key established on boot (*Id*., at 30.) The information transmitted by the emitted signal, i.e., the ephemerally re-encrypted file keys, is dependent on the availability attribute, i.e., the confirmation that a biometric "template match" exists. This confirmation is signaled by the issuance of the random secret (cf. step 3): Only if there is a confirmation of the match and the random secret is issued by the Touch ID or Face ID subsystem within the Secure Enclave, i.e. SBIO, the class key is available for re-encrypting the file keys. The re-encrypted file keys are therefore information which is emitted depending on the fact that the availability attribute has been emitted.

Claim 1	**Accused Instrumentalities**
1c. a receiver sub-system comprising:	***As set forth in elements 1c1 and 1c2 below, the Accused Instrumentalities include a receiver sub-system.*** The receiver subsystem is the part of the system outside the Secure Enclave that is responsible for reading encrypted files from the NAND Flash Storage and receives ephemerally re-encrypted file keys from the Secure Enclave for this purpose:

Claim 1	Accused Instrumentalities
	 NAND flash storage DRAM Enc. File (111) Memory controller NAND flash controller (109) AES engine Application Processor 118 Eph. Key Driver 117 TRNG Secure Enclave AES Engine PKA I2C bus Secure Enclave Processor Memory Protection Engine Secure Enclave System on chip Secure Nonvolatile Storage

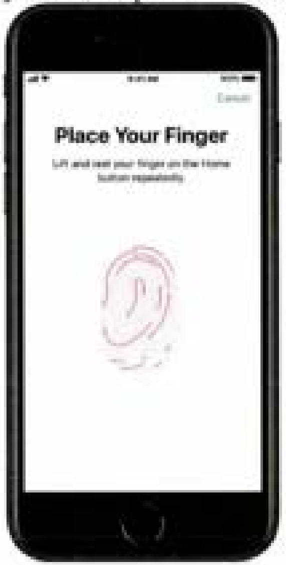
Claim 1	Accused Instrumentalities
	(Ex. A, Apple Platform Security, at 9.)
1c1. a receiver sub-system controller configured to: receive the transmitted secure access signal; and	***The Accused Instrumentalities include a receiver sub-system controller configured to: receive the transmitted secure access signal.*** An application processor (118) with file system driver, which receives the ephemerally re-encrypted file key. To read files from the NAND Flash storage, the application processor processes the received signal by creating a read command with the ephemerally wrapped file key ("IO command with ephemerally wrapped file_key") and sends it to the storage controller (109) (NAND Flash controller with AES engine). This read command provides the storage controller with all the information required to read and decrypt the encrypted file from the NAND flash storage:  Filesystem Data Protection User Kernel SEP open("foo.txt", ...) 1. Fetch wrapped file_key from metadata HFS Key Store 2. Unwrap file_key using keybag key 4. Send IO command with ephemerally wrapped file_key NVME Driver AES Engine 3. Wrap file_key using ephemeral_key, return ephemerally wrapped file_key to kernel Clear Text Hardware NAND Cipher Text Storage Controller Ephemeral Key established on boot (Ex. B, Behind the Scenes with iOS Security, at 30.)

Claim 1	Accused Instrumentalities
	"sepOS can then use the ephemeral wrapping key to wrap file keys **for use by the Application Processor file-system driver. When the file-system driver reads or writes a file, it sends the wrapped key to the AES Engine. "** (Ex. A, Apple Platform Security, at 14.) "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. [...] When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and **sent back to the Application Processor.**" (*Id.*, at 85.)
1c2. provide conditional access to the controlled item dependent upon said information;	***The Accused Instrumentalities include a receiver sub-system configured to provide conditional access to the controlled item dependent upon said information.*** More specifically, the controlled item is a locking mechanism of the door lock of the user's home. The Accused Instrumentalities are configured to provide secure access to the user's home via Yale Smart Locks when the user provides biometric signal to the Accused Instrumentalities via Touch ID or Face ID. "When the "Secure Remote Access" feature is turned on, the app will use your phone's built-in authentication tools to prompt fingerprint or facial recognition before you can unlock or lock your home remotely (note: if your phone does not have these features, it will prompt you to use your PIN code). This further ensures that your door is only operated by the right people at the time you intend for it." (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

Claim 1	Accused Instrumentalities
	 Open Yale Introducing Biometric Verification for August and Yale Locks (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

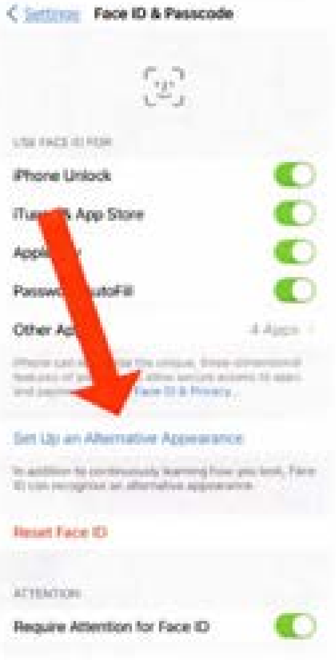
Claim 1	Accused Instrumentalities
	   (https://www.apple.com/shop/product/HPAR2ZM/A/yale-assure-lock-sl-touchscreen-deadbolt-black)

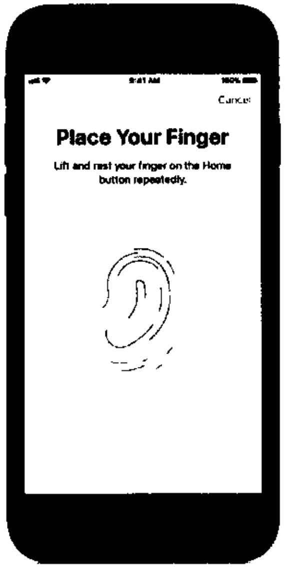
Claim 1	**Accused Instrumentalities**
1d. wherein the transmitter sub-system controller is further configured to:	***The Accused Instrumentalities include a transmitter sub-system controller that is configured to be used as set forth in elements 1d1, 1d2, and 1d3 below.***
1d1. receive a series of entries of the biometric signal, said series being characterized according to at least one of the number of said entries and a duration of each said entry;	***The Accused Instrumentalities include a transmitter sub-system controller configured to receive a series of entries of the biometric signal, said series being characterized according to at least one of the number of said entries and a duration of each said entry.*** More specifically, the Secure Enclave of the iPhone with the Secure Enclave Processor forms the means for receiving a series of entries of the biometric signal. "Apple's biometric security architecture relies on a strict separation of responsibilities between the biometric sensor and the Secure Enclave, and a secure connection between the two. The sensor captures the biometric image and securely transmits it to the Secure Enclave." (Ex. A, Apple Platform Security, at 19.) **Touch ID** When a finger is placed on the biometric sensor, the finger is scanned and the corresponding biometric signal entry is received by the Secure Enclave. "When the fingerprint sensor detects the touch of a finger, it triggers the advanced imaging array to scan the finger and sends the scan to the Secure Enclave." (*Id.*) To enroll a fingerprint in the database, the iPhone's fingerprint sensor records an entry of a biometric signal when the user places his finger on the sensor. This is done multiple times, resulting in a series of entries of such biometric signals. Receiving a series of entries of the biometric signal by repeatedly placing a finger on the Touch ID sensor will use Touch ID on iPhone.

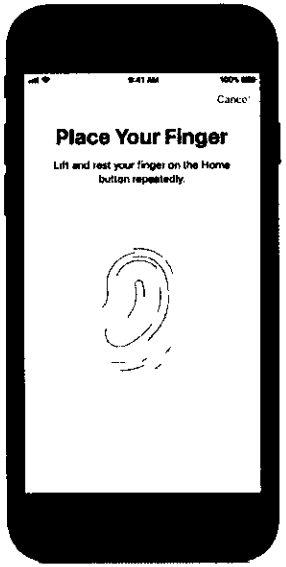
Claim 1	Accused Instrumentalities
	Set up Touch ID Before you can set up Touch ID, you must first create a code for your device,* then follow these steps: 1. Make sure the Touch ID sensor and your finger are clean and dry. 2. Tap Settings > Touch ID & Code, and then enter your code. 3. Tap "Add fingerprint" and hold the device as you normally would when touching the Touch ID sensor. 4. Touch the Touch ID sensor with one finger, but do not press. Keep your finger on the button until you feel a quick vibration or are prompted to lift your finger.  Cancel Place Your Finger Lift and rest your finger on the Home button repeatedly 5. Continue by raising and slowly lowering your finger over and over again, changing the position of your finger just a tiny bit at a time.

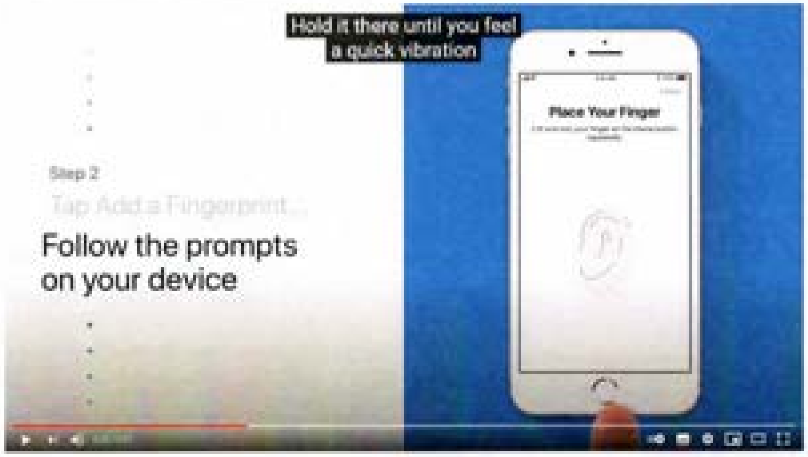
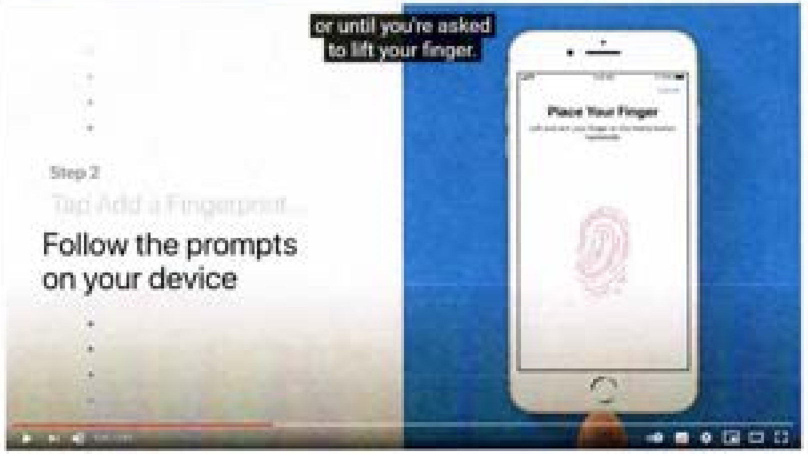
Claim 1	Accused Instrumentalities
	6. The next screen will ask you to change your finger position. Hold your device as you normally would when unlocking it. Touch the Touch ID sensor with the outer edges of your fingertip instead of the middle part as you would during the first scan." (https://support.apple.com/en-us/HT201371) Accordingly, the user is prompted to place his finger on the sensor several times, in particular in accordance with step 5. Each time the finger is placed on the sensor, a corresponding biometric entry is generated, i.e. a series of such entries. All these entries, which result from placing the same finger on the sensor, form a series. **Face ID** The means for receiving a series of entries of the biometric signal includes a Secure Neural Engine, which is protected by the Secure Enclave. The Secure Neural Engine transforms the series of entries of the biometric signal received by the Secure Enclave into a biometric signature ("mathematical representation"). "After the TrueDepth camera confirms the presence of an attentive face, it projects and reads over 30,000 infrared dots to form a depth map of the face along with a 2D infrared image. This data is used to create **a sequence of 2D images and depth maps**, which are digitally signed and **sent to the Secure Enclave**. To counter both digital and physical spoofs, the TrueDepth camera randomizes the sequence of 2D images and depth map captures, and projects a device-specific random pattern. A portion of the **Secure Neural Engine-protected** within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (Ex. A, Apple Platform Security, at 20.) Each entry of the biometric signal thus contains a two-dimensional infrared image with 30,000 infrared points for capturing depth information. By continuously capturing such infrared images into a Face ID scan while the user moves his head into different poses, a series of entries of the biometric signal

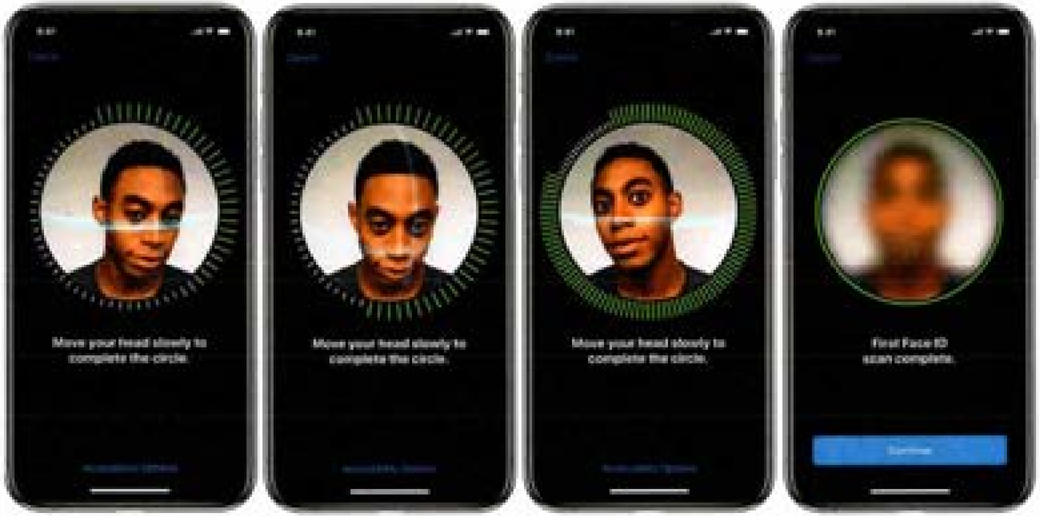
Claim 1	**Accused Instrumentalities**
	results. Two such Face ID scans are required to generate a biometric signature of a single face, so that two series of entries of the biometric signal are received accordingly. Using Face ID on iPhone 1. Tap Settings > Face ID & Code. Enter your code when prompted. 2. Tap on "Configure Face ID". 3. Hold the device in portrait mode in front of your face and tap "Let's go". 4. Make sure your face is inside the frame and slowly move your head until the circle shown is completed. If you can't move your head, tap on "Options for operating aids". 5. After performing the first Face ID scan, tap "Next". 6. Again, slowly describe a circle with your head until it is completed. 7. Tap "Done." (https://support.apple.com/en-us/HT208109) The biometric signature of a single face is thus determined by two successive Face ID scans, each of which receives a series of entries of the biometric signal (compare steps 4. and 6. above). To register a second face, the iPhone offers a corresponding option in its settings. If the user selects the option "Set up an alternative appearance" as shown in the figure below on https://www.macworld.co.uk/how-to/second-face-id-3803421/, a second face is registered by the iPhone in the same way as the first face.

Claim 1	**Accused Instrumentalities**
	 Settings Face ID & Passcode USE FACE ID FOR iPhone Unlock iTunes & App Store Apple Pay Password AutoFill Other Apps 4 Apps iPhone can [illegible] the unique, three-dimensional features of [illegible] allow secure access to apps and payments. [illegible] Face ID & Privacy... Set Up an Alternative Appearance In addition to continuously learning how you look, Face ID can recognize an alternative appearance. Reset Face ID ATTENTION Require Attention for Face ID The series of entries of the biometric signal is identified on the iPhone by both the number and duration of each such entry. **Touch ID** According to step 5 of the instructions https://support.apple.com/en-us/HT201371, for the enrollment of a single finger, the user has to repeatedly place the respective finger on the sensor and thus a number of entries in a row predetermined via the user guidance are captured by the iPhone. Each one of the entries must also be of a predetermined duration given to the user via the iPhone display, i.e. the user's finger must remain on the sensor for a predetermined duration for each entry of the biometric signal in order to capture the biometric signal during this time.

Claim 1	**Accused Instrumentalities**
	Receiving a series of entries of the biometric signal by repeatedly placing a finger on the Touch ID sensor will use Touch ID on iPhone and iPad. **Set up Touch ID** … 4. Touch the Touch ID sensor with one finger, but do not press. Keep your finger on the button until you feel a quick vibration or are prompted to lift your finger.  Cancel Place Your Finger Lift and rest your finger on the Home button repeatedly. 5. Continue by raising and slowly lowering your finger over and over again, changing the position of your finger just a tiny bit at a time. 6. The next screen will ask you to change your finger position. Hold your device as you normally would when unlocking it. Touch the Touch ID sensor with the outer edges of your fingertip instead of the middle part as you did during the first scan. (https://support.apple.com/en-us/HT201371)

Claim 1	**Accused Instrumentalities**
	After placing a finger on the home button, a fingerprint appears on the display with red progress bars spreading along some of the papillary bars until the capture of the biometric entry in question is complete:  9:41 AM 100% Cancel Place Your Finger Lift and rest your finger on the Home button repeatedly. When the required duration is reached, the iPhone vibrates after an entry of the biometric signal is received or it issues a prompt to the user to lift the finger. The user then lifts the finger in question and replaces the same finger so that the iPhone receives a series of biometric signal entries of sufficient duration for that finger. The process is repeated for the same finger for as long as required according to the iPhone's user guidance. This is shown in the Apple You Tube video (32) How to set up Touch ID on your iPhone or iPad - Apple Support - YouTube (https://www.youtube.com/watch?v=xTZ2LALWZlg):

Claim 1	Accused Instrumentalities
	 Hold it there until you feel a quick vibration Step 2 Tap Add a Fingerprint... Follow the prompts on your device Place Your Finger  or until you're asked to lift your finger. Step 2 Tap Add a Fingerprint... Follow the prompts on your device Place Your Finger Both the number of entries, i.e. the number of repetitions for placing the finger on the screen, and their respective duration are specified by the iPhone via the user guidance.

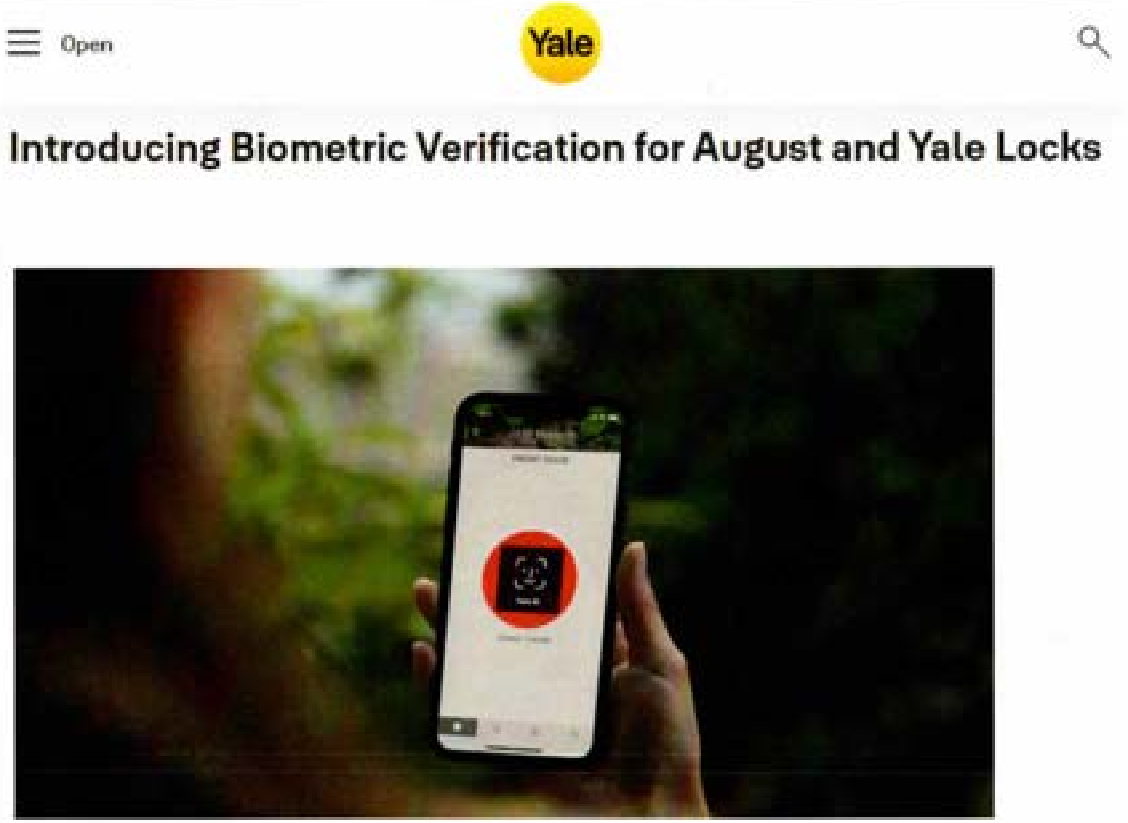
Claim 1	Accused Instrumentalities
	Face ID The user moves his face in front of the camera to strike different poses, and the camera system with image sensor continuously captures a large number of biometric entries, i.e. here the 2D images with depth information, in a row. "This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (Ex. A, Apple Platform Security, at 20.) The sufficient duration of an entry for a pose, i.e. an angular position of the head specified via the user interface of the iPhone, is indicated to the user by the transformation of a gray line into a green line:  Move your head slowly to complete the circle. Move your head slowly to complete the circle. Move your head slowly to complete the circle. First Face ID scan complete. Continue (Individual images taken from: https://support.apple.com/en-us/HT208109)

Claim 1	**Accused Instrumentalities**
1d2. map said series into an instruction; and	***The Accused Instrumentalities include a transmitter sub-system controller configured to map said series into an instruction.*** More specifically, the Secure Enclave of the iPhone contains means to assign the received row to an instruction: The Secure Enclave, after receiving the full set of entries of the biometric signal, assigns this set to an instruction for processing, encrypting and storing the biometric signature ("Touch ID and Face ID template data"). "The sensor captures the biometric image and securely transmits it to the Secure Enclave. During enrollment, the Secure Enclave processes, encrypts, and stores the corresponding Touch ID and Face ID template data." (Ex. A, Apple Platform Security, at 19.) To carry out this instruction, the Secure Enclave has its own processor: "The Secure Enclave Processor provides the main computing power for the Secure Enclave." (*Id.*, at 10.) **Touch ID** The instruction here involves the processing of under-the-skin fingerprint characteristics and their encrypted storage. "The analysis uses subdermal ridge flow angle mapping, a lossy process that discards "finger minutiae data" that would be required to reconstruct the user's actual fingerprint. During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches, but without any identity information." (*Id.*, at 19.) **Face ID**

Claim 1	**Accused Instrumentalities**
	The instruction involves the transformation of the set of entries of the biometric signal captured via the Face ID scans into a mathematical representation, i.e. the biometric signature of the face in question by the Secure Neural Engine of the Secure Enclave, as well as its encryption and storage. "A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses. " (*Id*., at 20.) "Face ID data, including mathematical representations of a user's face, is encrypted and available only to the Secure Enclave. This data never leaves the device. It's not sent to Apple, nor is it included in device backups. The following Face ID data is saved, encrypted only for use by the Secure Enclave, during normal operation: • The mathematical representations of a user's face calculated during enrollment • ..." (*Id*., at 23.)

Claim 1	**Accused Instrumentalities**
1d3. populate the database according to the instruction,	***The Accused Instrumentalities include a transmitter sub-system controller configured to populate the database according to the instruction.*** More specifically, the Secure Enclave stores the biometric signature, i.e. the encrypted mathematical representation of the fingerprint or face, in the database 105, i.e. the "secure nonvolatile storage": "The secure nonvolatile storage is used for all anti-replay services in the Secure Enclave. Anti-replay services on the Secure Enclave are used for revocation of data over events that mark anti-replay boundaries including, but not limited to, the following: • . . . • . . . • Adding or removing a Touch ID fingerprint or Face ID face". (Ex. A, Apple Platform Security, at 16.) "During enrollment, the Secure Enclave processes, encrypts, and stores the corresponding Touch ID and Face ID template data." (*Id*., at 19.) **Touch ID** "During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches...." (*Id.*) **Face ID** The following Face ID data is saved, encrypted only for use by the Secure Enclave, during normal operation: • The mathematical representations of a user's face calculated during enrollment". (*Id*., at 23.)

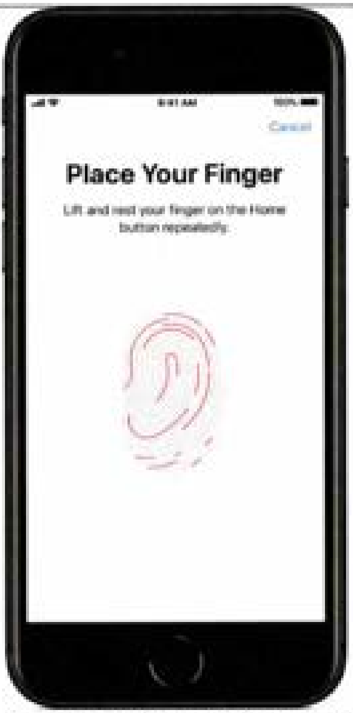
Claim 1	Accused Instrumentalities
wherein the controlled item is one of: a locking mechanism of a physical access structure or an electronic lock on an electronic computing device.	***The Accused Instrumentalities are configured to provide access to the controlled item, wherein the controlled item is one of: a locking mechanism of a physical access structure or an electronic lock on an electronic computing device.*** More specifically, the controlled item is a locking mechanism of the door lock of the user's home. The Accused Instrumentalities are configured to provide secure access to the user's home via Yale Smart Locks when the user provides biometric signal to the Accused Instrumentalities via Touch ID or Face ID. "When the "Secure Remote Access" feature is turned on, the app will use your phone's built-in authentication tools to prompt fingerprint or facial recognition before you can unlock or lock your home remotely (note: if your phone does not have these features, it will prompt you to use your PIN code). This further ensures that your door is only operated by the right people at the time you intend for it." (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

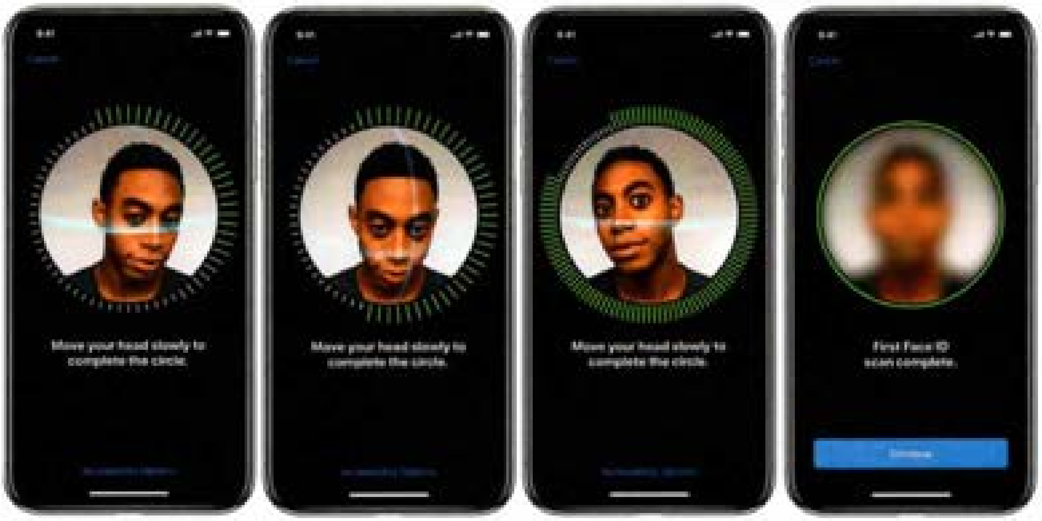
Claim 1	Accused Instrumentalities
	 Introducing Biometric Verification for August and Yale Locks (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

<u>Claim 1</u>	<u>Accused Instrumentalities</u>
	 (https://www.apple.com/shop/product/HPAR2ZM/A/yale-assure-lock-sl-touchscreen-deadbolt-black)

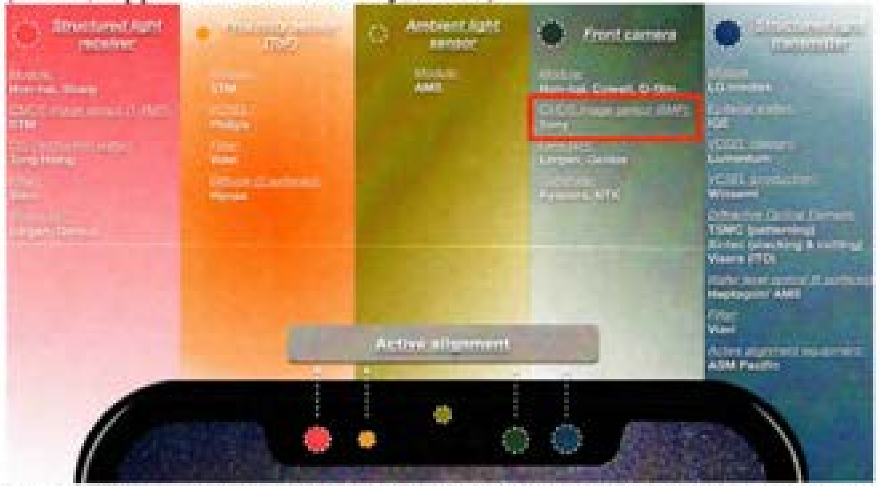
<u>Claim 2</u>	<u>Accused Instrumentalities</u>
2. The system according to claim 1, wherein the transmitter sub-system	*Upon information and belief, the Accused Instrumentalities include the transmitter sub-system controller that is configured to be used as set forth in elements 2a, 2b, and 2c below.*

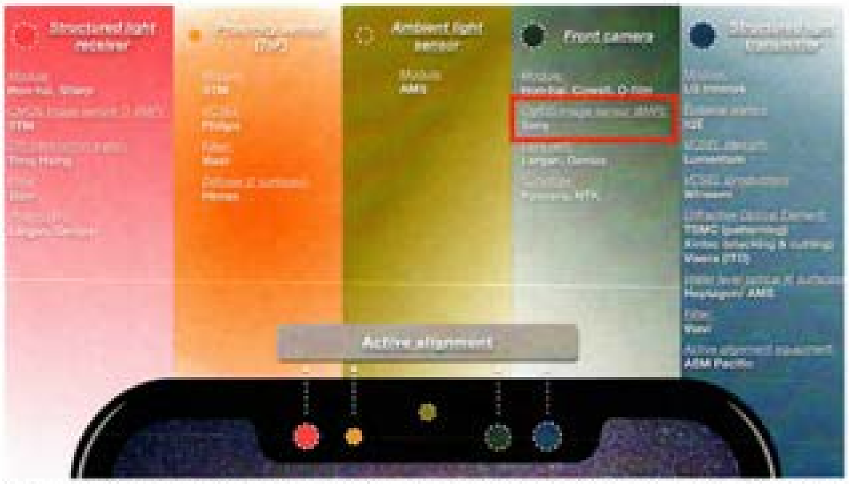
Claim 2	**Accused Instrumentalities**
controller is further configured to:	
2a. provide a signal for directing input of the series of entries of the biometric signal;	***Upon information and belief, the Accused Instrumentalities are configure to provide a signal for directing input of the series of entries of the biometric signal.*** More specifically, the Accused Instrumentalities provide instructions for the user to input a series of fingerprint or face images via Touch ID and Face ID. Touch ID: Register a fingerprint for Apple Touch ID by the user tapping a finger several times on the home button to record the fingerprint data. (https://video.search.yahoo.com/yhs/search?fr=yhs-pty-pty_ converter&hsimp=yhs-pty_converter&hspart=pty&p=registering+fingerprint+apple+touch+id+on+screen+instructions#id=1&vid=156de65ae06ca453643009fc0ea9cf79&action=click.) Touch ID: The user's finger must remain on the home button long enough for the data to be recorded. "Touch the Touch ID sensor with your finger, but don't press it. Hold it there until you feel a quick vibration, or until you're asked to lift your finger." "Continue to lift and rest your finger slowly, making small adjustments to the position of your finger each time." (https://support.apple.com/en-au/HT201371) Touch ID: "you shouldn't tap too quickly or move your finger around" (https://support.apple.com/en-us/HT207537) Face ID: Setting up Face ID requires two scans of the user's face. Each scan asks users to move their head slowly in a circle to register different angles of the user's face. (https://www.imore.com/how-set-face-id-iphone)

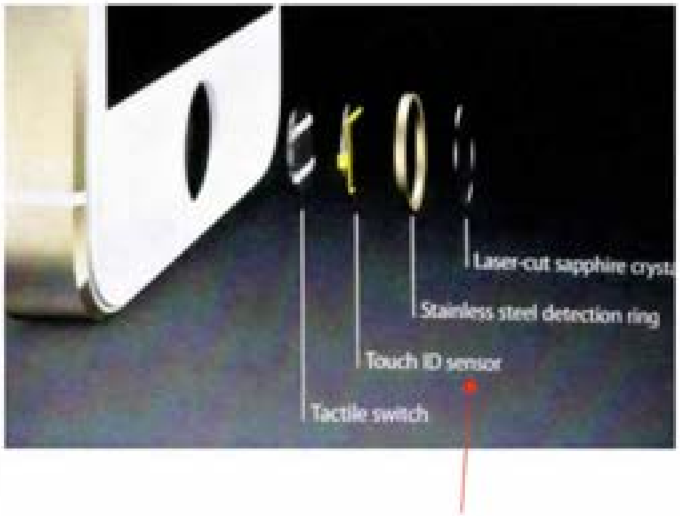
<u>**Claim 2**</u>	<u>**Accused Instrumentalities**</u>
	 Place Your Finger Lift and rest your finger on the Home button repeatedly. (https://support.apple.com/en-us/HT201371)

Claim 2	Accused Instrumentalities
	 Move your head slowly to complete the circle. Move your head slowly to complete the circle. Move your head slowly to complete the circle. First Face ID scan complete. (https://support.apple.com/en-us/HT208109)
2b. incorporate into the secure access signal an identification field identifying the biometric signal if the signal matches a member of the database; and	***Upon information and belief, the Accused Instrumentalities are configure to incorporate into the secure access signal an identification field identifying the biometric signal if the signal matches a member of the database.*** More specifically, upon information and belief, the Accused Instrumentalities are configured to provide secure access signal when the fingerprint or face image received via Touch ID and Face ID matches the fingerprint and face data stored in the Secure Nonvolatile Storage. "During matching, the Secure Enclave compares incoming data from the biometric sensor against the stored templates to determine whether to unlock the device or respond that a match is valid (for Apple Pay, in-app, and other uses of Touch ID and Face ID). The architecture supports devices that include both the sensor and Secure Enclave (such as iPhone, iPad, and many Mac systems), as well as the ability to physically separate the sensor into a peripheral that is then securely paired to the Secure Enclave in a Mac with Apple silicon." (https://support.apple.com/ko-kr/guide/security/sec067eb0c9e/1/web/1)

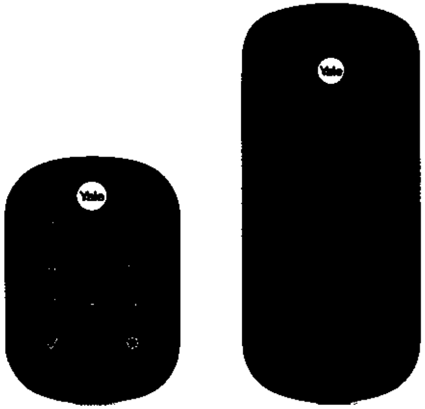
Claim 2	**Accused Instrumentalities**
	With Touch ID and Face ID, the keys for the highest class of Data Protection are held in the Secure Enclave,"[w]hen a user attempts to unlock the device or account, if the device detects a successful match, it provides the key for unwrapping the Data Protection keys, and the device or account is unlocked." (Ex. A, Apple Platform Security, at 24.)
2c. construct an audit trail of biometric signals provided to the biometric sensor in order to access the controlled item.	***Upon information and belief, the Accused Instrumentalities are configure to construct an audit trail of biometric signals provided to the biometric sensor in order to access the controlled item.*** More specifically, upon information and belief, the Accused Instrumentalities are configured to construct an audit trail of the enrolled fingerprint and face data to continually improve matching accuracy. "Touch ID will incrementally update the mathematical representation of enrolled fingerprints over time to improve matching accuracy." (https://support.apple.com/en-us/HT204587) "Face ID data - including mathematical representations of your face - is encrypted and protected by the Secure Enclave. This data will be refined and updated as you use Face ID to improve your experience, including when you successfully authenticate. Face ID will also update this data when it detects a close match but a passcode is subsequently entered to unlock the device." (https://support.apple.com/en-us/HT208108) In an alternative read, upon information and belief, every time a user uses Touch ID or Face ID to access an iPhone, the iPhone keeps a record of fingerprint and face unlocking, or some kind record for subsequent auditing.

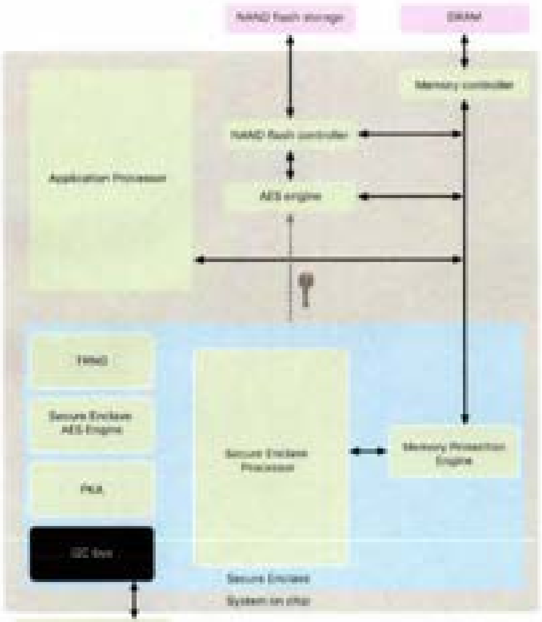
Claim 4	**Accused Instrumentalities**
4. The system according to claim 1, wherein the biometric sensor is responsive to one of voice, retinal pattern, iris pattern, face pattern, and palm configuration, and/or the database of biometric signatures is located in at least one of the transmitter sub-system and the receiver sub-system.	***The Accused Instrumentalities includes a biometric sensor that is responsive to one of voice, retinal pattern, iris pattern, face pattern, and palm configuration, and/or the database of biometric signatures is located in at least one of the transmitter sub-system and the receiver sub-system.*** More specifically, the Accused Instrumentalities include a CMOS image sensor in the front camera of the iPhones that is responsive to face pattern of the user. Upon information and belief, the Secure Nonvolatile Storage is a memory including a database of the face data. **Face ID** The biometric sensor for facial biometrics is a camera system ("TrueDepth camera system") with an image sensor. "With a simple glance, Face ID securely unlocks supported Apple devices. It provides intuitive and secure authentication enabled by the TrueDepth camera system, which uses advanced technologies to accurately map the geometry of a user's face. " (Ex. A, Apple Platform Security, at 20.)  Structured light receiver Ambient light sensor Module AMS Front camera Active alignment (https://appleinsider.com/articles/17/09/09/inner-workings-of-apples-face-id-camera-detailed-in-report)

Claim 6	Accused Instrumentalities
6. The system as claimed in claim 1, wherein the biometric sensor is further configured to authenticate the identity of a user;	***The Accused Instrumentalities includes a biometric sensor that is further configured to authenticate the identity of a user.*** More specifically, the iPhones uses Face ID and Touch ID to authenticate the user's identity. **Face ID** The biometric sensor for facial biometrics is a camera system ("TrueDepth camera system") with an image sensor. "With a simple glance, Face ID securely unlocks supported Apple devices. It provides intuitive and secure authentication enabled by the TrueDepth camera system, which uses advanced technologies to accurately map the geometry of a user's face. " (Ex. A, Apple Platform Security, at 20.)  Structured light receiver Ambient light sensor Module AMS Front camera Module TSMC (patterning) Viavi (TFD) AEM Pacific Active alignment (https://appleinsider.com/articles/17/09/09/inner-workings-of-apples-face-id-camera-detailed-in-report) **Touch ID**

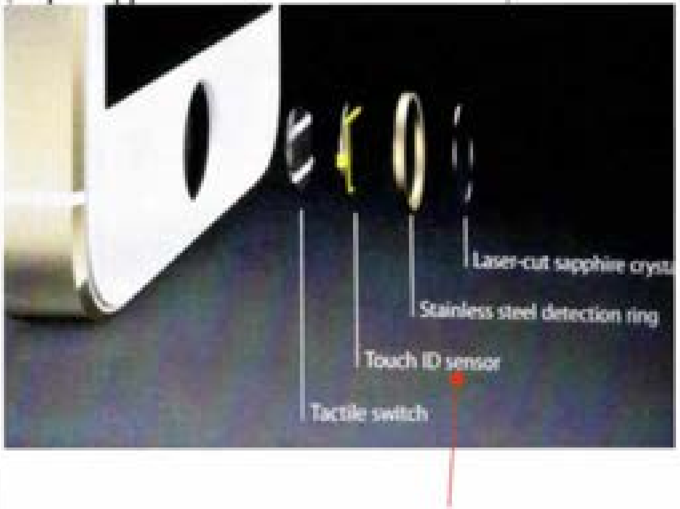
	"Apple devices with a Touch ID sensor can be unlocked using a fingerprint." (Ex. A, Apple Platform Security, at 9.) "Touch ID is the fingerprint sensing system that makes secure access to supported Apple devices faster and easier. This technology reads fingerprint data from any angle and learns more about a user's fingerprint over time, with the sensor continuing to expand the fingerprint map as additional overlapping nodes are identified with each use." (*Id.* at 19.)  Laser-cut sapphire crysta Stainless steel detection ring Touch ID sensor Tactile switch Biometric sensor 121

6a. wherein the transmitter is further configured to transmit information capable of granting access to the controlled item using a secure wireless signal dependent upon a request from the user and the authentication of the user identity; and	***The Accused Instrumentalities includes a transmitter configured to transmit information capable of granting access to the controlled item using a secure wireless signal dependent upon a request from the user and the authentication of the user identity.*** Upon information and belief, the Secure Enclave of the iPhone is configured to grant access to the controlled item (e.g., a locking mechanism of the door lock) via Wi-Fi, mobile data or Bluetooth dependent upon the user's request to unlock and the user's authentication via Touch ID or Face ID. "When the 'Secure Remote Access' feature is turned on, the app will use your phone's built-in authentication tools to prompt fingerprint or facial recognition before you can unlock or lock your home remotely (note: if your phone does not have these features, it will prompt you to use your PIN code). This further ensures that your door is only operated by the right people at the time you intend for it." "The feature applies to operations done via Wi-Fi, mobile data or Bluetooth. You'll be able to opt in to this security feature, and it will not be enacted when checking your lock status in order to preserve a seamless app experience." (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

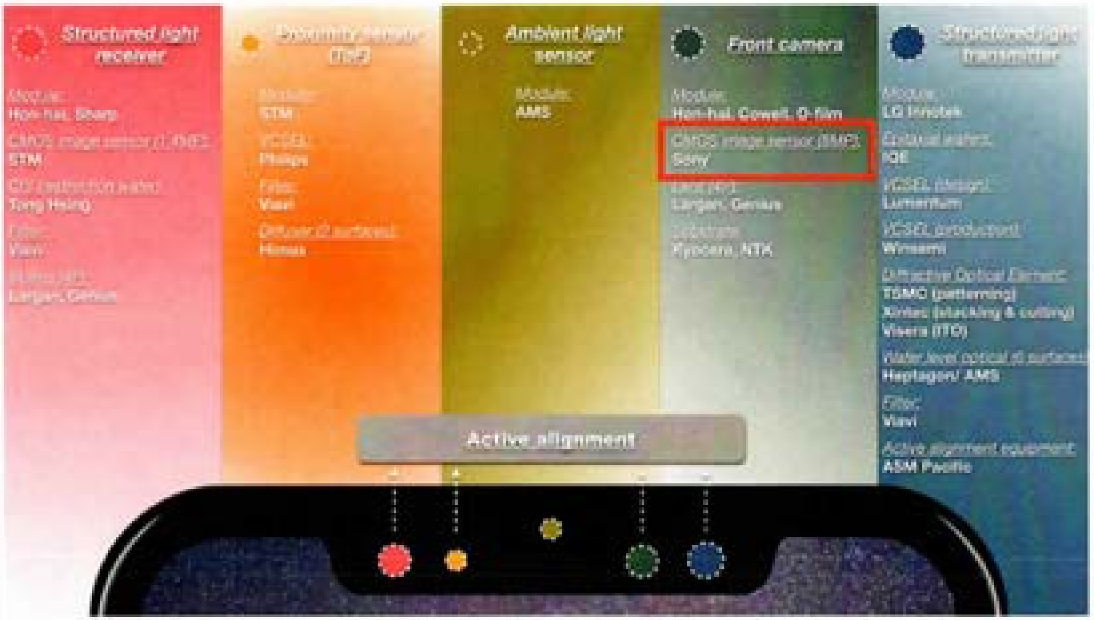
6b. the system further comprising a control panel configured to receive the information and provide the secure access requested.	***The Accused Instrumentalities includes a control panel configured to receive the information and provide the secure access requested.*** More specifically, upon information and belief, the Yale Home Smart Lock is configured to receive information allowing its unlocking from the Secure Enclave of the iPhone. "Upgrade your door with the Assure Lock SL, a touchscreen deadbolt for key-free entry. The lock is HomeKit-enabled so it allows you to lock or unlock and share access all from your Yale Secure app." (https://www.apple.com/shop/product/HPAR2ZM/A/yale-assure-lock-sl-touchscreen-deadbolt-black)  (https://www.apple.com/shop/product/HPAR2ZM/A/yale-assure-lock-sl-touchscreen-deadbolt-black)

Claim 9	**Accused Instrumentalities**
9. The system according to claim 1, wherein: the transmitter sub-system and the receiver sub-system are collocated in the electronic computing device.	***The transmitter sub-system and the receiver sub-system are collocated in the Accused Instrumentalities.*** More specifically, the iPhone is a computing device that includes the transmitter sub-system and the receiver sub-system.  NAND flash storage DRAM Memory controller NAND flash controller Application Processor AES engine TRNG Secure Enclave AES Engine PKA I2C bus Secure Enclave Processor Memory Protection Engine Secure Enclave System on chip Secure Nonvolatile Storage The Secure Enclave components (Ex. A, Apple Plaform Security, at 9.)

Claim 10	**Accused Instrumentalities**
10. A transmitter sub-system for operating in a system for providing secure access to a controlled item, wherein the transmitter sub-system comprises:	***To the extent that the preamble is deemed to be a limitation, the Accused Instrumentalities are configured to use a system in accordance with this claim.***
10a. a biometric sensor configured to receiving a biometric signal;	***The Accused Instrumentalities include a biometric sensor configured to receive a biometric signal.*** More specifically, the iPhone has at least one biometric sensor for capturing a fingerprint or a face (Touch ID and/or Face ID), namely a Touch ID sensor and a camera system with image sensor, respectively. **Touch ID** "Apple devices with a Touch ID sensor can be unlocked using a fingerprint." (Ex. A, Apple Platform Security, at 19.) "Touch ID is the fingerprint sensing system that makes secure access to supported Apple devices faster and easier. This technology reads fingerprint data from any angle and learns more about a user's fingerprint over time, with the **sensor** continuing to expand the fingerprint map as additional overlapping nodes are identified with each use." (*Id.*) "When the fingerprint sensor detects the touch of a finger, it triggers the advanced imaging array to scan the finger and sends the scan to the Secure Enclave." (*Id.*)

Claim 10	Accused Instrumentalities
	The biometric sensor for Touch ID is located below the home button: "The Home button is a stack of different materials, capped with a sapphire crystal lens. The surrounding stainless-steel ring works as a ground and detects the user's finger. This action activates a capacitive touch sensor installed underneath the cover: A CMOS chip with small capacitors." (https://appleinsider.com/inside/touch-id)  Laser-cut sapphire cryst Stainless steel detection ring Touch ID sensor Tactile switch Biometric sensor 121 "Where is the Touch ID sensor located? The Touch ID sensor is located either in the home button or - on the iPad Air (4th generation) - in the top button. (https://support.apple.com/en-us/HT201371) The image sensor captures an 88-by-88-pixel, 500 PPI raster scan:

Claim 10	**Accused Instrumentalities**
	"The 88-by-88-pixel, 500-ppi raster scan is temporarily stored in encrypted memory within the Secure Enclave while being vectorized for analysis, and then it's discarded. The analysis utilizes subdermal ridge flow angle mapping, which is a lossy process that discards minutia data that would be required to reconstruct the user's actual fingerprint. The resulting map of nodes is stored without any identity information in an encrypted format that can only be read by the Secure Enclave, and is never sent to Apple or backed up to iCloud or iTunes. " (Ex. C, iOS Security white paper, at 8.) **Face ID** The biometric sensor for facial biometrics is a camera system ("**TrueDepth** camera **system**") with an image sensor. "With a simple glance, Face ID securely unlocks supported Apple devices. It provides intuitive and secure authentication enabled by the TrueDepth camera system, which uses advanced technologies to accurately map the geometry of a user's face. " (Ex. A, Apple Platform Security, at 20.) To receive a biometric signal, the camera system with image sensor reads over 30,000 infrared points to capture depth information along with a two-dimensional infrared image. "After the TrueDepth camera confirms the presence of an attentive face, it projects and **reads over 30,000 infrared dots to form a depth map of the face along with a 2D infrared image**. This data is used to **create a sequence of 2D images and depth maps**, which are digitally signed and sent to the Secure Enclave. To counter both digital and physical spoofs, the TrueDepth camera randomizes the sequence of 2D images and depth map captures, and projects a device-specific random pattern. A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (*Id.*)

Claim 10	**Accused Instrumentalities**
	The camera system includes a biometric image sensor, namely a "CMOS image" sensor from Sony, to perform facial biometrics:  Structured light receiver Module: Hon-hai, Sharp CMOS image sensor (1.4MP): STM CIS (instruction wafer): Tong Hsing Filter: Viavi Lens (IR): Largan, Genius Proximity sensor (ToF) Module: STM VCSEL: Philips Filter: Viavi Diffuser (2 surfaces): Himax Ambient light sensor Module: AMS Front camera Module: Hon-hai, Cowell, O-film CMOS image sensor (8MP): Sony Lens (4P): Largan, Genius Substrate: Kyocera, NTK Structured light transmitter Module: LG Innotek Epitaxial wafers: IQE VCSEL (design): Lumentum VCSEL (production): Winsemi Diffractive Optical Element: TSMC (patterning) Xintec (stacking & cutting) Visera (ITO) Wafer level optical (6 surfaces): Heptagon/ AMS Filter: Viavi Active alignment equipment: ASM Pacific Active alignment (https://appleinsider.com/articles/17/09/09/inner-workings-of-apples-face-id-camera-detailed-in-report)
10b. a controller configured to match the biometric signal against members of a database of biometric signatures to	***The Accused Instrumentalities include a transmitter controller configured to emit a secure access signal conveying information dependent upon said accessibility attribute.***

Claim 10	**Accused Instrumentalities**
thereby output an accessibility attribute; and	More specifically, the iPhone's System on Chip (SOC), i.e. the Secure Enclave with its Secure Enclave Processor (SEP) or a Secure Neural Engine contained therein, is a means (103) to check a match of the biometric signal with elements of the biometric signature database. "The *Secure Enclave* is a system on chip (SoC) that is included on all recent iPhone, ... devices" (Ex. A, Apple Platform Security, at 7.) "During **matching**, the Secure Enclave **compares** incoming data from the biometric sensor against the stored templates **to determine whether to unlock the device** or respond that a match is valid (for Apple Pay, in-app, and other uses of Touch ID and Face ID). " (*Id.*, at 19.) The biometric signal received from the biometric sensor ("incoming data from the biometric sensor") is thus checked by the Secure Enclave and its SEP with the elements of the database of biometric signatures 105, i.e. the "stored templates", for the presence of a match. For Touch ID, the Secure Enclave match verification is performed as follows: "The Secure Enclave is responsible for processing fingerprint data from the Touch ID sensor, determining if there is a match against registered fingerprints, and then enabling access or purchases on behalf of the user ..." (Ex. C, iOS Security white paper, at 7.) "During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches...." (Ex. A, Apple Platform Security, at 19.) "Touch ID can read multiple fingerprints, and it can read fingerprints in 360-degrees of orientation. It then creates a mathematical representation of your fingerprint and compares this to your enrolled fingerprint data to identify a match and unlock your device. " (https://support.apple.com/en-us/HT204587)

Claim 10	**Accused Instrumentalities**
	"Touch ID can read multiple fingerprints and recognize fingerprints at any orientation of the finger. The system then creates a mathematical representation of your fingerprint and compares it to the registered fingerprint data to determine a match and unlock your device." (https://support.apple.com/de-de/HT204587) For **Face ID,** the Secure Enclave has a neural network protected by it, i.e., a Secure Neural Engine, which is used to verify the match: "Face ID uses neural networks for determining attention, **matching**, and antispoofing, so a user can unlock their phone with a glance." (Ex. A, Apple Platform Security, at 20.) "A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (*Id.*). "Facial matching security Facial matching is performed within the Secure Enclave using neural networks trained specifically for that purpose... Face ID data, including mathematical representations of a user's face, is encrypted and available only to the Secure Enclave. This data never leaves the device." (*Id.* at 23.) When the Secure Enclave, or more precisely the Touch ID or Face ID subsystem within the Secure Enclave, has determined that a match exists, an accessibility attribute is issued by the corresponding Touch ID or Face ID subsystem. This Touch ID or Face ID subsystem is also referred to as the SBIO. The accessibility attribute confirms that there is a match and that the iPhone is to be unlocked ("... determine whether to unlock the device ...").

Claim 10	Accused Instrumentalities
	This confirmation of the match is signaled by the SBIO by issuing a random secret to which only the Touch ID or Face ID subsystem within the Secure Enclave has access: "During matching, the Secure Enclave compares incoming data from the biometric sensor against the stored templates to determine whether to unlock the device [...]." (*Id.* at 19.) "Uses for Touch ID and Face ID **Unlocking a device or user account** [...] **keys for the highest class of Data Protection-which** are **held in the Secure Enclave** [...]. With Touch ID or Face ID enabled, the keys aren't discarded when the device or account locks; instead, **they're wrapped with a key that's given to the Touch ID or Face ID subsystem inside the Secure Enclave**. When a user attempts to unlock the device or account, **if the device detects a successful match, it provides the key for unwrapping the Data Protection keys**, and the device or account is unlocked. This process provides additional protection by requiring cooperation between the Data Protection and Touch ID or Face ID subsystems to unlock the device." (*Id.* at 24.) "The class key is protected with the hardware UID and, for some classes, the user's passcode." (*Id.* at 85.) **"Complete Protection** *(NSFileProtectionComplete):* The class key is protected with a key derived from the user passcode or password and the device UID. Shortly after the user locks a device (10 seconds, if the Require Password setting is Immediately), the decrypted class key is discarded, **rendering all data in this class inaccessible until the user** enters the passcode again or **unlocks** (logs in to) **the device using Touch ID or Face ID.**" (*Id.* at 86.)

<table>
<tr><th>Claim 10</th><th>Accused Instrumentalities</th></tr>
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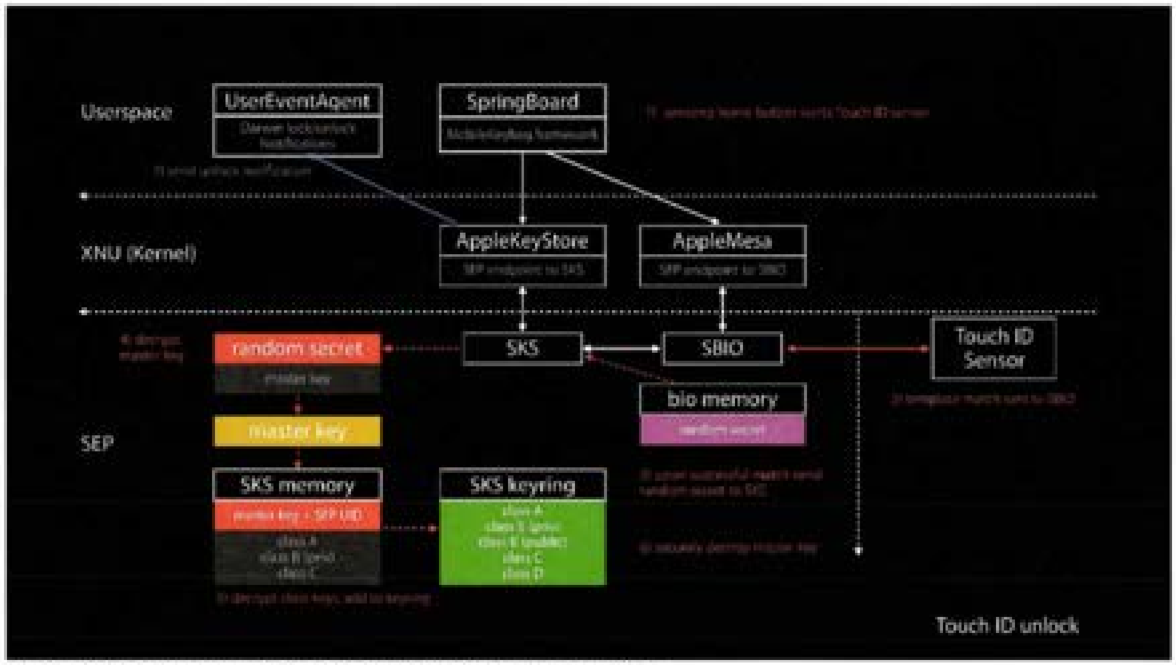
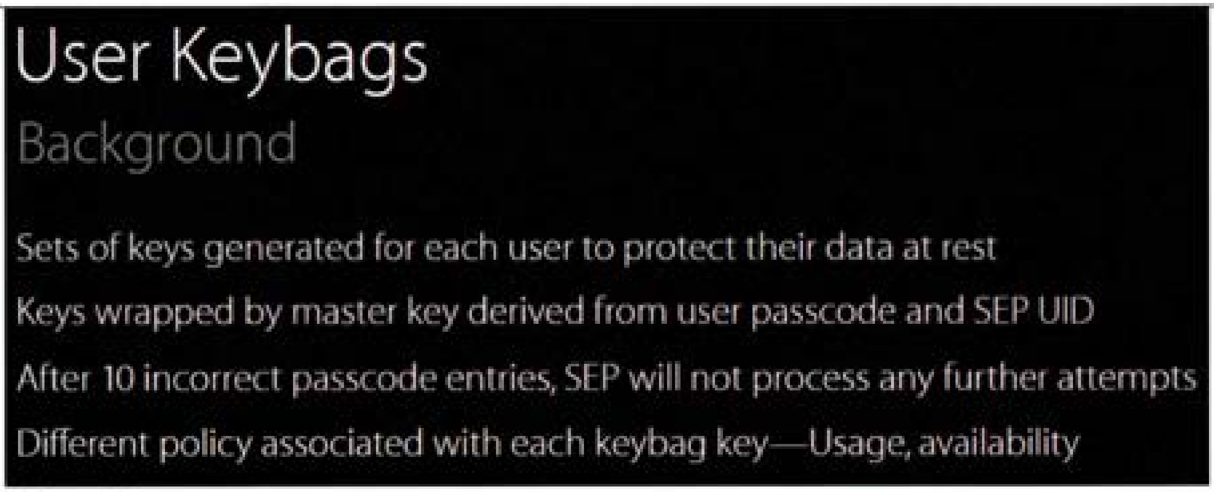
The Touch ID or Face ID subsystem within the Secure Enclave is the SBIO shown below. SBIO is an application that runs within the Secure Enclave on the SEP and is responsible for checking the match of biometric features. SBIO receives the corresponding biometric data from a biometric sensor, such as the Touch ID sensor. The random secret is stored in a memory ("bio memory") associated with the SBIO and is output from the bio memory upon match, see step 3 in the diagram below ("3) upon sucessful match send random secret to SKS"):

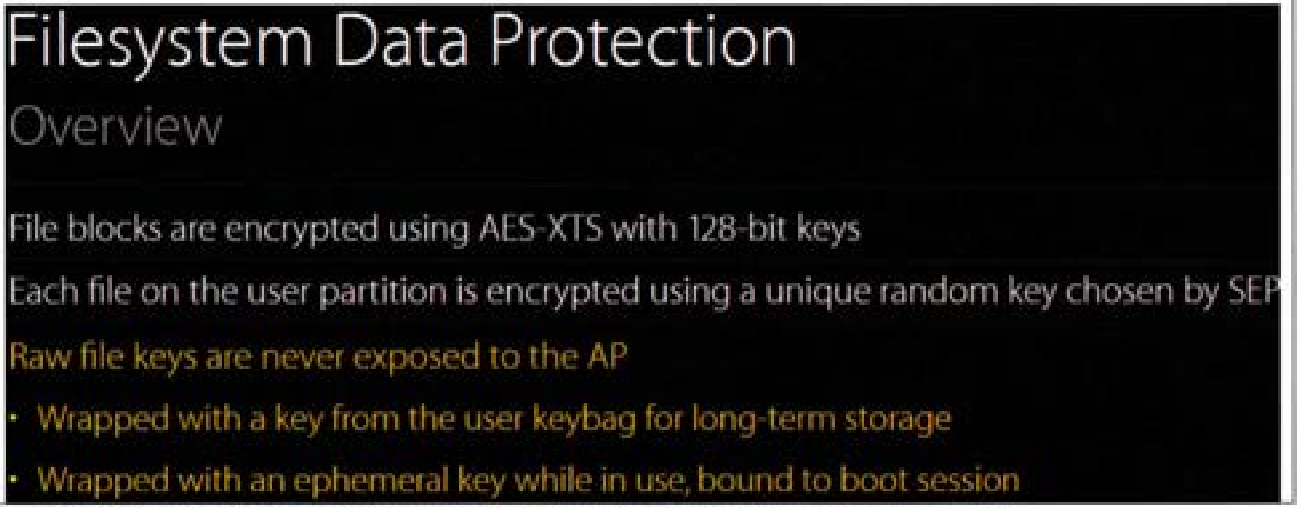


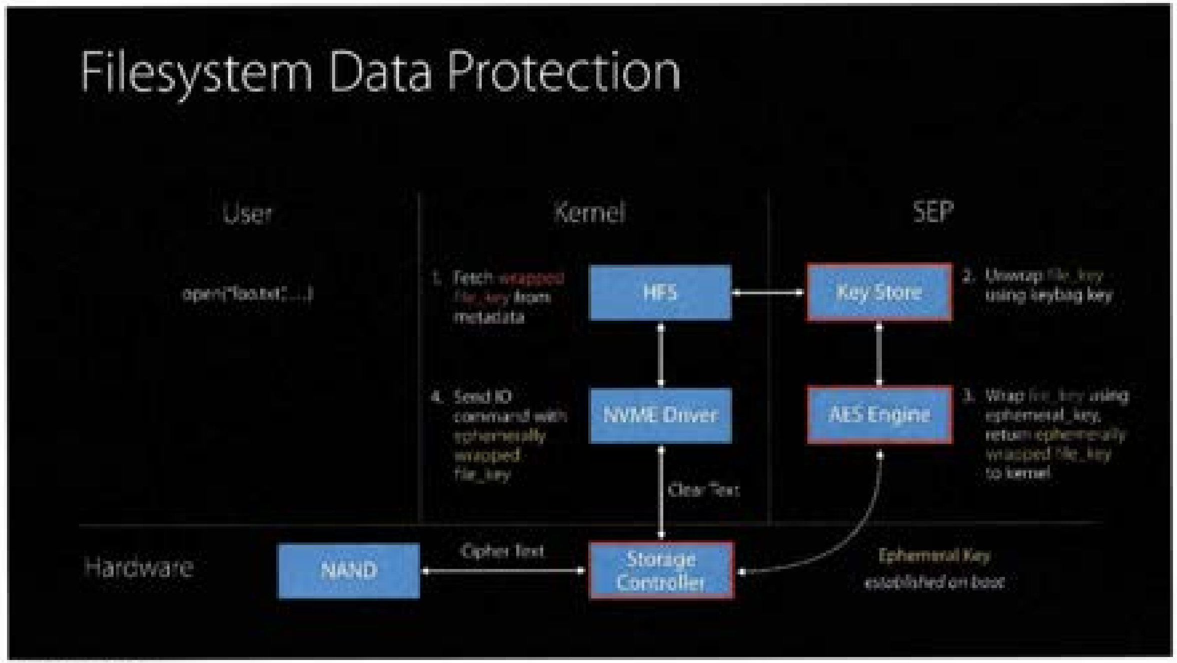
(Ex. B, Behind the Scenes with iOS Security, at 34.)

The class keys are encrypted with a master key:

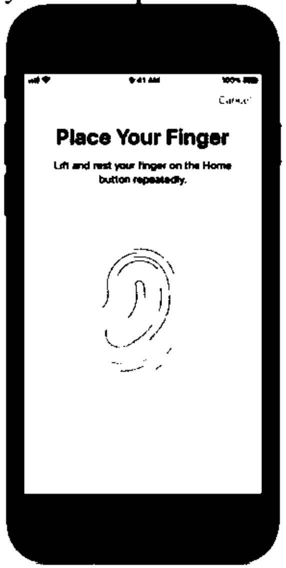
</td></tr>
</table>

Claim 10	**Accused Instrumentalities**
	 User Keybags Background Sets of keys generated for each user to protect their data at rest Keys wrapped by master key derived from user passcode and SEP UID After 10 incorrect passcode entries, SEP will not process any further attempts Different policy associated with each keybag key—Usage, availability (*Id.*, at 25.) The random secret is issued to SKS. SKS is a Secure Key Service application which is located within the Secure Enclave on the SEP and is responsible for decrypting class keys. The random secret provided by SBIO is used to decrypt a master key ("4) decrypt master key"). The master key is concatenated with the UID of the SEP and thus class keys are decrypted and added to the SKS keyring ("5) decrypt class keys, add to keyring") for further use by the Secure Enclave. The decrypted class keys include, for example, the class key of class A.
10c. a transmitter configured to emit a secure access signal conveying said information dependent upon said accessibility attribute;	***The Accused Instrumentalities include a transmitter configured to emit a secure access signal conveying information dependent upon said accessibility attribute.*** For example, the Secure Enclave emits a signal with ephemerally re-encrypted file keys: "sepOS can then use the ephemeral wrapping key to wrap file keys for use by the Application Processor file-system driver. When the file-system driver reads or writes a file, it sends the wrapped key to the AES Engine."

Claim 10	**Accused Instrumentalities**
	(Ex. A, Apple Platform Security, at 14.) "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. [...] When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and sent back to the Application Processor." (*Id.* at 85.) The signal with the ephemerally re-encrypted file keys is a secure signal because it comes from the Secure Enclave and thus from a secure environment. Furthermore, the signal is secure because the transmitted information is encrypted. The emitted file keys are encrypted with the ephemeral key: "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. At startup, the Secure Enclave negotiates an ephemeral key with the AES Engine. When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and sent back to the Application Processor." (*Id.*)  Filesystem Data Protection Overview File blocks are encrypted using AES-XTS with 128-bit keys Each file on the user partition is encrypted using a unique random key chosen by SEP Raw file keys are never exposed to the AP • Wrapped with a key from the user keybag for long-term storage • Wrapped with an ephemeral key while in use, bound to boot session

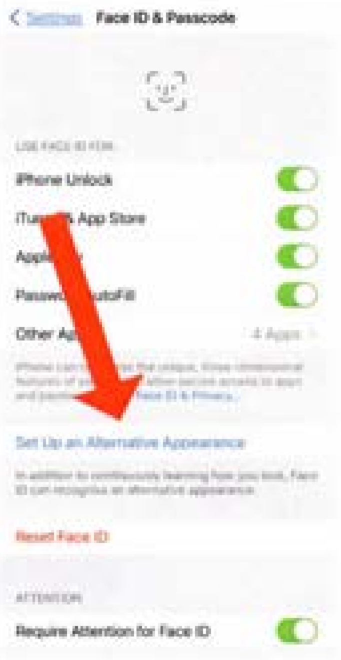
Claim 10	Accused Instrumentalities
	(Ex. B, Behind the Scenes with iOS Security, at 29.)  Filesystem Data Protection User Kernel SEP open("foo.txt",...) HFS Key Store NVME Driver AES Engine Clear Text Hardware NAND Cipher Text Storage Controller Ephemeral Key established on boot 1. Fetch wrapped file_key from metadata 2. Unwrap file_key using keybag key 3. Wrap file_key using ephemeral_key, return ephemerally wrapped file_key to kernel 4. Send IO command with ephemerally wrapped file_key (*Id.*, at 30.) The information transmitted by the emitted signal, i.e., the ephemerally re-encrypted file keys, is dependent on the availability attribute, i.e., the confirmation that a biometric "template match" exists. This confirmation is signaled by the issuance of the random secret (cf. step 3): Only if there is a confirmation of the match and the random secret is issued by the Touch ID or Face ID subsystem within the Secure Enclave, i.e. SBIO, the class key is available for re-encrypting the file keys. The re-encrypted file keys are therefore information which is emitted depending on the fact that the availability attribute has been emitted.

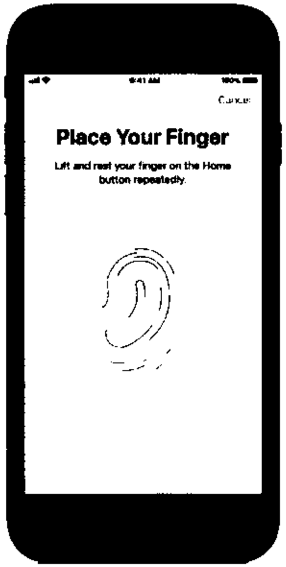
Claim 10	**Accused Instrumentalities**
10d. wherein the controller is further configured to:	***The Accused Instrumentalities include a controller that is configured to be used as set forth in elements 10d1, 10d2, and 10d3 below.***
10d1. receive a series of entries of the biometric signal, said series being characterised according to at least one of the number of said entries and a duration of each said entry;	***The Accused Instrumentalities include a transmitter sub-system controller configured to receive a series of entries of the biometric signal, said series being characterized according to at least one of the number of said entries and a duration of each said entry.*** More specifically, the Secure Enclave of the iPhone with the Secure Enclave Processor forms the means for receiving a series of entries of the biometric signal. "Apple's biometric security architecture relies on a strict separation of responsibilities between the biometric sensor and the Secure Enclave, and a secure connection between the two. The sensor captures the biometric image and securely transmits it to the Secure Enclave." (Ex. A, Apple Platform Security, at 19.) **Touch ID** When a finger is placed on the biometric sensor, the finger is scanned and the corresponding biometric signal entry is received by the Secure Enclave. "When the fingerprint sensor detects the touch of a finger, it triggers the advanced imaging array to scan the finger and sends the scan to the Secure Enclave." (*Id.*) To enroll a fingerprint in the database, the iPhone's fingerprint sensor records an entry of a biometric signal when the user places his finger on the sensor. This is done multiple times, resulting in a series of entries of such biometric signals. Receiving a series of entries of the biometric signal by repeatedly placing a finger on the Touch ID sensor will use Touch ID on iPhone.

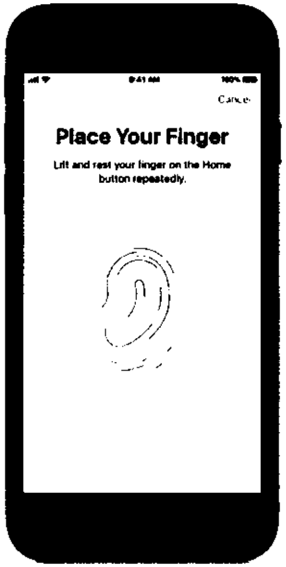
Claim 10	**Accused Instrumentalities**
	Set up Touch ID Before you can set up Touch ID, you must first create a code for your device,* then follow these steps: 7. Make sure the Touch ID sensor and your finger are clean and dry. 8. Tap Settings > Touch ID & Code, and then enter your code. 9. Tap "Add fingerprint" and hold the device as you normally would when touching the Touch ID sensor. 10. Touch the Touch ID sensor with one finger, but do not press. Keep your finger on the button until you feel a quick vibration or are prompted to lift your finger.  Place Your Finger Lift and rest your finger on the Home button repeatedly. 11. Continue by raising and slowly lowering your finger over and over again, changing the position of your finger just a tiny bit at a time.

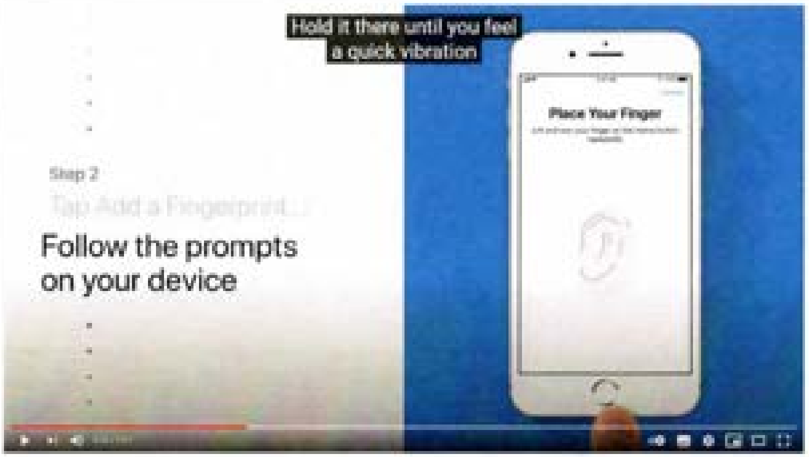
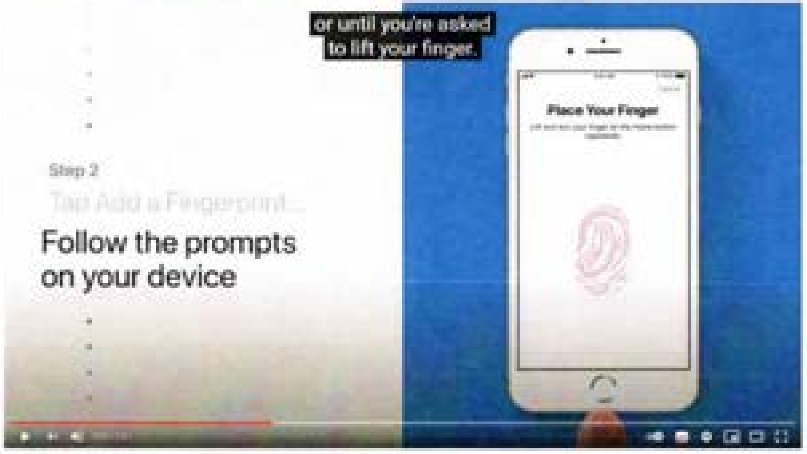
Claim 10	Accused Instrumentalities
	12. The next screen will ask you to change your finger position. Hold your device as you normally would when unlocking it. Touch the Touch ID sensor with the outer edges of your fingertip instead of the middle part as you would during the first scan." (https://support.apple.com/en-us/HT201371) Accordingly, the user is prompted to place his finger on the sensor several times, in particular in accordance with step 5. Each time the finger is placed on the sensor, a corresponding biometric entry is generated, i.e. a series of such entries. All these entries, which result from placing the same finger on the sensor, form a series. **Face ID** The means for receiving a series of entries of the biometric signal includes a Secure Neural Engine, which is protected by the Secure Enclave. The Secure Neural Engine transforms the series of entries of the biometric signal received by the Secure Enclave into a biometric signature ("mathematical representation"). "After the TrueDepth camera confirms the presence of an attentive face, it projects and reads over 30,000 infrared dots to form a depth map of the face along with a 2D infrared image. This data is used to create **a sequence of 2D images and depth maps**, which are digitally signed and **sent to the Secure Enclave**. To counter both digital and physical spoofs, the TrueDepth camera randomizes the sequence of 2D images and depth map captures, and projects a device-specific random pattern. A portion of the **Secure Neural Engine-protected** within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (Ex. A, Apple Platform Security, at 20.) Each entry of the biometric signal thus contains a two-dimensional infrared image with 30,000 infrared points for capturing depth information. By continuously capturing such infrared images into a Face ID scan while the user moves his head into different poses, a series of entries of the biometric signal

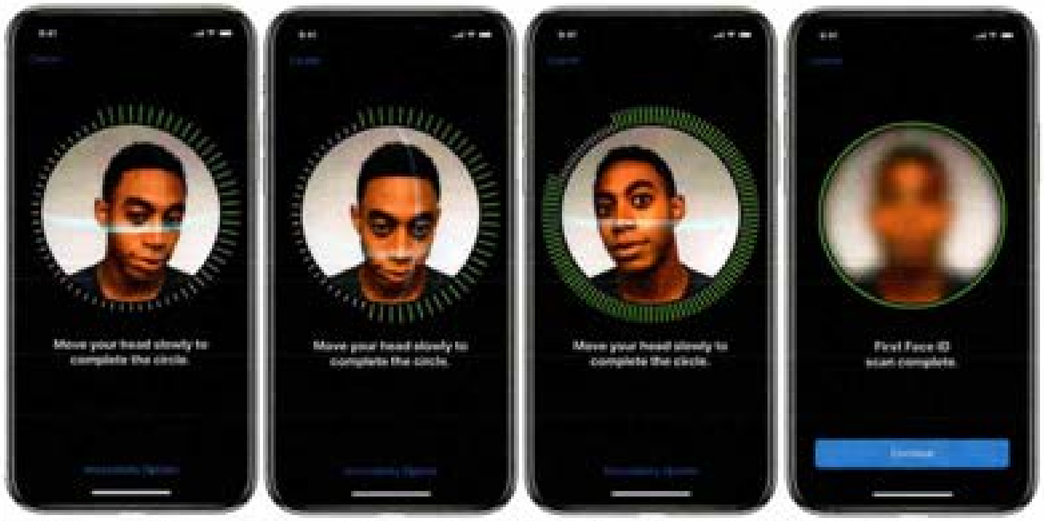
Claim 10	**Accused Instrumentalities**
	results. Two such Face ID scans are required to generate a biometric signature of a single face, so that two series of entries of the biometric signal are received accordingly. Using Face ID on iPhone 1. Tap Settings > Face ID & Code. Enter your code when prompted. 2. Tap on "Configure Face ID". 3. Hold the device in portrait mode in front of your face and tap "Let's go". 4. Make sure your face is inside the frame and slowly move your head until the circle shown is completed. If you can't move your head, tap on "Options for operating aids". 5. After performing the first Face ID scan, tap "Next". 6. Again, slowly describe a circle with your head until it is completed. 7. Tap "Done.” (https://support.apple.com/en-us/HT208109) The biometric signature of a single face is thus determined by two successive Face ID scans, each of which receives a series of entries of the biometric signal (compare steps 4. and 6. above). To register a second face, the iPhone offers a corresponding option in its settings. If the user selects the option "Set up an alternative appearance" as shown in the figure below on https://www.macworld.co.uk/how-to/second-face-id-3803421/, a second face is registered by the iPhone in the same way as the first face.

Claim 10	Accused Instrumentalities
	 < Settings Face ID & Passcode USE FACE ID FOR: iPhone Unlock iTu[illegible] App Store Appl[illegible] Passw[illegible]utoFill Other Ap[illegible] 4 Apps iPhone can [illegible] the unique, three-dimensional features of yo[illegible] allow secure access to apps and paym[illegible] Face ID & Privacy... Set Up an Alternative Appearance In addition to continuously learning how you look, Face ID can recognise an alternative appearance. Reset Face ID ATTENTION Require Attention for Face ID The series of entries of the biometric signal is identified on the iPhone by both the number and duration of each such entry. **Touch ID** According to step 5 of the instructions https://support.apple.com/en-us/HT201371, for the enrollment of a single finger, the user has to repeatedly place the respective finger on the sensor and thus a number of entries in a row predetermined via the user guidance are captured by the iPhone. Each one of the entries must also be of a predetermined duration given to the user via the iPhone display, i.e. the user's finger must remain on the sensor for a predetermined duration for each entry of the biometric signal in order to capture the biometric signal during this time.

Claim 10	**Accused Instrumentalities**
	Receiving a series of entries of the biometric signal by repeatedly placing a finger on the Touch ID sensor will use Touch ID on iPhone and iPad. **Set up Touch ID** … 4. Touch the Touch ID sensor with one finger, but do not press. Keep your finger on the button until you feel a quick vibration or are prompted to lift your finger.  Cancel Place Your Finger Lift and rest your finger on the Home button repeatedly. 5. Continue by raising and slowly lowering your finger over and over again, changing the position of your finger just a tiny bit at a time. 6. The next screen will ask you to change your finger position. Hold your device as you normally would when unlocking it. Touch the Touch ID sensor with the outer edges of your fingertip instead of the middle part as you did during the first scan. (https://support.apple.com/en-us/HT201371)

Claim 10	**Accused Instrumentalities**
	After placing a finger on the home button, a fingerprint appears on the display with red progress bars spreading along some of the papillary bars until the capture of the biometric entry in question is complete:  9:41 AM 100% Cancel Place Your Finger Lift and rest your finger on the Home button repeatedly. When the required duration is reached, the iPhone vibrates after an entry of the biometric signal is received or it issues a prompt to the user to lift the finger. The user then lifts the finger in question and replaces the same finger so that the iPhone receives a series of biometric signal entries of sufficient duration for that finger. The process is repeated for the same finger for as long as required according to the iPhone's user guidance. This is shown in the Apple You Tube video (32) How to set up Touch ID on your iPhone or iPad - Apple Support - YouTube (https://www.youtube.com/watch?v=xTZ2LALWZlg):

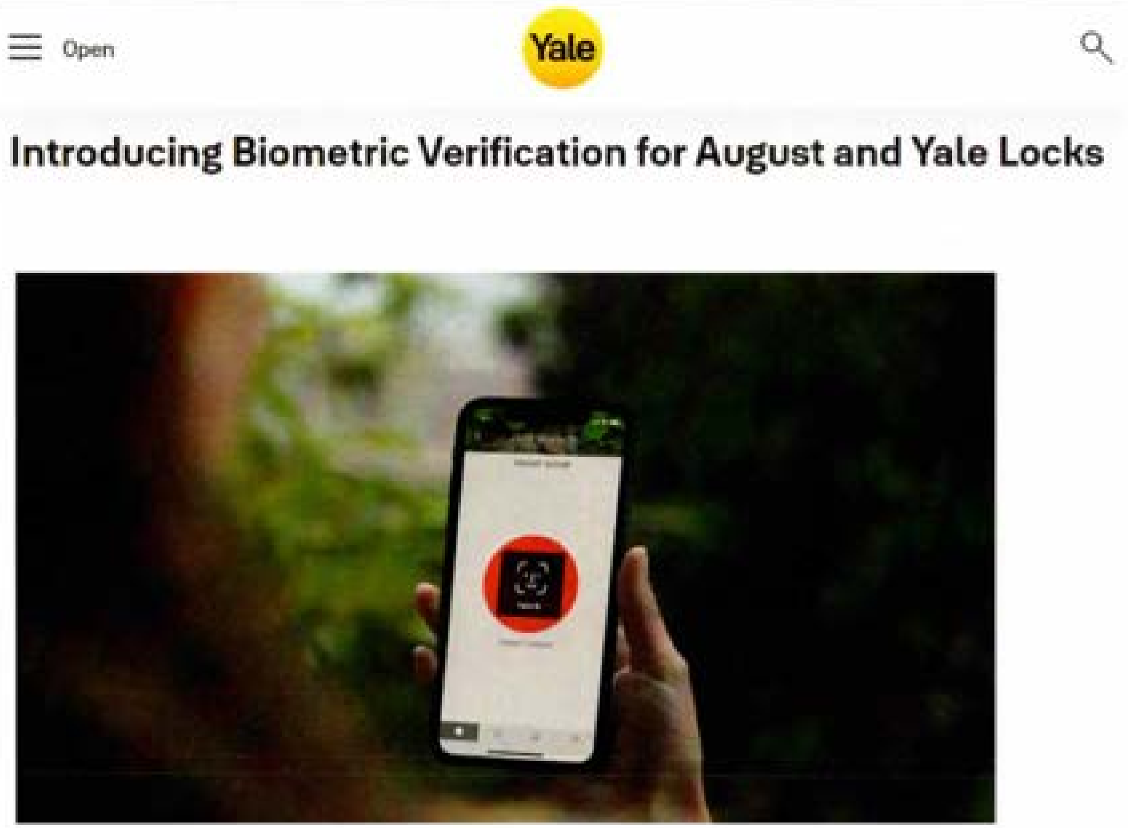
Claim 10	Accused Instrumentalities
	 Hold it there until you feel a quick vibration Step 2 Tap Add a Fingerprint... Follow the prompts on your device Place Your Finger  or until you're asked to lift your finger. Step 2 Tap Add a Fingerprint... Follow the prompts on your device Place Your Finger Both the number of entries, i.e. the number of repetitions for placing the finger on the screen, and their respective duration are specified by the iPhone via the user guidance.

Claim 10	Accused Instrumentalities
	Face ID The user moves his face in front of the camera to strike different poses, and the camera system with image sensor continuously captures a large number of biometric entries, i.e. here the 2D images with depth information, in a row. "This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (Ex. A, Apple Platform Security, at 20.) The sufficient duration of an entry for a pose, i.e. an angular position of the head specified via the user interface of the iPhone, is indicated to the user by the transformation of a gray line into a green line:  Move your head slowly to complete the circle. Move your head slowly to complete the circle. Move your head slowly to complete the circle. First Face ID scan complete. (Individual images taken from: https://support.apple.com/en-us/HT208109)
10d2. map said series into an instruction; and	***The Accused Instrumentalities include a transmitter sub-system controller configured to map said series into an instruction.***

Claim 10	**Accused Instrumentalities**
	More specifically, the Secure Enclave of the iPhone contains means to assign the received row to an instruction: The Secure Enclave, after receiving the full set of entries of the biometric signal, assigns this set to an instruction for processing, encrypting and storing the biometric signature ("Touch ID and Face ID template data"). "The sensor captures the biometric image and securely transmits it to the Secure Enclave. During enrollment, the Secure Enclave processes, encrypts, and stores the corresponding Touch ID and Face ID template data." (Ex. A, Apple Platform Security, at 19.) To carry out this instruction, the Secure Enclave has its own processor: "The Secure Enclave Processor provides the main computing power for the Secure Enclave." (*Id.*, at 10.) **Touch ID** The instruction here involves the processing of under-the-skin fingerprint characteristics and their encrypted storage. "The analysis uses subdermal ridge flow angle mapping, a lossy process that discards "finger minutiae data" that would be required to reconstruct the user's actual fingerprint. During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches, but without any identity information." (*Id.*, at 19.) **Face ID** The instruction involves the transformation of the set of entries of the biometric signal captured via the Face ID scans into a mathematical representation, i.e. the biometric signature of the face in question by the Secure Neural Engine of the Secure Enclave, as well as its encryption and storage.

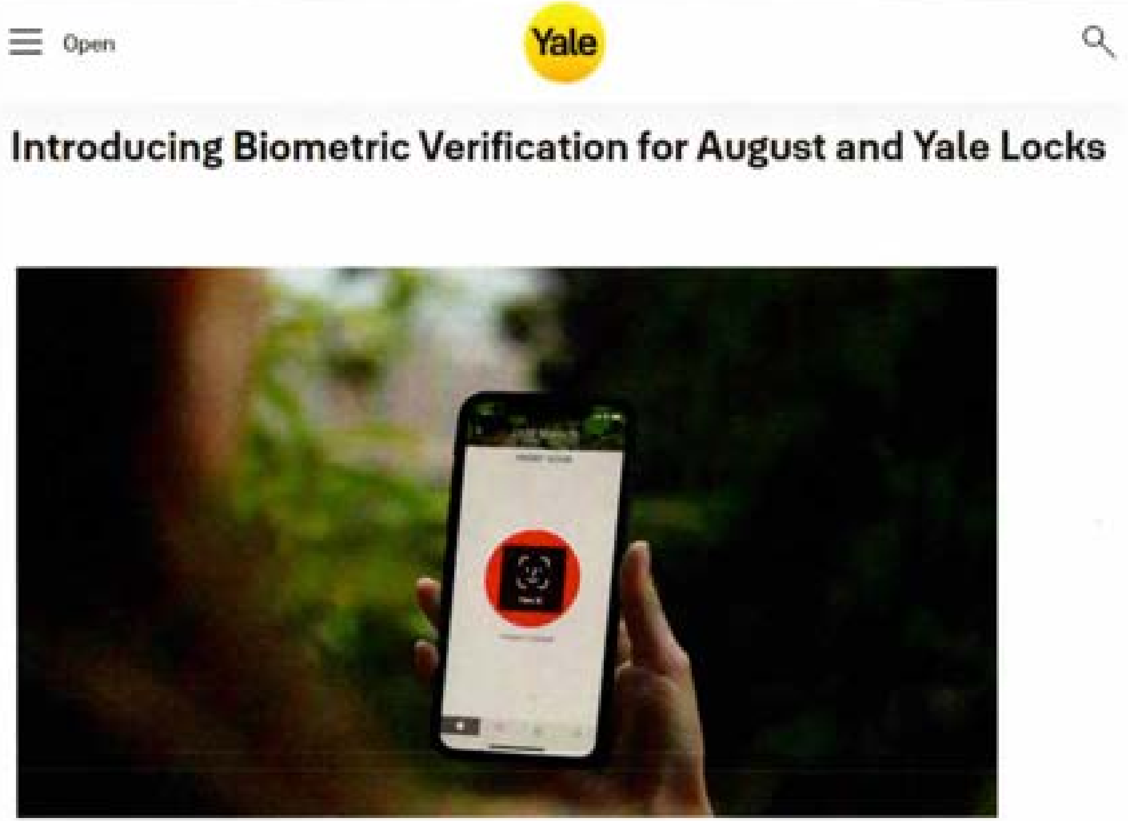
Claim 10	**Accused Instrumentalities**
	"A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses. " (*Id.*, at 20.) "Face ID data, including mathematical representations of a user's face, is encrypted and available only to the Secure Enclave. This data never leaves the device. It's not sent to Apple, nor is it included in device backups. The following Face ID data is saved, encrypted only for use by the Secure Enclave, during normal operation: • The mathematical representations of a user's face calculated during enrollment • ..." (*Id.*, at 23.)
10d3. populate the database according to the instruction, wherein the controlled item is one of: a locking mechanism of a physical access structure or an electronic lock on an electronic computing device.	***The Accused Instrumentalities include a transmitter sub-system controller configured to populate the database according to the instruction.*** More specifically, the Secure Enclave stores the biometric signature, i.e. the encrypted mathematical representation of the fingerprint or face, in the database 105, i.e. the "secure nonvolatile storage": "The secure nonvolatile storage is used for all anti-replay services in the Secure Enclave. Anti-replay services on the Secure Enclave are used for revocation of data over events that mark anti-replay boundaries including, but not limited to, the following: • ... • ... • Adding or removing a Touch ID fingerprint or Face ID face". (Ex. A, Apple Platform Security, at 16.) "During enrollment, the Secure Enclave processes, encrypts, and stores the corresponding Touch ID and Face ID template data." (*Id.*, at 19.)

Claim 10	Accused Instrumentalities
	Touch ID "During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches...." (*Id.*) **Face ID** The following Face ID data is saved, encrypted only for use by the Secure Enclave, during normal operation: • The mathematical representations of a user's face calculated during enrollment". (*Id.*, at 23.) More specifically, the controlled item is a locking mechanism of the door lock of the user's home. The Accused Instrumentalities are configured to provide secure access to the user's home via Yale Smart Locks when the user provides biometric signal to the Accused Instrumentalities via Touch ID or Face ID. "When the "Secure Remote Access" feature is turned on, the app will use your phone's built-in authentication tools to prompt fingerprint or facial recognition before you can unlock or lock your home remotely (note: if your phone does not have these features, it will prompt you to use your PIN code). This further ensures that your door is only operated by the right people at the time you intend for it." (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

Claim 10	Accused Instrumentalities
	 Open Yale Introducing Biometric Verification for August and Yale Locks (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

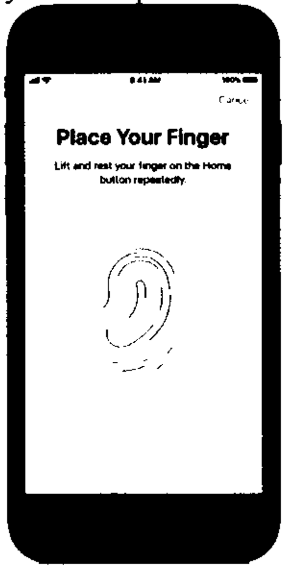
Claim 10	Accused Instrumentalities
	(https://www.apple.com/shop/product/HPAR2ZM/A/yale-assure-lock-sl-touchscreen-deadbolt-black)

Claim 11	Accused Instrumentalities
11. A method for providing secure access to a controlled item in a system comprising a database of biometric signatures, a transmitter sub-system comprising a biometric sensor configured to receive a biometric signal, and a transmitter configured to emit a secure access signal capable of granting access to the controlled item, and a receiver sub-system comprising a receiver sub-system controller configured to receive the transmitted secure access signal, and provide conditional access to the controlled item dependent upon information in said secure access signal, the method comprising:	***To the extent that the preamble is deemed to be a limitation, the Accused Instrumentalities are configured to use a method in accordance with this claim.*** More specifically, the controlled item is a locking mechanism of the door lock of the user's home. The Accused Instrumentalities are configured to provide secure access to the user's home via Yale Smart Locks when the user provides biometric signal to the Accused Instrumentalities via Touch ID or Face ID. "When the "Secure Remote Access" feature is turned on, the app will use your phone's built-in authentication tools to prompt fingerprint or facial recognition before you can unlock or lock your home remotely (note: if your phone does not have these features, it will prompt you to use your PIN code). This further ensures that your door is only operated by the right people at the time you intend for it." (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

Claim 11	Accused Instrumentalities
	 Introducing Biometric Verification for August and Yale Locks (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

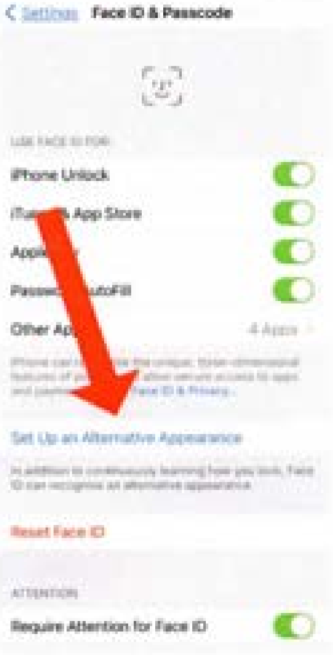
Claim 11	Accused Instrumentalities
	 (https://www.apple.com/shop/product/HPAR2ZM/A/yale-assure-lock-sl-touchscreen-deadbolt-black)
11a. populating the database of biometric signatures by:	***The Accused Instrumentalities are configured to populate the database of biometric signatures as set forth in elements 11a1, 11a2, and 11a3 below.***

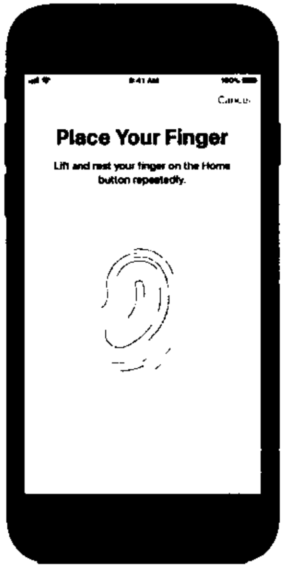
Claim 11	Accused Instrumentalities
11a1. receiving a series of entries of the biometric signal;	***The Accused Instrumentalities are configured to populate the database of biometric signatures by: receiving a series of entries of the biometric signal.*** More specifically, the Secure Enclave of the iPhone with the Secure Enclave Processor forms the means for receiving a series of entries of the biometric signal. "Apple's biometric security architecture relies on a strict separation of responsibilities between the biometric sensor and the Secure Enclave, and a secure connection between the two. The sensor captures the biometric image and securely transmits it to the Secure Enclave." (Ex. A, Apple Platform Security, at 19.) **Touch ID** When a finger is placed on the biometric sensor, the finger is scanned and the corresponding biometric signal entry is received by the Secure Enclave. "When the fingerprint sensor detects the touch of a finger, it triggers the advanced imaging array to scan the finger and sends the scan to the Secure Enclave." (Ex. A, Apple Platform Security, at 19.) To enroll a fingerprint in the database, the iPhone's fingerprint sensor records an entry of a biometric signal when the user places his finger on the sensor. This is done multiple times, resulting in a series of entries of such biometric signals. Receiving a series of entries of the biometric signal by repeatedly placing a finger on the Touch ID sensor will use Touch ID on iPhone. **Set up Touch ID** Before you can set up Touch ID, you must first create a code for your device,* then follow these steps: 1. Make sure the Touch ID sensor and your finger are clean and dry.

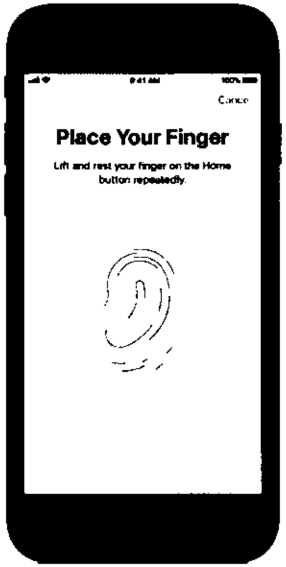
Claim 11	**Accused Instrumentalities**
	2. Tap Settings > Touch ID & Code, and then enter your code. 3. Tap "Add fingerprint" and hold the device as you normally would when touching the Touch ID sensor. 4. Touch the Touch ID sensor with one finger, but do not press. Keep your finger on the button until you feel a quick vibration or are prompted to lift your finger.  Place Your Finger Lift and rest your finger on the Home button repeatedly. 5. Continue by raising and slowly lowering your finger over and over again, changing the position of your finger just a tiny bit at a time. 6. The next screen will ask you to change your finger position. Hold your device as you normally would when unlocking it. Touch the Touch ID sensor with the outer edges of your fingertip instead of the middle part as you would during the first scan." (https://support.apple.com/en-us/HT201371)

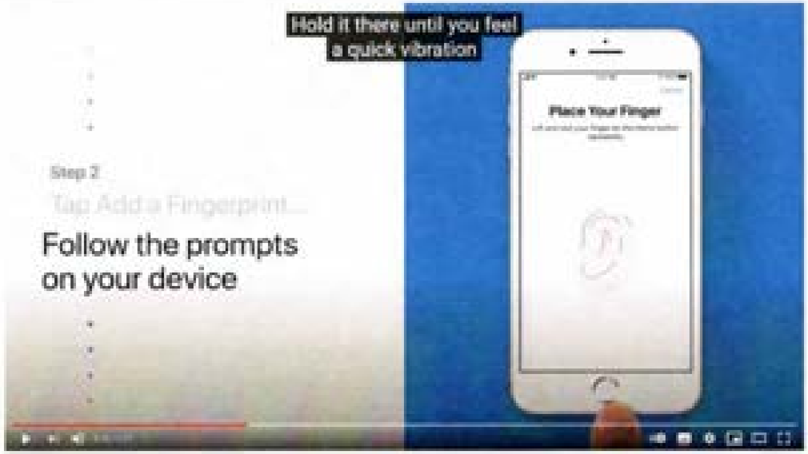
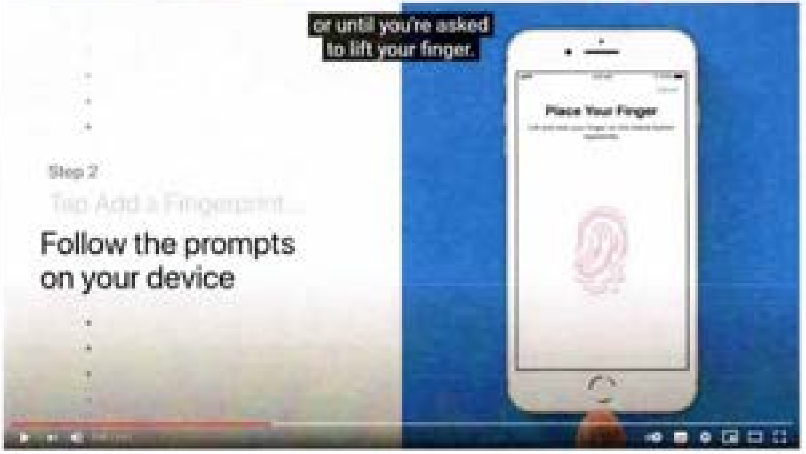
Claim 11	**Accused Instrumentalities**
	Accordingly, the user is prompted to place his finger on the sensor several times, in particular in accordance with step 5. Each time the finger is placed on the sensor, a corresponding biometric entry is generated, i.e. a series of such entries. All these entries, which result from placing the same finger on the sensor, form a series. **Face ID** The means for receiving a series of entries of the biometric signal includes a Secure Neural Engine, which is protected by the Secure Enclave. The Secure Neural Engine transforms the series of entries of the biometric signal received by the Secure Enclave into a biometric signature ("mathematical representation"). "After the TrueDepth camera confirms the presence of an attentive face, it projects and reads over 30,000 infrared dots to form a depth map of the face along with a 2D infrared image. This data is used to create **a sequence of 2D images and depth maps**, which are digitally signed and **sent to the Secure Enclave**. To counter both digital and physical spoofs, the TrueDepth camera randomizes the sequence of 2D images and depth map captures, and projects a device-specific random pattern. A portion of the **Secure Neural Engine-protected** within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (emphasis added) (Ex. A, Apple Platform Security, at 20.) Each entry of the biometric signal thus contains a two-dimensional infrared image with 30,000 infrared points for capturing depth information. By continuously capturing such infrared images into a Face ID scan while the user moves his head into different poses, a series of entries of the biometric signal results. Two such Face ID scans are required to generate a biometric signature of a single face, so that two series of entries of the biometric signal are received accordingly. Using Face ID on iPhone or iPad Pro - Apple Support

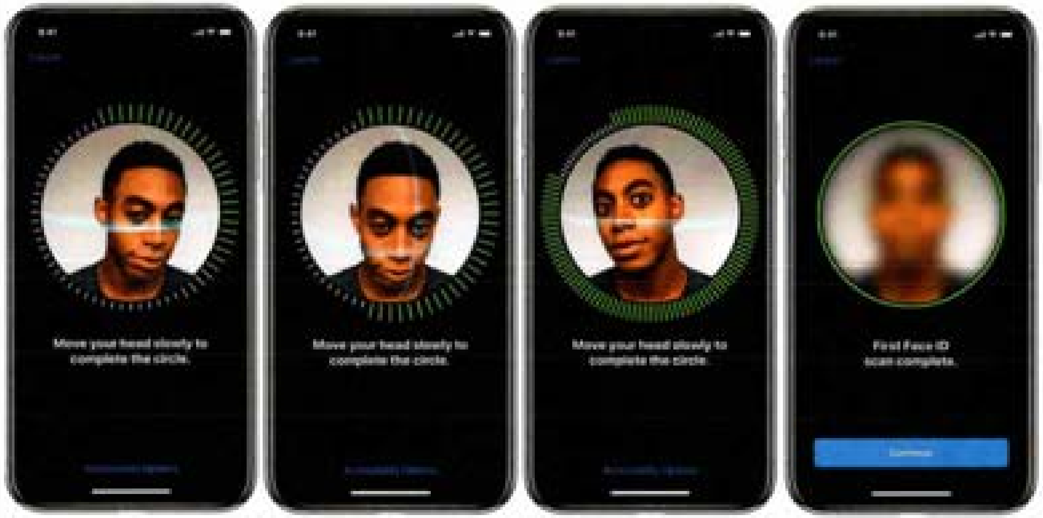
Claim 11	**Accused Instrumentalities**
	Configure Face ID Before configuring Face ID, make sure that neither the TrueDepth camera nor your face are covered by anything.... Follow the steps below to configure Face ID: 1. Tap Settings > Face ID & Code. Enter your code when prompted. 2. Tap on "Configure Face ID". 3. Hold the device in portrait mode in front of your face and tap "Let's go". 4. Make sure your face is inside the frame and slowly move your head until the circle shown is completed. If you can't move your head, tap on "Options for operating aids". 5. After performing the first Face ID scan, tap "Next". 6. Again, slowly describe a circle with your head until it is completed. 7. Tap "Done." (https://support.apple.com/en-us/HT208109) The biometric signature of a single face is thus determined by two successive Face ID scans, each of which receives a series of entries of the biometric signal (compare steps 4. and 6. above). To register a second face, the iPhone offers a corresponding option in its settings. If the user selects the option "Set up an alternative appearance" as shown in the figure below on https://www.macworld.co.uk/how-to/second-face-id-3803421/, a second face is registered by the iPhone in the same way as the first face.

<u>Claim 11</u>	<u>Accused Instrumentalities</u>
	 < Settings Face ID & Passcode USE FACE ID FOR: iPhone Unlock iTun… App Store Appl… Passw… utoFill Other Ap… 4 Apps iPhone can … the unique, three-dimensional features of … allow secure access to apps and paym… Face ID & Privacy… Set Up an Alternative Appearance In addition to continuously learning how you look, Face ID can recognize an alternative appearance. Reset Face ID ATTENTION Require Attention for Face ID The series of entries of the biometric signal is identified on the iPhone by both the number and duration of each such entry. **Touch ID** According to step 5 of the instructions https://support.apple.com/en-us/HT201371, for the enrollment of a single finger, the user has to repeatedly place the respective finger on the sensor and thus a number of entries in a row predetermined via the user guidance are captured by the iPhone. Each one of the entries must also be of a predetermined duration given to the user via the iPhone display, i.e. the user's finger must remain on the sensor for a predetermined duration for each entry of the biometric signal in order to capture the biometric signal during this time.

Claim 11	**Accused Instrumentalities**
	Receiving a series of entries of the biometric signal by repeatedly placing a finger on the Touch ID sensor will use Touch ID on iPhone. **Set up Touch ID** … 4. Touch the Touch ID sensor with one finger, but do not press. Keep your finger on the button until you feel a quick vibration or are prompted to lift your finger.  Place Your Finger Lift and rest your finger on the Home button repeatedly. 5. Continue by raising and slowly lowering your finger over and over again, changing the position of your finger just a tiny bit at a time. 6. The next screen will ask you to change your finger position. Hold your device as you normally would when unlocking it. Touch the Touch ID sensor with the outer edges of your fingertip instead of the middle part as you did during the first scan. (https://support.apple.com/en-us/HT201371)

Claim 11	**Accused Instrumentalities**
	After placing a finger on the home button, a fingerprint appears on the display with red progress bars spreading along some of the papillary bars until the capture of the biometric entry in question is complete:  9:41 AM 100% Cancel Place Your Finger Lift and rest your finger on the Home button repeatedly. When the required duration is reached, the iPhone vibrates after an entry of the biometric signal is received or it issues a prompt to the user to lift the finger. The user then lifts the finger in question and replaces the same finger so that the iPhone receives a series of biometric signal entries of sufficient duration for that finger. The process is repeated for the same finger for as long as required according to the iPhone's user guidance. This is shown in the Apple You Tube video (32) How to set up Touch ID on your iPhone or iPad - Apple Support - YouTube (https://www.youtube.com/watch?v=xTZ2LALWZlg):

Claim 11	Accused Instrumentalities
	 Hold it there until you feel a quick vibration Step 2 Tap Add a Fingerprint... Follow the prompts on your device  or until you're asked to lift your finger. Step 2 Tap Add a Fingerprint... Follow the prompts on your device Both the number of entries, i.e. the number of repetitions for placing the finger on the screen, and their respective duration are specified by the iPhone via the user guidance.

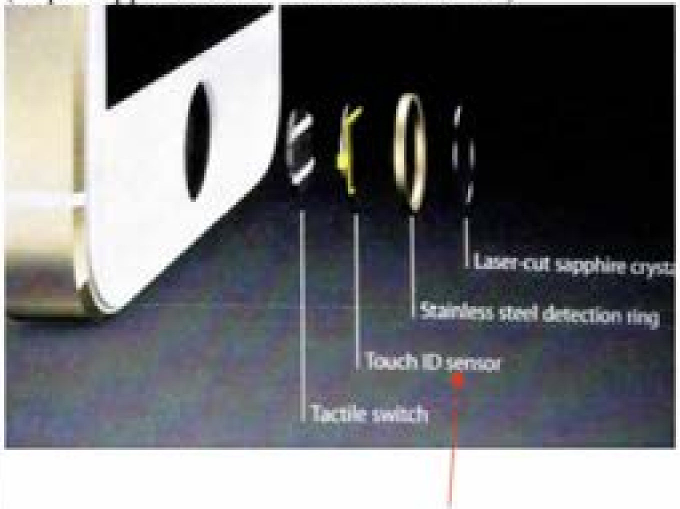
Claim 11	Accused Instrumentalities
	Face ID The user moves his face in front of the camera to strike different poses, and the camera system with image sensor continuously captures a large number of biometric entries, i.e. here the 2D images with depth information, in a row. "This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (Ex. A, Apple Platform Security, at 20.) The sufficient duration of an entry for a pose, i.e. an angular position of the head specified via the user interface of the iPhone, is indicated to the user by the transformation of a gray line into a green line:  Move your head slowly to complete the circle. Move your head slowly to complete the circle. Move your head slowly to complete the circle. First Face ID scan complete. (Individual images taken from: https://support.apple.com/en-us/HT208109)

Claim 11	**Accused Instrumentalities**
11a2. determining at least one of the number of said entries and a duration of each said entry;	***The Accused instrumentalities are configured to populate the database of biometric signatures by: determining at least one of the number of said entries and a duration of each said entry.*** More specifically, as discussed above, both Face ID and Touch ID require a specific number of entries to enroll a Touch ID or Face ID. The Accused Instrumentalities must determine that the specific number of entries have been input. Likewise, while not necessary for the claim, upon information and belief, the Accused Instrumentalities determine that each input of either facial or fingerprint data is of a sufficient duration. Again, when setting up Touch ID in the Accused Instrumentalities, the users are required to touch the home button with their finger several times for a certain duration. Similarly, the users need to scan their face twice, and each scan requires the users to move their head in a circle for a certain duration for Face ID. Touch ID: Register a fingerprint for Apple Touch ID by the user tapping a finger several times on the home button to record the fingerprint data. (https://video.search.yahoo.com/yhs/search?fr=yhs-pty-pty_ converter&hsimp=yhs-pty_converter&hspart=pty&p=registering+ fingerprint+apple+touch+id+on+screen+instructions#id=1&vid= 156de65ae06ca453643009fc0ea9cf79&action=click) Touch ID: The user's finger must remain on the home button long enough for the data to be recorded. "Touch the Touch ID sensor with your finger, but don't press it. Hold it there until you feel a quick vibration, or until you're asked to lift your finger." "Continue to lift and rest your finger slowly, making small adjustments to the position of your finger each time." (https://support.apple.com/en-au/HT201371) Touch ID: "you shouldn't tap too quickly or move your finger around" (https://support.apple.com/en-us/HT207537) Face ID: Setting up Face ID requires two scans of the user's face. Each scan asks users to move their head slowly in a circle to register different angles of the user's face. (https://www.imore.com/how-set-face-id-iphone)

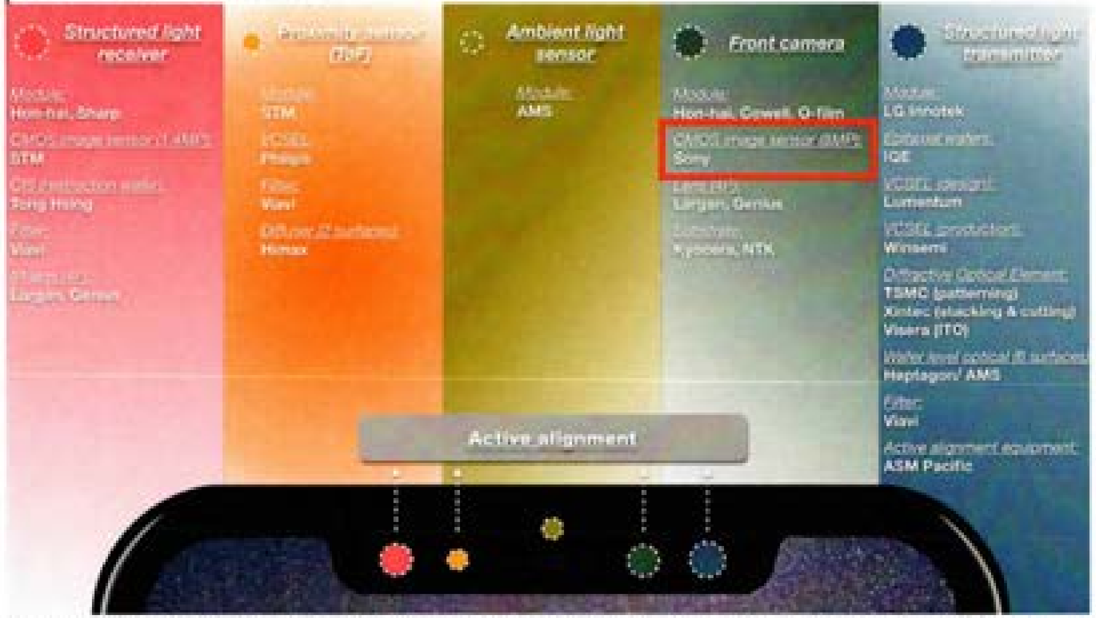
Claim 11	**Accused Instrumentalities**
11a3. mapping said series into an instruction; and	***The Accused Instrumentalities include a transmitter sub-system controller configured to map said series into an instruction.*** More specifically, the Secure Enclave of the iPhone contains means to assign the received row to an instruction: The Secure Enclave, after receiving the full set of entries of the biometric signal, assigns this set to an instruction for processing, encrypting and storing the biometric signature ("Touch ID and Face ID template data"). "The sensor captures the biometric image and securely transmits it to the Secure Enclave. During enrollment, the Secure Enclave processes, encrypts, and stores the corresponding Touch ID and Face ID template data." (Ex. A, Apple Platform Security, at 19.) To carry out this instruction, the Secure Enclave has its own processor: "The Secure Enclave Processor provides the main computing power for the Secure Enclave." (*Id.*, at 10.) **Touch ID** The instruction here involves the processing of under-the-skin fingerprint characteristics and their encrypted storage. "The analysis uses subdermal ridge flow angle mapping, a lossy process that discards "finger minutiae data" that would be required to reconstruct the user's actual fingerprint. During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches, but without any identity information." (*Id.*, at 19.) **Face ID**

Claim 11	**Accused Instrumentalities**
	The instruction involves the transformation of the set of entries of the biometric signal captured via the Face ID scans into a mathematical representation, i.e. the biometric signature of the face in question by the Secure Neural Engine of the Secure Enclave, as well as its encryption and storage. "A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses. " (*Id*., at 20.) "Face ID data, including mathematical representations of a user's face, is encrypted and available only to the Secure Enclave. This data never leaves the device. It's not sent to Apple, nor is it included in device backups. The following Face ID data is saved, encrypted only for use by the Secure Enclave, during normal operation: • The mathematical representations of a user's face calculated during enrollment • ..." (*Id*., at 23.)
11a4. populating the database according to the instruction;	***The Accused Instrumentalities include a transmitter sub-system controller configured to populate the database according to the instruction.*** More specifically, the Secure Enclave stores the biometric signature, i.e. the encrypted mathematical representation of the fingerprint or face, in the database 105, i.e. the "secure nonvolatile storage": "The secure nonvolatile storage is used for all anti-replay services in the Secure Enclave. Anti-replay services on the Secure Enclave are used for revocation of data over events that mark anti-replay boundaries including, but not limited to, the following: • ... • ... • Adding or removing a Touch ID fingerprint or Face ID face". (Ex. A, Apple Platform Security, at 16.)

Claim 11	**Accused Instrumentalities**
	"During enrollment, the Secure Enclave processes, encrypts, and stores the corresponding Touch ID and Face ID template data." (*Id.*, at 19.) **Touch ID** "During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches...." (*Id.*) **Face ID** The following Face ID data is saved, encrypted only for use by the Secure Enclave, during normal operation: • The mathematical representations of a user's face calculated during enrollment". (*Id.*, at 23.)
11b. receiving the biometric signal;	***The Accused Instrumentalities include a biometric sensor configured to receive the biometric signal.*** More specifically, the iPhone has at least one biometric sensor for capturing a fingerprint or a face (Touch ID and/or Face ID), namely a Touch ID sensor and a camera system with image sensor, respectively. **Touch ID** "Apple devices with a Touch ID sensor can be unlocked using a fingerprint." (Ex. A, Apple Platform Security, at 19.) "Touch ID is the fingerprint sensing system that makes secure access to supported Apple devices faster and easier. This technology reads fingerprint data from any angle and learns more about a user's fingerprint over time, with the **sensor** continuing to expand the fingerprint map as additional overlapping nodes are identified with each use."

Claim 11	Accused Instrumentalities
	(*Id.*) "When the fingerprint sensor detects the touch of a finger, it triggers the advanced imaging array to scan the finger and sends the scan to the Secure Enclave." (*Id.*) The biometric sensor for Touch ID is located below the home button: "The Home button is a stack of different materials, capped with a sapphire crystal lens. The surrounding stainless-steel ring works as a ground and detects the user's finger. This action activates a capacitive touch sensor installed underneath the cover: A CMOS chip with small capacitors." (https://appleinsider.com/inside/touch-id)  Biometric sensor 121 "Where is the Touch ID sensor located?

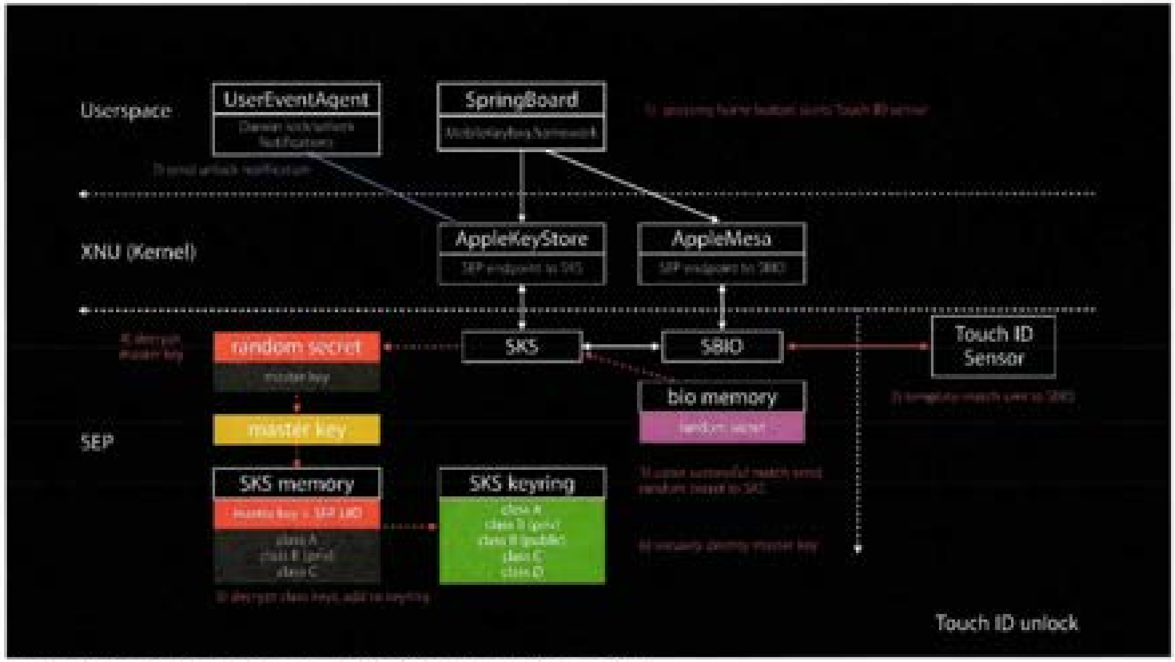
Claim 11	**Accused Instrumentalities**
	The Touch ID sensor is located either in the home button or - on the iPad Air (4th generation) - in the top button. (https://support.apple.com/en-us/HT201371) The image sensor captures an 88-by-88-pixel, 500 PPI raster scan: "The 88-by-88-pixel, 500-ppi raster scan is temporarily stored in encrypted memory within the Secure Enclave while being vectorized for analysis, and then it's discarded. The analysis utilizes subdermal ridge flow angle mapping, which is a lossy process that discards minutia data that would be required to reconstruct the user's actual fingerprint. The resulting map of nodes is stored without any identity information in an encrypted format that can only be read by the Secure Enclave, and is never sent to Apple or backed up to iCloud or iTunes. " (Ex. C, iOS Security white paper, at 8.) **Face ID** The biometric sensor for facial biometrics is a camera system ("TrueDepth camera system") with an image sensor. "With a simple glance, Face ID securely unlocks supported Apple devices. It provides intuitive and secure authentication enabled by the TrueDepth camera system, which uses advanced technologies to accurately map the geometry of a user's face. " (Ex. A, Apple Platform Security, at 20.) To receive a biometric signal, the camera system with image sensor reads over 30,000 infrared points to capture depth information along with a two-dimensional infrared image. "After the TrueDepth camera confirms the presence of an attentive face, it projects and **reads over 30,000 infrared dots to form a depth map of the face along with a 2D infrared image**. This data is

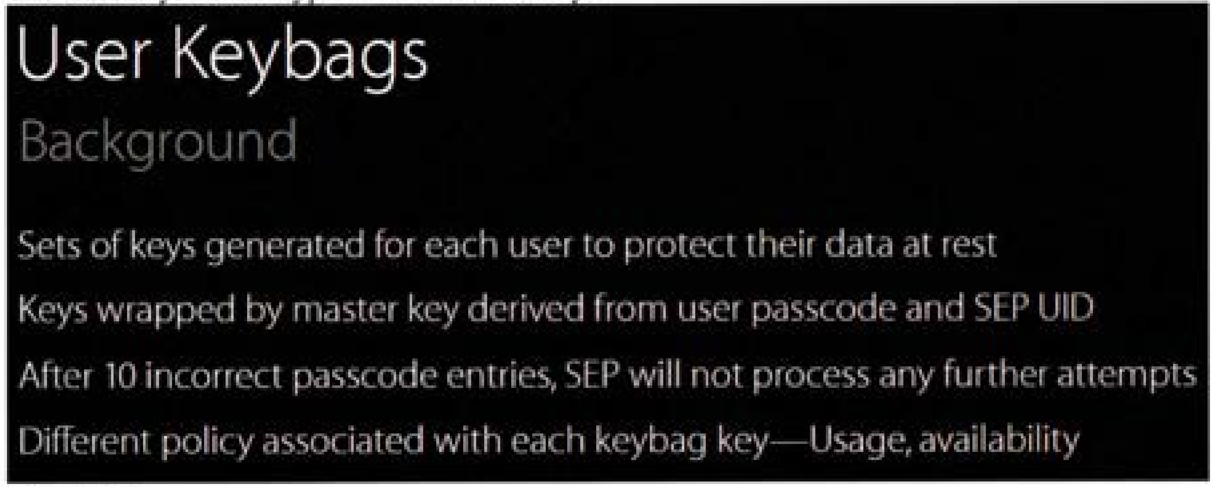
Claim 11	Accused Instrumentalities
	used to **create a sequence of 2D images and depth maps**, which are digitally signed and sent to the Secure Enclave. To counter both digital and physical spoofs, the TrueDepth camera randomizes the sequence of 2D images and depth map captures, and projects a device-specific random pattern. A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (*Id.*, at 20.) The camera system includes a biometric image sensor, namely a "CMOS image" sensor from Sony, to perform facial biometrics:  Structured light receiver Module: Hon-hai, Sharp CMOS image sensor (1.4MP): STM Filter: Viavi Largan, Genius Proximity sensor (ToF) Module: STM VCSEL: Philips Filter: Viavi Diffuser (2 surfaces): Himax Ambient light sensor Module: AMS Front camera Module: Hon-hai, Cowell, O-film CMOS image sensor (8MP): Sony Lens (7P): Largan, Genius Substrate: Kyocera, NTK Structured light transmitter Module: LG Innotek Epitaxial wafers: IQE VCSEL design: Lumentum VCSEL production: Winsemi Diffractive Optical Element: TSMC (patterning) Xintec (stacking & cutting) Visera (ITO) Wafer level optical (8 surfaces): Heptagon/ AMS Filter: Viavi Active alignment equipment: ASM Pacific Active alignment (https://appleinsider.com/articles/17/09/09/inner-workings-of-apples-face-id-camera-detailed-in-report)

Claim 11	**Accused Instrumentalities**
11c. matching the biometric signal against members of the database of biometric signatures to thereby output an accessibility attribute;	***The Accused Instrumentalities include a transmitter controller configured to emit a secure access signal conveying information dependent upon said accessibility attribute.*** More specifically, the iPhone's System on Chip (SOC), i.e. the Secure Enclave with its Secure Enclave Processor (SEP) or a Secure Neural Engine contained therein, is a means (103) to check a match of the biometric signal with elements of the biometric signature database. "The *Secure Enclave* is a system on chip (SoC) that is included on all recent iPhone, ... devices" (Ex. A, Apple Platform Security, at 7.) "During **matching**, the Secure Enclave **compares** incoming data from the biometric sensor against the stored templates **to determine whether to unlock the device** or respond that a match is valid (for Apple Pay, in-app, and other uses of Touch ID and Face ID). " (*Id.*, at 19.) The biometric signal received from the biometric sensor ("incoming data from the biometric sensor") is thus checked by the Secure Enclave and its SEP with the elements of the database of biometric signatures 105, i.e. the "stored templates", for the presence of a match. For Touch ID, the Secure Enclave match verification is performed as follows: "The Secure Enclave is responsible for processing fingerprint data from the Touch ID sensor, determining if there is a match against registered fingerprints, and then enabling access or purchases on behalf of the user ..." (Ex. C, iOS Security white paper, at 7.) "During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches...." (Ex. A, Apple Platform Security, at 19.)

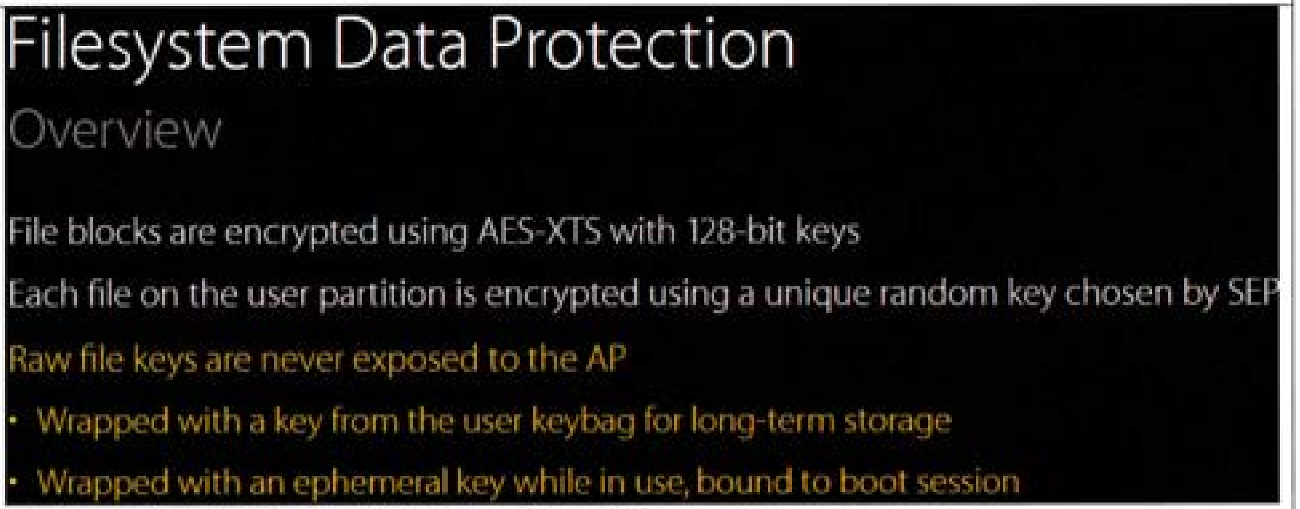
Claim 11	**Accused Instrumentalities**
	"Touch ID can read multiple fingerprints, and it can read fingerprints in 360-degrees of orientation. It then creates a mathematical representation of your fingerprint and compares this to your enrolled fingerprint data to identify a match and unlock your device. " (https://support.apple.com/en-us/HT204587) "Touch ID can read multiple fingerprints and recognize fingerprints at any orientation of the finger. The system then creates a mathematical representation of your fingerprint and compares it to the registered fingerprint data to determine a match and unlock your device." (https://support.apple.com/de-de/HT204587) For **Face ID,** the Secure Enclave has a neural network protected by it, i.e., a Secure Neural Engine, which is used to verify the match: "Face ID uses neural networks for determining attention, **matching**, and antispoofing, so a user can unlock their phone with a glance." (Ex. A, Apple Platform Security, at 20.) "A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (*Id.*). "Facial matching security Facial matching is performed within the Secure Enclave using neural networks trained specifically for that purpose... Face ID data, including mathematical representations of a user's face, is encrypted and available only to the Secure Enclave. This data never leaves the device." (*Id.* at 23.) When the Secure Enclave, or more precisely the Touch ID or Face ID subsystem within the Secure Enclave, has determined that a match exists, an accessibility attribute is issued by the corresponding

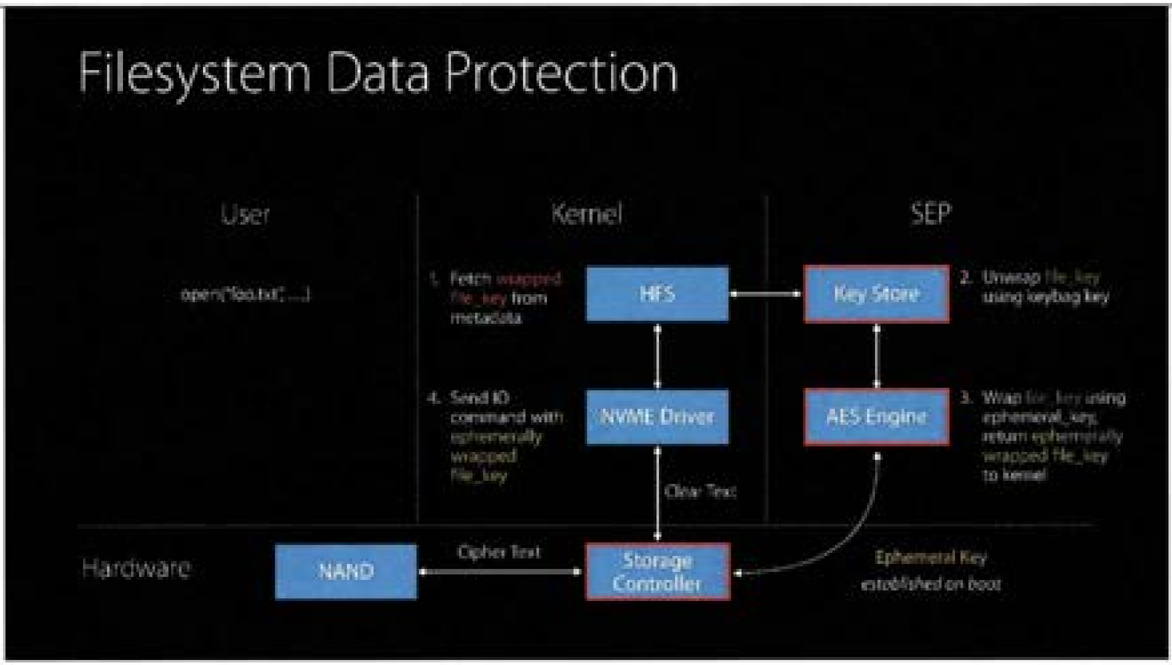
Claim 11	**Accused Instrumentalities**
	Touch ID or Face ID subsystem. This Touch ID or Face ID subsystem is also referred to as the SBIO. The accessibility attribute confirms that there is a match and that the iPhone is to be unlocked ("... determine whether to unlock the device ..."). This confirmation of the match is signaled by the SBIO by issuing a random secret to which only the Touch ID or Face ID subsystem within the Secure Enclave has access: "During matching, the Secure Enclave compares incoming data from the biometric sensor against the stored templates to determine whether to unlock the device [...]." (*Id.* at 19.) "Uses for Touch ID and Face ID **Unlocking a device or user account** [...] **keys for the highest class of Data Protection-which** are **held in the Secure Enclave** [...]. With Touch ID or Face ID enabled, the keys aren't discarded when the device or account locks; instead, **they're wrapped with a key that's given to the Touch ID or Face ID subsystem inside the Secure Enclave**. When a user attempts to unlock the device or account, **if the device detects a successful match, it provides the key for unwrapping the Data Protection keys**, and the device or account is unlocked. This process provides additional protection by requiring cooperation between the Data Protection and Touch ID or Face ID subsystems to unlock the device." (*Id.* at 24.) "The class key is protected with the hardware UID and, for some classes, the user's passcode." (*Id.* at 85.) **"Complete Protection** *(NSFileProtectionComplete):* The class key is protected with a key derived from the user passcode or password and the device UID. Shortly after the user locks a device (10 seconds, if the Require

Claim 11	**Accused Instrumentalities**
	Password setting is Immediately), the decrypted class key is discarded, **rendering all data in this class inaccessible until the user** enters the passcode again or **unlocks** (logs in to) **the device using Touch ID or Face ID."** (*Id.* at 86.) The Touch ID or Face ID subsystem within the Secure Enclave is the SBIO shown below. SBIO is an application that runs within the Secure Enclave on the SEP and is responsible for checking the match of biometric features. SBIO receives the corresponding biometric data from a biometric sensor, such as the Touch ID sensor. The random secret is stored in a memory ("bio memory") associated with the SBIO and is output from the bio memory upon match, see step 3 in the diagram below ("3) upon sucessful match send random secret to SKS"):  Userspace UserEventAgent Darwin lock/unlock notifications SpringBoard MobileKeyBag.framework 1) pressing home button starts Touch ID sensor 7) send unlock notification XNU (Kernel) AppleKeyStore SEP endpoint to SKS AppleMesa SEP endpoint to SBIO 4) decrypt master key random secret master key SKS SBIO Touch ID Sensor bio memory random secret 2) template match sent to SBIO SEP master key SKS memory master key ⊕ SEP UID class A class B (priv) class C SKS keyring class A class B (priv) class B (public) class C class D 3) upon successful match send random secret to SKS 6) securely destroy master key 5) decrypt class keys, add to keyring Touch ID unlock (Ex. B, Behind the Scenes with iOS Security, at 34.)

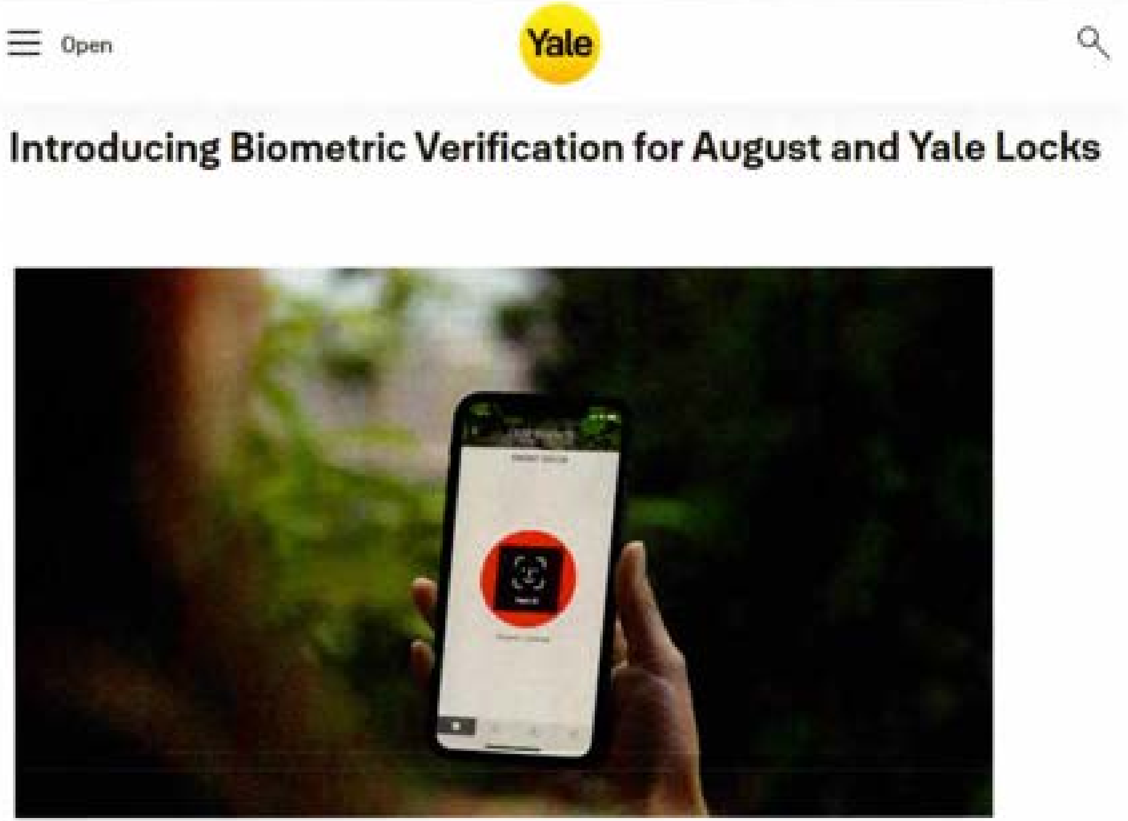
Claim 11	Accused Instrumentalities
	The class keys are encrypted with a master key:  User Keybags Background Sets of keys generated for each user to protect their data at rest Keys wrapped by master key derived from user passcode and SEP UID After 10 incorrect passcode entries, SEP will not process any further attempts Different policy associated with each keybag key—Usage, availability (*Id.*, at 25.) The random secret is issued to SKS. SKS is a Secure Key Service application which is located within the Secure Enclave on the SEP and is responsible for decrypting class keys. The random secret provided by SBIO is used to decrypt a master key ("4) decrypt master key"). The master key is concatenated with the UID of the SEP and thus class keys are decrypted and added to the SKS keyring ("5) decrypt class keys, add to keyring") for further use by the Secure Enclave. The decrypted class keys include, for example, the class key of class A.
11d. emitting a secure access signal conveying information dependent upon said accessibility attribute; and	***The Accused Instrumentalities include a transmitter configured to emit a secure access signal conveying information dependent upon said accessibility attribute.*** For example, the Secure Enclave emits a signal with ephemerally re-encrypted file keys:

Claim 11	**Accused Instrumentalities**
	“sepOS can then use the ephemeral wrapping key to wrap file keys for use by the Application Processor file-system driver. When the file-system driver reads or writes a file, it sends the wrapped key to the AES Engine.” (Ex. A, Apple Platform Security, at 14.) "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. [...] When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and sent back to the Application Processor." (*Id.* at 85.) The signal with the ephemerally re-encrypted file keys is a secure signal because it comes from the Secure Enclave and thus from a secure environment. Furthermore, the signal is secure because the transmitted information is encrypted. The emitted file keys are encrypted with the ephemeral key: "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. At startup, the Secure Enclave negotiates an ephemeral key with the AES Engine. When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and sent back to the Application Processor." (*Id.*)

<u>**Claim 11**</u>	<u>**Accused Instrumentalities**</u>
	 Filesystem Data Protection Overview File blocks are encrypted using AES-XTS with 128-bit keys Each file on the user partition is encrypted using a unique random key chosen by SEP Raw file keys are never exposed to the AP • Wrapped with a key from the user keybag for long-term storage • Wrapped with an ephemeral key while in use, bound to boot session (Ex. B, Behind the Scenes with iOS Security, at 29.)

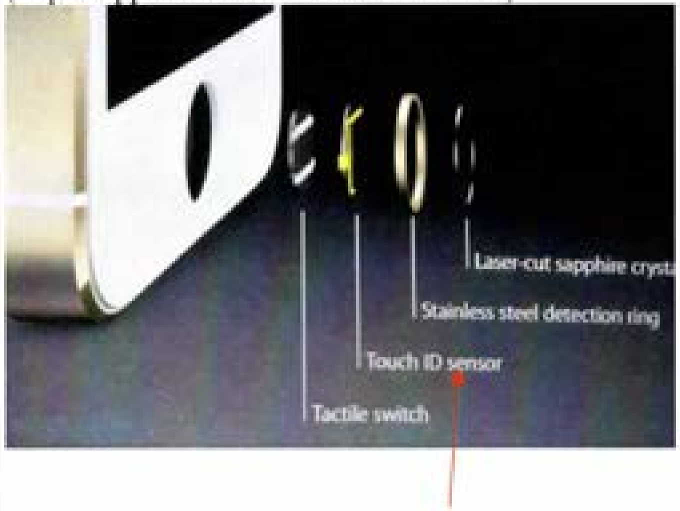
Claim 11	**Accused Instrumentalities**
	 Filesystem Data Protection User Kernel SEP open("foo.txt", ...) 1. Fetch wrapped file_key from metadata HFS Key Store 2. Unwrap file_key using keybag key 4. Send IO command with ephemerally wrapped file_key NVME Driver AES Engine 3. Wrap file_key using ephemeral_key, return ephemerally wrapped file_key to kernel Clear Text Hardware NAND Cipher Text Storage Controller Ephemeral Key established on boot (*Id.*, at 30.) The information transmitted by the emitted signal, i.e., the ephemerally re-encrypted file keys, is dependent on the availability attribute, i.e., the confirmation that a biometric "template match" exists. This confirmation is signaled by the issuance of the random secret (cf. step 3): Only if there is a confirmation of the match and the random secret is issued by the Touch ID or Face ID subsystem within the Secure Enclave, i.e. SBIO, the class key is available for re-encrypting the file keys. The re-encrypted file keys are therefore information which is emitted depending on the fact that the availability attribute has been emitted.

<u>Claim 11</u>	<u>Accused Instrumentalities</u>
11e. providing conditional access to the controlled item dependent upon said information, wherein the controlled item is one of: a locking mechanism of a physical access structure or an electronic lock on an electronic computing device.	***The Accused Instrumentalities are configured to provide conditional access to the controlled item dependent upon said information, wherein the controlled item is one of: a locking mechanism of a physical access structure or an electronic lock on an electronic computing device*** More specifically, the controlled item is a locking mechanism of the door lock of the user's home. The Accused Instrumentalities are configured to provide secure access to the user's home via Yale Smart Locks when the user provides biometric signal to the Accused Instrumentalities via Touch ID or Face ID. "When the "Secure Remote Access" feature is turned on, the app will use your phone's built-in authentication tools to prompt fingerprint or facial recognition before you can unlock or lock your home remotely (note: if your phone does not have these features, it will prompt you to use your PIN code). This further ensures that your door is only operated by the right people at the time you intend for it." (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

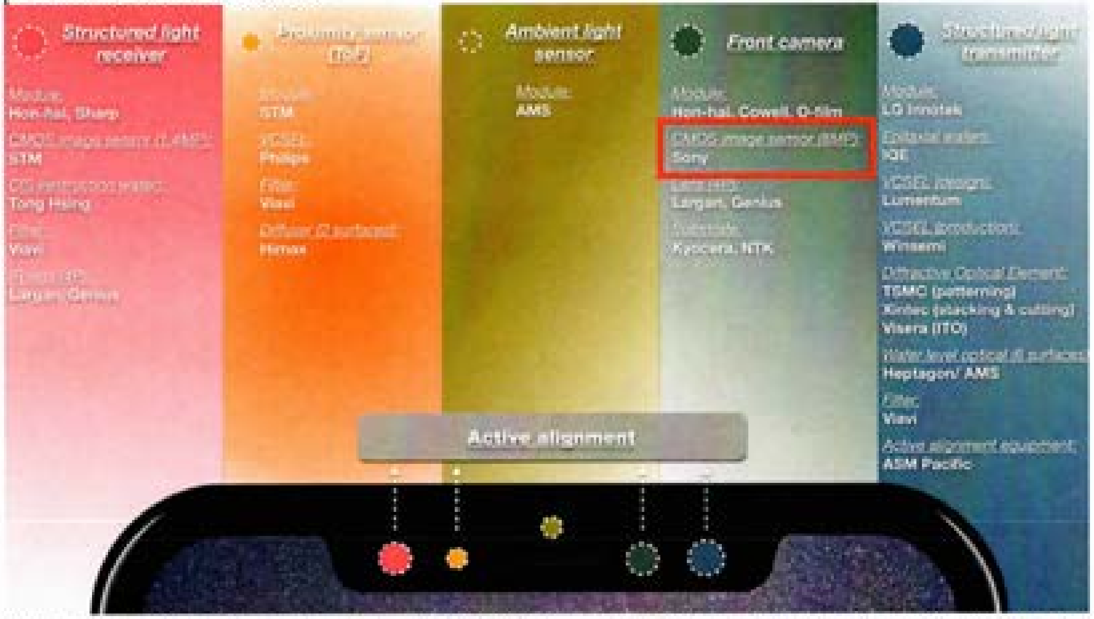
Claim 11	Accused Instrumentalities
	 Introducing Biometric Verification for August and Yale Locks (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

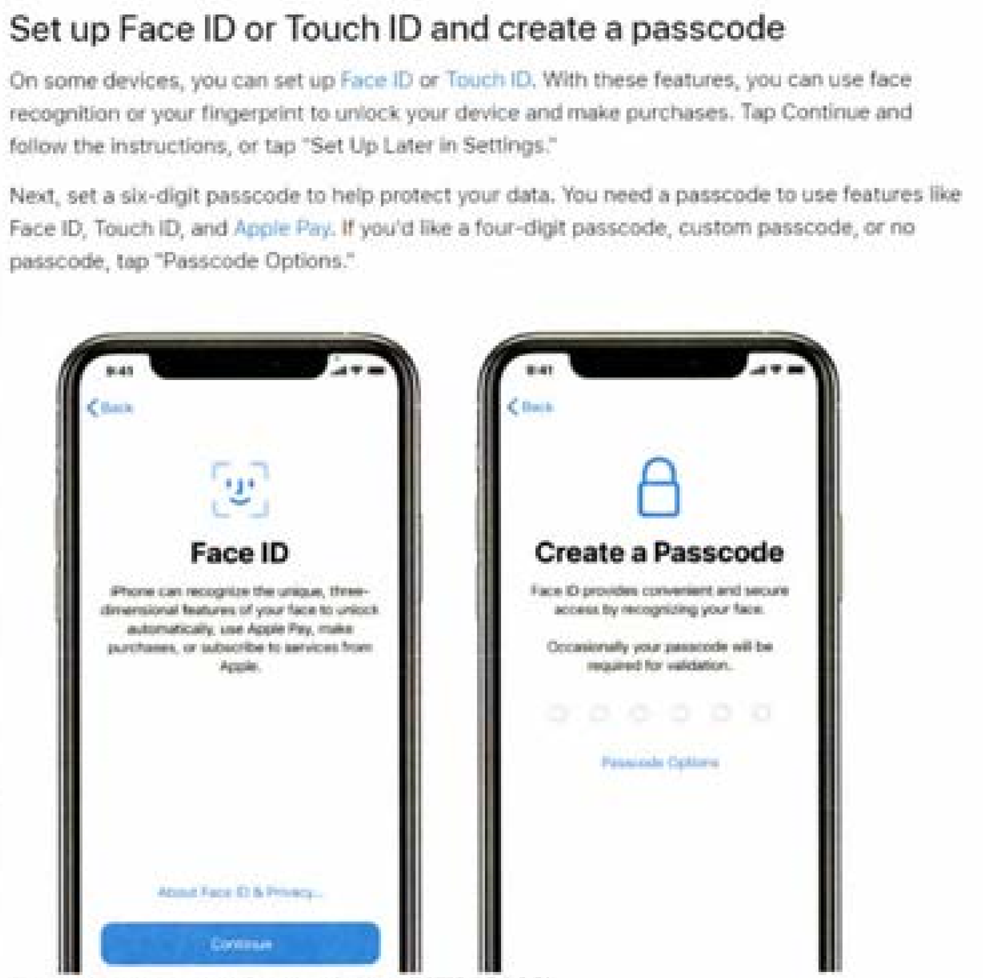
Claim 11	Accused Instrumentalities
	 (https://www.apple.com/shop/product/HPAR2ZM/A/yale-assure-lock-sl-touchscreen-deadbolt-black)

<u>**Claim 12**</u>	<u>**Accused Instrumentalities**</u>
12. The method according to claim 11, wherein populating the database of biometric signatures further comprises enrolling a biometric signature into the database of biometric signatures, and wherein enrolling the biometric signature into the database comprises:	***The Accused Instrumentalities are configured to enroll a biometric signature into the database of biometric signatures as set forth in elements 12a and 12b below.***
12a. receiving a biometric signal; and	***The Accused Instrumentalities include a biometric sensor configured to receive the biometric signal.*** More specifically, the iPhone has at least one biometric sensor for capturing a fingerprint or a face (Touch ID and/or Face ID), namely a Touch ID sensor and a camera system with image sensor, respectively. **Touch ID** "Apple devices with a Touch ID sensor can be unlocked using a fingerprint." (Ex. A, Apple Platform Security, at 19.) "Touch ID is the fingerprint sensing system that makes secure access to supported Apple devices faster and easier. This technology reads fingerprint data from any angle and learns more about a user's fingerprint over time, with the **sensor** continuing to expand the fingerprint map as additional overlapping nodes are identified with each use." (*Id.*) "When the fingerprint sensor detects the touch of a finger, it triggers the advanced imaging array to scan the finger and sends the scan to the Secure Enclave."

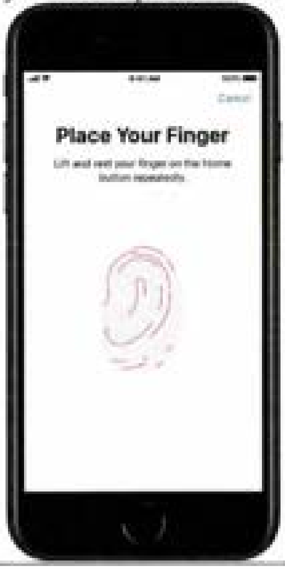
Claim 12	Accused Instrumentalities
	(*Id.*) The biometric sensor for Touch ID is located below the home button: "The Home button is a stack of different materials, capped with a sapphire crystal lens. The surrounding stainless-steel ring works as a ground and detects the user's finger. This action activates a capacitive touch sensor installed underneath the cover: A CMOS chip with small capacitors." (https://appleinsider.com/inside/touch-id)  Laser-cut sapphire crysta Stainless steel detection ring Touch ID sensor Tactile switch Biometric sensor 121 "Where is the Touch ID sensor located? The Touch ID sensor is located either in the home button or - on the iPad Air (4th generation) - in the top button. (https://support.apple.com/en-us/HT201371)

Claim 12	Accused Instrumentalities
	The image sensor captures an 88-by-88-pixel, 500 PPI raster scan: "The 88-by-88-pixel, 500-ppi raster scan is temporarily stored in encrypted memory within the Secure Enclave while being vectorized for analysis, and then it's discarded. The analysis utilizes subdermal ridge flow angle mapping, which is a lossy process that discards minutia data that would be required to reconstruct the user's actual fingerprint. The resulting map of nodes is stored without any identity information in an encrypted format that can only be read by the Secure Enclave, and is never sent to Apple or backed up to iCloud or iTunes. " (Ex. C, iOS Security white paper, at 8.) **Face ID** The biometric sensor for facial biometrics is a camera system ("TrueDepth camera system") with an image sensor. "With a simple glance, Face ID securely unlocks supported Apple devices. It provides intuitive and secure authentication enabled by the TrueDepth camera system, which uses advanced technologies to accurately map the geometry of a user's face. " (Ex. A, Apple Platform Security, at 20.) To receive a biometric signal, the camera system with image sensor reads over 30,000 infrared points to capture depth information along with a two-dimensional infrared image. "After the TrueDepth camera confirms the presence of an attentive face, it projects and **reads over 30,000 infrared dots to form a depth map of the face along with a 2D infrared image**. This data is used to **create a sequence of 2D images and depth maps**, which are digitally signed and sent to the Secure Enclave. To counter both digital and physical spoofs, the TrueDepth camera randomizes the sequence of 2D images and depth map captures, and projects a device-specific random pattern. A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a

Claim 12	Accused Instrumentalities
	mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (*Id.*, at 20.) The camera system includes a biometric image sensor, namely a "CMOS image" sensor from Sony, to perform facial biometrics:  Structured light receiver Module: Hon-hai, Sharp CMOS image sensor (1.4MP): STM Tong Hsing Filter: Viavi Largan, Genius Proximity sensor (ToF) Module: STM VCSEL: Philips Filter: Viavi Diffuser (2 surfaces): Himax Ambient light sensor Module: AMS Front camera Module: Hon-hai, Cowell, O-film CMOS image sensor (8MP): Sony Largan, Genius Substrate: Kyocera, NTK Structured light transmitter Module: LG Innotek Epitaxial wafers: IQE VCSEL designs: Lumentum VCSEL production: Winsemi Diffractive Optical Element: TSMC (patterning) Xintec (stacking & cutting) Visera (ITO) Heptagon/ AMS Filter: Viavi Active alignment equipment: ASM Pacific Active alignment (https://appleinsider.com/articles/17/09/09/inner-workings-of-apples-face-id-camera-detailed-in-report)
12b. enrolling the biometric signal as an administrator signature in response to the database of	***The Accused instrumentalities are configured to enroll the biometric signal as an administrator signature in response to the database of biometric signatures being empty.*** More specifically, upon information and belief, the iPhone allows the users to enroll their biometric signature as an administrator when the user is setting up their first iOS device. The biometric

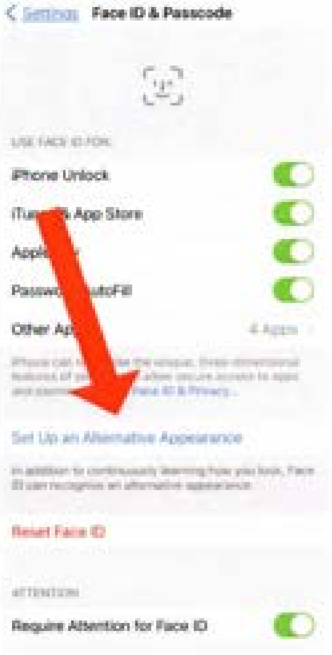
Claim 12	Accused Instrumentalities
biometric signatures being empty.	signature enrolled upon the initial set up of the iOS device will be required to add additional fingerprints or faces on the device.  **Set up Face ID or Touch ID and create a passcode** On some devices, you can set up Face ID or Touch ID. With these features, you can use face recognition or your fingerprint to unlock your device and make purchases. Tap Continue and follow the instructions, or tap "Set Up Later in Settings." Next, set a six-digit passcode to help protect your data. You need a passcode to use features like Face ID, Touch ID, and Apple Pay. If you'd like a four-digit passcode, custom passcode, or no passcode, tap "Passcode Options." **Face ID** iPhone can recognize the unique, three-dimensional features of your face to unlock automatically, use Apple Pay, make purchases, or subscribe to services from Apple. **Create a Passcode** Face ID provides convenient and secure access by recognizing your face. Occasionally your passcode will be required for validation. 9:41 Back About Face ID & Privacy... Continue 9:41 Back Passcode Options (https://support.apple.com/en-us/HT202033)

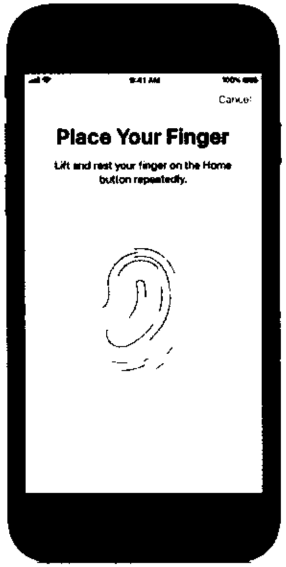
Claim 14	**Accused Instrumentalities**
14. A non-transitory computer readable storage medium storing a computer program comprising instructions, which when executed by processors causes the processors to:	***The Accused Instrumentalities are non-transitory computer readable storage medium storing a computer program comprising instructions as set forth below.***
14a. receive a series of entries of a biometric signal;	***The Accused Instrumentalities include a transmitter sub-system controller configured to receive a series of entries of the biometric signal.*** More specifically, the Secure Enclave of the iPhone with the Secure Enclave Processor forms the means for receiving a series of entries of the biometric signal. "Apple's biometric security architecture relies on a strict separation of responsibilities between the biometric sensor and the Secure Enclave, and a secure connection between the two. The sensor captures the biometric image and securely transmits it to the Secure Enclave." (Ex. A, Apple Platform Security, at 19.) **Touch ID** When a finger is placed on the biometric sensor, the finger is scanned and the corresponding biometric signal entry is received by the Secure Enclave. "When the fingerprint sensor detects the touch of a finger, it triggers the advanced imaging array to scan the finger and sends the scan to the Secure Enclave." (*Id.*) To enroll a fingerprint in the database, the iPhone's fingerprint sensor records an entry of a biometric signal when the user places his finger on the sensor. This is done multiple times, resulting in a series of entries of such biometric signals.

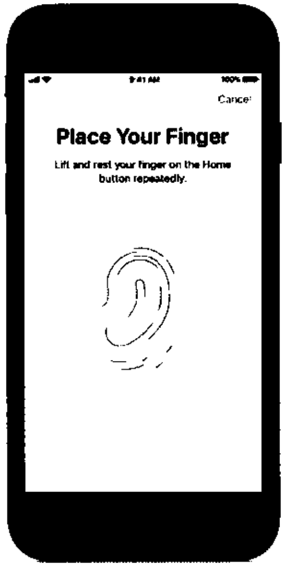
Claim 14	Accused Instrumentalities
	Receiving a series of entries of the biometric signal by repeatedly placing a finger on the Touch ID sensor will use Touch ID on iPhone. **Set up Touch ID** Before you can set up Touch ID, you must first create a code for your device,* then follow these steps: 13. Make sure the Touch ID sensor and your finger are clean and dry. 14. Tap Settings > Touch ID & Code, and then enter your code. 15. Tap "Add fingerprint" and hold the device as you normally would when touching the Touch ID sensor. 16. Touch the Touch ID sensor with one finger, but do not press. Keep your finger on the button until you feel a quick vibration or are prompted to lift your finger.  Place Your Finger Lift and rest your finger on the home button repeatedly.

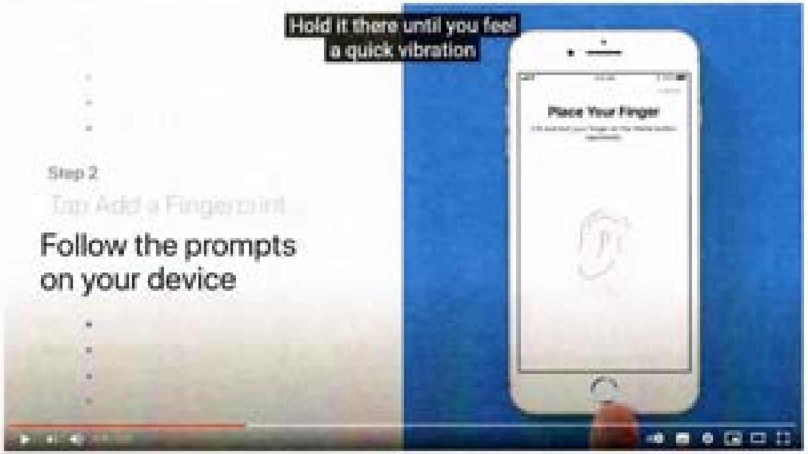
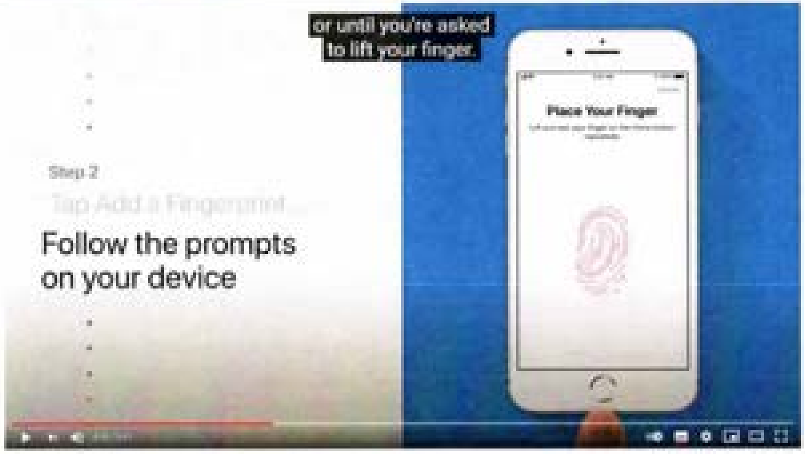
Claim 14	**Accused Instrumentalities**
	17. Continue by raising and slowly lowering your finger over and over again, changing the position of your finger just a tiny bit at a time. 18. The next screen will ask you to change your finger position. Hold your device as you normally would when unlocking it. Touch the Touch ID sensor with the outer edges of your fingertip instead of the middle part as you would during the first scan." (https://support.apple.com/en-us/HT201371) Accordingly, the user is prompted to place his finger on the sensor several times, in particular in accordance with step 5. Each time the finger is placed on the sensor, a corresponding biometric entry is generated, i.e. a series of such entries. All these entries, which result from placing the same finger on the sensor, form a series. **Face ID** The means for receiving a series of entries of the biometric signal includes a Secure Neural Engine, which is protected by the Secure Enclave. The Secure Neural Engine transforms the series of entries of the biometric signal received by the Secure Enclave into a biometric signature ("mathematical representation"). "After the TrueDepth camera confirms the presence of an attentive face, it projects and reads over 30,000 infrared dots to form a depth map of the face along with a 2D infrared image. This data is used to create **a sequence of 2D images and depth maps**, which are digitally signed and **sent to the Secure Enclave**. To counter both digital and physical spoofs, the TrueDepth camera randomizes the sequence of 2D images and depth map captures, and projects a device-specific random pattern. A portion of the **Secure Neural Engine-protected** within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (Ex. A, Apple Platform Security, at 20.)

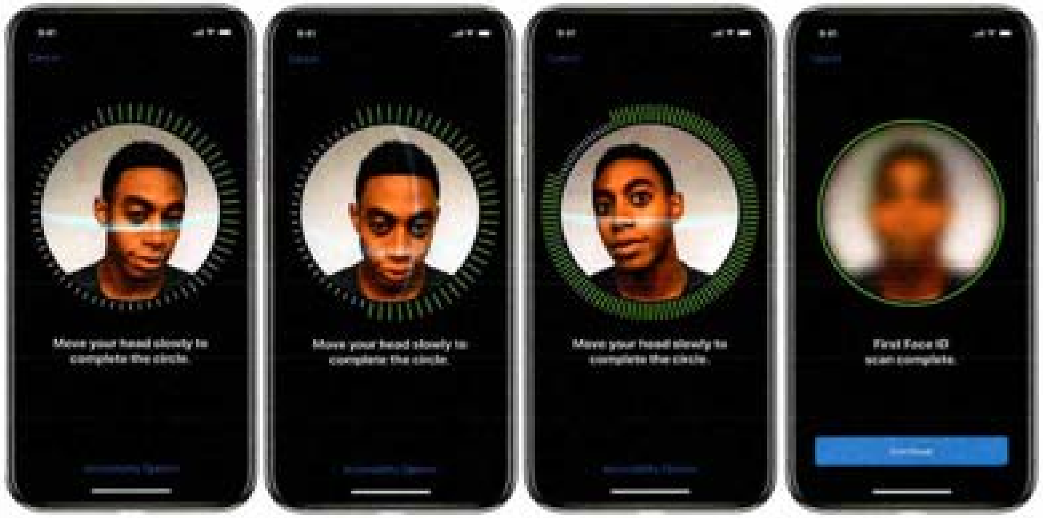
Claim 14	**Accused Instrumentalities**
	Each entry of the biometric signal thus contains a two-dimensional infrared image with 30,000 infrared points for capturing depth information. By continuously capturing such infrared images into a Face ID scan while the user moves his head into different poses, a series of entries of the biometric signal results. Two such Face ID scans are required to generate a biometric signature of a single face, so that two series of entries of the biometric signal are received accordingly. Using Face ID on iPhone 1. Tap Settings > Face ID & Code. Enter your code when prompted. 2. Tap on "Configure Face ID". 3. Hold the device in portrait mode in front of your face and tap "Let's go". 4. Make sure your face is inside the frame and slowly move your head until the circle shown is completed. If you can't move your head, tap on "Options for operating aids". 5. After performing the first Face ID scan, tap "Next". 6. Again, slowly describe a circle with your head until it is completed. 7. Tap "Done." (https://support.apple.com/en-us/HT208109) The biometric signature of a single face is thus determined by two successive Face ID scans, each of which receives a series of entries of the biometric signal (compare steps 4. and 6. above). To register a second face, the iPhone offers a corresponding option in its settings. If the user selects the option "Set up an alternative appearance" as shown in the figure below on https://www.macworld.co.uk/how-to/second-face-id-3803421/, a second face is registered by the iPhone in the same way as the first face.

Claim 14	Accused Instrumentalities
	 Settings Face ID & Passcode USE FACE ID FOR: iPhone Unlock iTu[illegible] App Store Appl[illegible] Passw[illegible]utoFill Other Ap[illegible] 4 Apps iPhone can [illegible] the unique, three-dimensional features of [illegible] allow secure access to apps and paym[illegible] Face ID & Privacy... Set Up an Alternative Appearance In addition to continuously learning how you look, Face ID can recognise an alternative appearance. Reset Face ID ATTENTION Require Attention for Face ID The series of entries of the biometric signal is identified on the iPhone by both the number and duration of each such entry. **Touch ID** According to step 5 of the instructions https://support.apple.com/en-us/HT201371, for the enrollment of a single finger, the user has to repeatedly place the respective finger on the sensor and thus a number of entries in a row predetermined via the user guidance are captured by the iPhone. Each one of the entries must also be of a predetermined duration given to the user via the iPhone display, i.e. the user's finger must remain on the sensor for a predetermined duration for each entry of the biometric signal in order to capture the biometric signal during this time.

Claim 14	Accused Instrumentalities
	Receiving a series of entries of the biometric signal by repeatedly placing a finger on the Touch ID sensor will use Touch ID on iPhone and iPad. **Set up Touch ID** … 4. Touch the Touch ID sensor with one finger, but do not press. Keep your finger on the button until you feel a quick vibration or are prompted to lift your finger.  9:41 AM 100% Cancel Place Your Finger Lift and rest your finger on the Home button repeatedly. 5. Continue by raising and slowly lowering your finger over and over again, changing the position of your finger just a tiny bit at a time. 6. The next screen will ask you to change your finger position. Hold your device as you normally would when unlocking it. Touch the Touch ID sensor with the outer edges of your fingertip instead of the middle part as you did during the first scan. (https://support.apple.com/en-us/HT201371)

Claim 14	**Accused Instrumentalities**
	After placing a finger on the home button, a fingerprint appears on the display with red progress bars spreading along some of the papillary bars until the capture of the biometric entry in question is complete:  9:41 AM 100% Cancel Place Your Finger Lift and rest your finger on the Home button repeatedly. When the required duration is reached, the iPhone vibrates after an entry of the biometric signal is received or it issues a prompt to the user to lift the finger. The user then lifts the finger in question and replaces the same finger so that the iPhone receives a series of biometric signal entries of sufficient duration for that finger. The process is repeated for the same finger for as long as required according to the iPhone's user guidance. This is shown in the Apple You Tube video (32) How to set up Touch ID on your iPhone or iPad - Apple Support - YouTube (https://www.youtube.com/watch?v=xTZ2LALWZlg):

Claim 14	Accused Instrumentalities
	 Hold it there until you feel a quick vibration Step 2 Tap Add a Fingerprint... Follow the prompts on your device Place Your Finger  or until you're asked to lift your finger. Step 2 Tap Add a Fingerprint... Follow the prompts on your device Place Your Finger Both the number of entries, i.e. the number of repetitions for placing the finger on the screen, and their respective duration are specified by the iPhone via the user guidance.

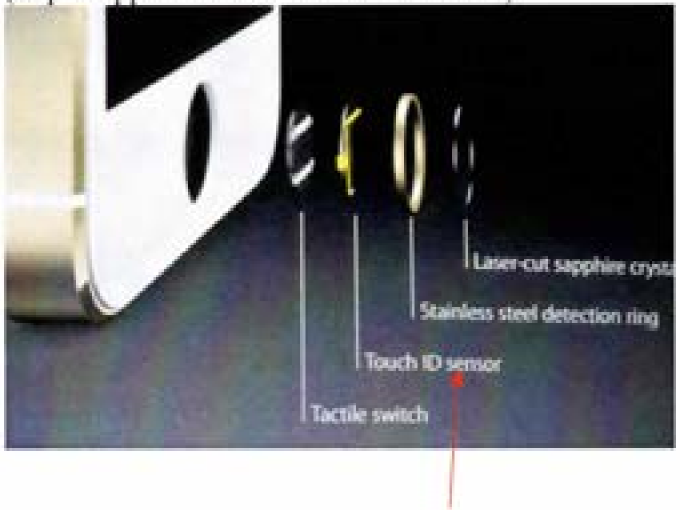
Claim 14	Accused Instrumentalities
	Face ID The user moves his face in front of the camera to strike different poses, and the camera system with image sensor continuously captures a large number of biometric entries, i.e. here the 2D images with depth information, in a row. "This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (Ex. A, Apple Platform Security, at 20.) The sufficient duration of an entry for a pose, i.e. an angular position of the head specified via the user interface of the iPhone, is indicated to the user by the transformation of a gray line into a green line:  Move your head slowly to complete the circle. Move your head slowly to complete the circle. Move your head slowly to complete the circle. First Face ID scan complete. (Individual images taken from: https://support.apple.com/en-us/HT208109)
14b. determine at least one of a number of said entries	***The Accused instrumentalities are configured to populate the database of biometric signatures by: determining at least one of the number of said entries and a duration of each said entry.***

Claim 14	**Accused Instrumentalities**
and a duration of each of said entries;	More specifically, as discussed above, both Face ID and Touch ID require a specific number of entries to enroll a Touch ID or Face ID. The Accused Instrumentalities must determine that the specific number of entries have been input. Likewise, while not necessary for the claim, upon information and belief, the Accused Instrumentalities determine that each input of either facial or fingerprint data is of a sufficient duration. Again, when setting up Touch ID in the Accused Instrumentalities, the users are required to touch the home button with their finger several times for a certain duration. Similarly, the users need to scan their face twice, and each scan requires the users to move their head in a circle for a certain duration for Face ID. Touch ID: Register a fingerprint for Apple Touch ID by the user tapping a finger several times on the home button to record the fingerprint data. (https://video.search.yahoo.com/yhs/search?fr=yhs-pty-pty_ converter&hsimp=yhs-pty_converter&hspart=pty&p=registering+ fingerprint+apple+touch+id+on+screen+instructions#id=1&vid= 156de65ae06ca453643009fc0ea9cf79&action=click) Touch ID: The user's finger must remain on the home button long enough for the data to be recorded. "Touch the Touch ID sensor with your finger, but don't press it. Hold it there until you feel a quick vibration, or until you're asked to lift your finger." "Continue to lift and rest your finger slowly, making small adjustments to the position of your finger each time." (https://support.apple.com/en-au/HT201371) Touch ID: "you shouldn't tap too quickly or move your finger around" (https://support.apple.com/en-us/HT207537) Face ID: Setting up Face ID requires two scans of the user's face. Each scan asks users to move their head slowly in a circle to register different angles of the user's face. (https://www.imore.com/how-set-face-id-iphone)
14c. map said series into an instruction;	***The Accused Instrumentalities include a transmitter sub-system controller configured to map said series into an instruction.***

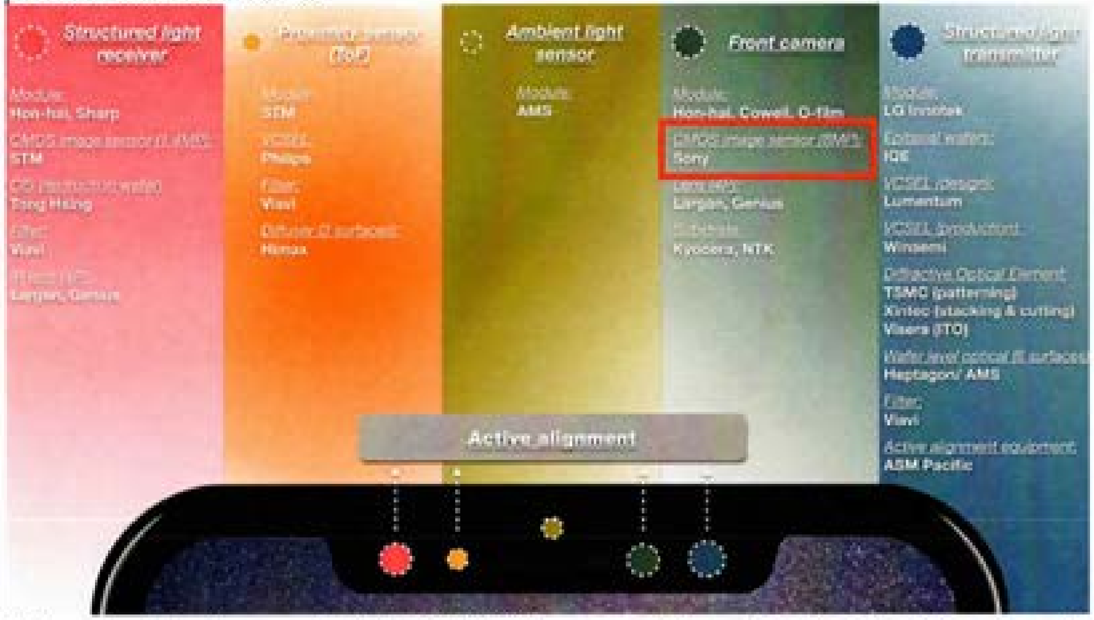
Claim 14	**Accused Instrumentalities**
	More specifically, the Secure Enclave of the iPhone contains means to assign the received row to an instruction: The Secure Enclave, after receiving the full set of entries of the biometric signal, assigns this set to an instruction for processing, encrypting and storing the biometric signature ("Touch ID and Face ID template data"). "The sensor captures the biometric image and securely transmits it to the Secure Enclave. During enrollment, the Secure Enclave processes, encrypts, and stores the corresponding Touch ID and Face ID template data." (Ex. A, Apple Platform Security, at 19.) To carry out this instruction, the Secure Enclave has its own processor: "The Secure Enclave Processor provides the main computing power for the Secure Enclave." (*Id.*, at 10.) **Touch ID** The instruction here involves the processing of under-the-skin fingerprint characteristics and their encrypted storage. "The analysis uses subdermal ridge flow angle mapping, a lossy process that discards "finger minutiae data" that would be required to reconstruct the user's actual fingerprint. During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches, but without any identity information." (*Id.*, at 19.) **Face ID** The instruction involves the transformation of the set of entries of the biometric signal captured via the Face ID scans into a mathematical representation, i.e. the biometric signature of the face in question by the Secure Neural Engine of the Secure Enclave, as well as its encryption and storage.

Claim 14	**Accused Instrumentalities**
	"A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses. " (*Id.*, at 20.) "Face ID data, including mathematical representations of a user's face, is encrypted and available only to the Secure Enclave. This data never leaves the device. It's not sent to Apple, nor is it included in device backups. The following Face ID data is saved, encrypted only for use by the Secure Enclave, during normal operation: • The mathematical representations of a user's face calculated during enrollment • …" (*Id.*, at 23.)
14d. populate a database of biometric signatures according to the instruction;	***The Accused Instrumentalities include a transmitter sub-system controller configured to populate the database according to the instruction.*** More specifically, the Secure Enclave stores the biometric signature, i.e. the encrypted mathematical representation of the fingerprint or face, in the database 105, i.e. the "secure nonvolatile storage": "The secure nonvolatile storage is used for all anti-replay services in the Secure Enclave. Anti-replay services on the Secure Enclave are used for revocation of data over events that mark anti-replay boundaries including, but not limited to, the following: • … • … • Adding or removing a Touch ID fingerprint or Face ID face". (Ex. A, Apple Platform Security, at 16.) "During enrollment, the Secure Enclave processes, encrypts, and stores the corresponding Touch ID and Face ID template data." (*Id.*, at 19.)

Claim 14	**Accused Instrumentalities**
	Touch ID "During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches...." (*Id.*) **Face ID** The following Face ID data is saved, encrypted only for use by the Secure Enclave, during normal operation: • The mathematical representations of a user's face calculated during enrollment". (*Id.*, at 23.)
14e. receive the biometric signal;	***The Accused Instrumentalities include a biometric sensor configured to receive the biometric signal.*** More specifically, the iPhone has at least one biometric sensor for capturing a fingerprint or a face (Touch ID and/or Face ID), namely a Touch ID sensor and a camera system with image sensor, respectively. **Touch ID** "Apple devices with a Touch ID sensor can be unlocked using a fingerprint." (Ex. A, Apple Platform Security, at 19.) "Touch ID is the fingerprint sensing system that makes secure access to supported Apple devices faster and easier. This technology reads fingerprint data from any angle and learns more about a user's fingerprint over time, with the **sensor** continuing to expand the fingerprint map as additional overlapping nodes are identified with each use." (*Id.*) "When the fingerprint sensor detects the touch of a finger, it triggers the advanced imaging array to scan the finger and sends the scan to the Secure Enclave."

Claim 14	Accused Instrumentalities
	(*Id.*) The biometric sensor for Touch ID is located below the home button: "The Home button is a stack of different materials, capped with a sapphire crystal lens. The surrounding stainless-steel ring works as a ground and detects the user's finger. This action activates a capacitive touch sensor installed underneath the cover: A CMOS chip with small capacitors." (https://appleinsider.com/inside/touch-id)  Laser-cut sapphire crysta Stainless steel detection ring Touch ID sensor Tactile switch Biometric sensor 121 "Where is the Touch ID sensor located? The Touch ID sensor is located either in the home button or - on the iPad Air (4th generation) - in the top button. (https://support.apple.com/en-us/HT201371)

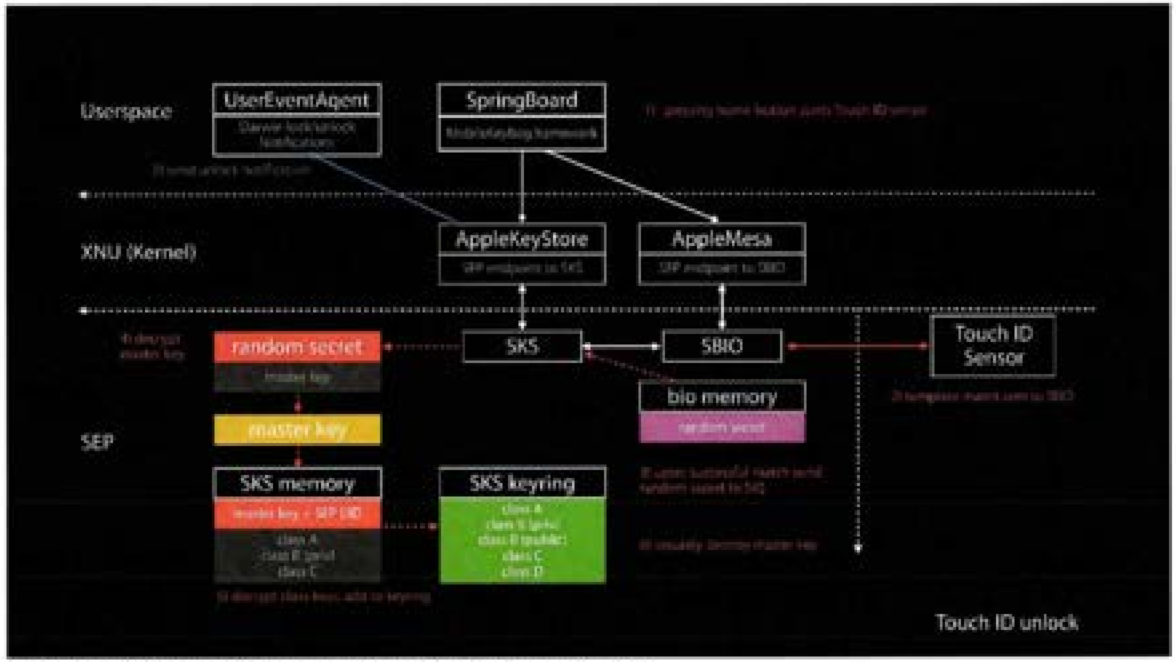
Claim 14	**Accused Instrumentalities**
	The image sensor captures an 88-by-88-pixel, 500 PPI raster scan: "The 88-by-88-pixel, 500-ppi raster scan is temporarily stored in encrypted memory within the Secure Enclave while being vectorized for analysis, and then it's discarded. The analysis utilizes subdermal ridge flow angle mapping, which is a lossy process that discards minutia data that would be required to reconstruct the user's actual fingerprint. The resulting map of nodes is stored without any identity information in an encrypted format that can only be read by the Secure Enclave, and is never sent to Apple or backed up to iCloud or iTunes. " (Ex. C, iOS Security white paper, at 8.) **Face ID** The biometric sensor for facial biometrics is a camera system ("TrueDepth camera system") with an image sensor. "With a simple glance, Face ID securely unlocks supported Apple devices. It provides intuitive and secure authentication enabled by the TrueDepth camera system, which uses advanced technologies to accurately map the geometry of a user's face. " (Ex. A, Apple Platform Security, at 20.) To receive a biometric signal, the camera system with image sensor reads over 30,000 infrared points to capture depth information along with a two-dimensional infrared image. "After the TrueDepth camera confirms the presence of an attentive face, it projects and **reads over 30,000 infrared dots to form a depth map of the face along with a 2D infrared image**. This data is used to **create a sequence of 2D images and depth maps**, which are digitally signed and sent to the Secure Enclave. To counter both digital and physical spoofs, the TrueDepth camera randomizes the sequence of 2D images and depth map captures, and projects a device-specific random pattern. A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a

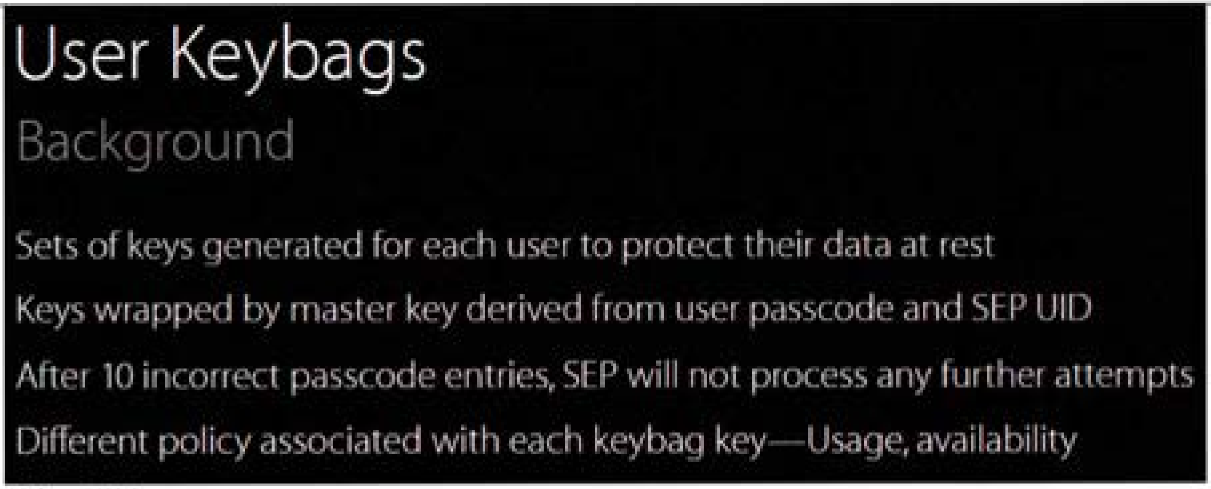
Claim 14	Accused Instrumentalities
	mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (*Id.*, at 20.) The camera system includes a biometric image sensor, namely a "CMOS image" sensor from Sony, to perform facial biometrics:  Structured light receiver Module: Hon-hai, Sharp CMOS image sensor (1.4MP): STM Tong Hsing Filter: Viavi Largan, Genius Proximity sensor (ToF) Module: STM VCSEL: Philips Filter: Viavi Diffuser (2 surfaces): Himax Ambient light sensor Module: AMS Front camera Module: Hon-hai, Cowell, O-film CMOS image sensor (8MP): Sony Largan, Genius Substrate: Kyocera, NTK Structured light transmitter Module: LG Innotek Epitaxial wafers: IQE VCSEL (design): Lumentum VCSEL (production): Win Semi Diffractive Optical Element: TSMC (patterning) Xintec (stacking & cutting) Visera (ITO) Wafer level optical (6 surfaces): Heptagon/ AMS Filter: Viavi Active alignment equipment: ASM Pacific Active alignment (https://appleinsider.com/articles/17/09/09/inner-workings-of-apples-face-id-camera-detailed-in-report)
14f. match the biometric signal against members of the database of biometric signatures to thereby	***The Accused Instrumentalities include a transmitter controller configured to emit a secure access signal conveying information dependent upon said accessibility attribute.***

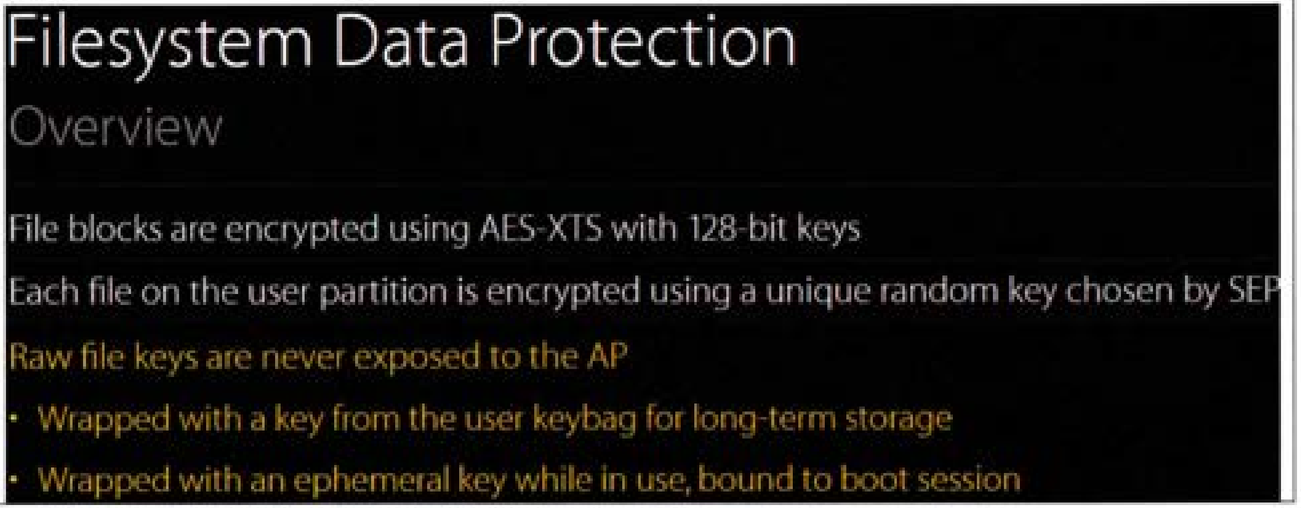
Claim 14	**Accused Instrumentalities**
output an accessibility attribute;	More specifically, the iPhone's System on Chip (SOC), i.e. the Secure Enclave with its Secure Enclave Processor (SEP) or a Secure Neural Engine contained therein, is a means (103) to check a match of the biometric signal with elements of the biometric signature database. "The *Secure Enclave* is a system on chip (SoC) that is included on all recent iPhone, ... devices" (Ex. A, Apple Platform Security, at 7.) "During **matching**, the Secure Enclave **compares** incoming data from the biometric sensor against the stored templates **to determine whether to unlock the device** or respond that a match is valid (for Apple Pay, in-app, and other uses of Touch ID and Face ID). " (*Id*., at 19.) The biometric signal received from the biometric sensor ("incoming data from the biometric sensor") is thus checked by the Secure Enclave and its SEP with the elements of the database of biometric signatures 105, i.e. the "stored templates", for the presence of a match. For Touch ID, the Secure Enclave match verification is performed as follows: "The Secure Enclave is responsible for processing fingerprint data from the Touch ID sensor, determining if there is a match against registered fingerprints, and then enabling access or purchases on behalf of the user ..." (Ex. C, iOS Security white paper, at 7.) "During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches...." (Ex. A, Apple Platform Security, at 19.) "Touch ID can read multiple fingerprints, and it can read fingerprints in 360-degrees of orientation. It then creates a mathematical representation of your fingerprint and compares this to your enrolled fingerprint data to identify a match and unlock your device. " (https://support.apple.com/en-us/HT204587)

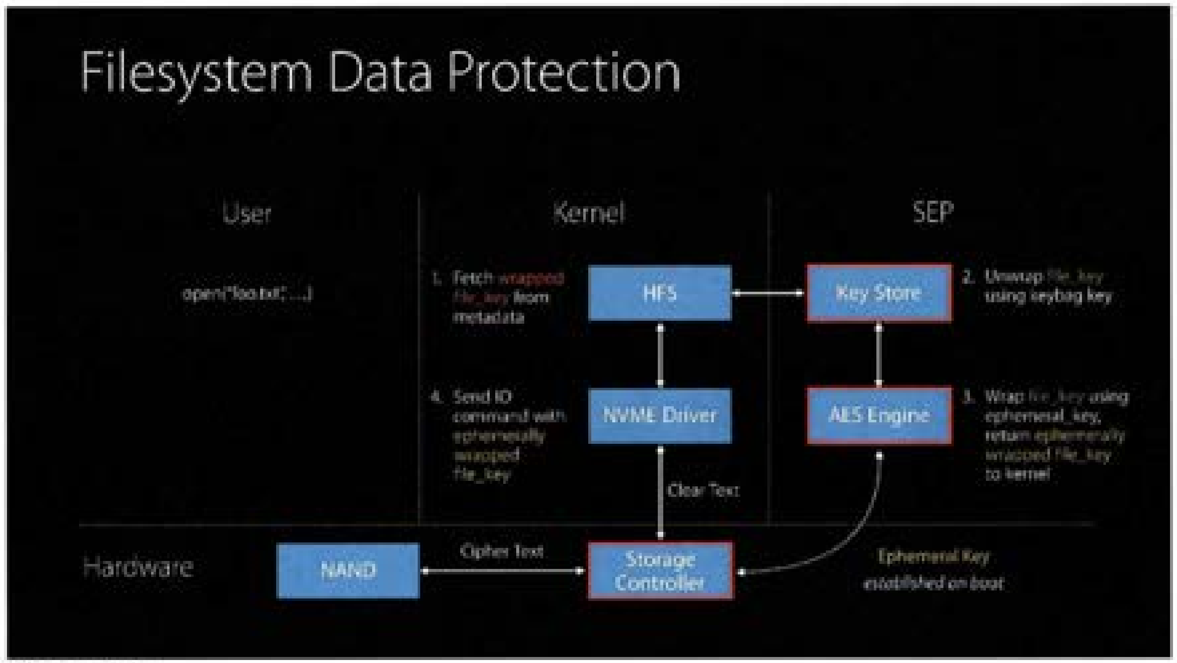
Claim 14	**Accused Instrumentalities**
	"Touch ID can read multiple fingerprints and recognize fingerprints at any orientation of the finger. The system then creates a mathematical representation of your fingerprint and compares it to the registered fingerprint data to determine a match and unlock your device." (https://support.apple.com/de-de/HT204587) For **Face ID,** the Secure Enclave has a neural network protected by it, i.e., a Secure Neural Engine, which is used to verify the match: "Face ID uses neural networks for determining attention, **matching**, and antispoofing, so a user can unlock their phone with a glance." (Ex. A, Apple Platform Security, at 20.) "A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (*Id.*). "Facial matching security Facial matching is performed within the Secure Enclave using neural networks trained specifically for that purpose... Face ID data, including mathematical representations of a user's face, is encrypted and available only to the Secure Enclave. This data never leaves the device." (*Id.* at 23.) When the Secure Enclave, or more precisely the Touch ID or Face ID subsystem within the Secure Enclave, has determined that a match exists, an accessibility attribute is issued by the corresponding Touch ID or Face ID subsystem. This Touch ID or Face ID subsystem is also referred to as the SBIO. The accessibility attribute confirms that there is a match and that the iPhone is to be unlocked ("... determine whether to unlock the device ...").

Claim 14	**Accused Instrumentalities**
	This confirmation of the match is signaled by the SBIO by issuing a random secret to which only the Touch ID or Face ID subsystem within the Secure Enclave has access: "During matching, the Secure Enclave compares incoming data from the biometric sensor against the stored templates to determine whether to unlock the device [...]." (*Id.* at 19.) "Uses for Touch ID and Face ID **Unlocking a device or user account** [...] **keys for the highest class of Data Protection-which** are **held in the Secure Enclave** [...]. With Touch ID or Face ID enabled, the keys aren't discarded when the device or account locks; instead, **they're wrapped with a key that's given to the Touch ID or Face ID subsystem inside the Secure Enclave**. When a user attempts to unlock the device or account, **if the device detects a successful match, it provides the key for unwrapping the Data Protection keys**, and the device or account is unlocked. This process provides additional protection by requiring cooperation between the Data Protection and Touch ID or Face ID subsystems to unlock the device." (*Id.* at 24.) "The class key is protected with the hardware UID and, for some classes, the user's passcode." (*Id.* at 85.) **"Complete Protection** *(NSFileProtectionComplete):* The class key is protected with a key derived from the user passcode or password and the device UID. Shortly after the user locks a device (10 seconds, if the Require Password setting is Immediately), the decrypted class key is discarded, **rendering all data in this class inaccessible until the user** enters the passcode again or **unlocks** (logs in to) **the device using Touch ID or Face ID."** (*Id.* at 86.)

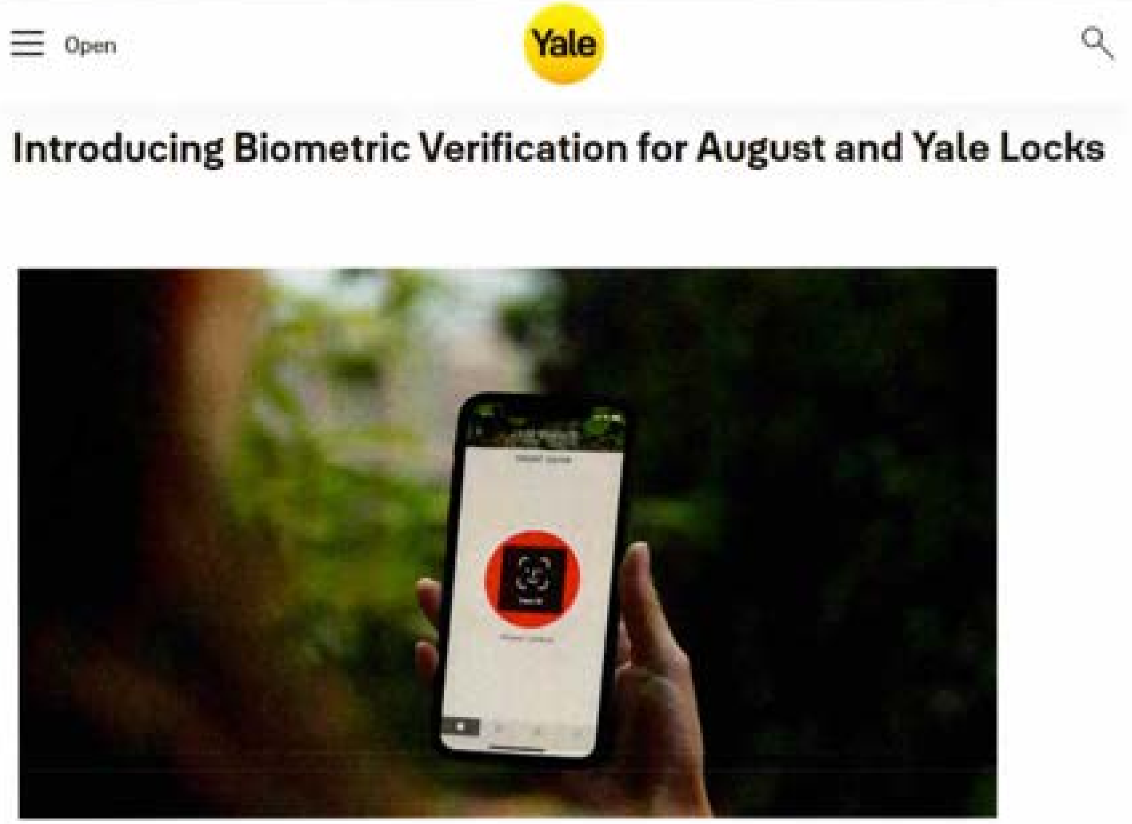
Claim 14	**Accused Instrumentalities**
	The Touch ID or Face ID subsystem within the Secure Enclave is the SBIO shown below. SBIO is an application that runs within the Secure Enclave on the SEP and is responsible for checking the match of biometric features. SBIO receives the corresponding biometric data from a biometric sensor, such as the Touch ID sensor. The random secret is stored in a memory ("bio memory") associated with the SBIO and is output from the bio memory upon match, see step 3 in the diagram below ("3) upon sucessful match send random secret to SKS"):  Userspace UserEventAgent Darwin lock/unlock notifications SpringBoard MobileKeyBag.framework 1) pressing home button wakes Touch ID sensor 7) send unlock notification XNU (Kernel) AppleKeyStore SEP endpoint to SKS AppleMesa SEP endpoint to SBIO 4) decrypt master key random secret master key SKS SBIO Touch ID Sensor bio memory random secret 2) template match sent to SBIO SEP master key SKS memory master key + SEP UID class A class B (priv) class C SKS keyring class A class B (priv) class B (public) class C class D 3) upon successful match send random secret to SKS 6) securely destroy master key 5) decrypt class keys, add to keyring Touch ID unlock (Ex. B, Behind the Scenes with iOS Security, at 34.) The class keys are encrypted with a master key:

Claim 14	**Accused Instrumentalities**
	 User Keybags Background Sets of keys generated for each user to protect their data at rest Keys wrapped by master key derived from user passcode and SEP UID After 10 incorrect passcode entries, SEP will not process any further attempts Different policy associated with each keybag key—Usage, availability (*Id.*, at 25.) The random secret is issued to SKS. SKS is a Secure Key Service application which is located within the Secure Enclave on the SEP and is responsible for decrypting class keys. The random secret provided by SBIO is used to decrypt a master key ("4) decrypt master key"). The master key is concatenated with the UID of the SEP and thus class keys are decrypted and added to the SKS keyring ("5) decrypt class keys, add to keyring") for further use by the Secure Enclave. The decrypted class keys include, for example, the class key of class A.
14g. emit a secure access signal conveying information dependent upon said accessibility attribute; and	***The Accused Instrumentalities include a transmitter configured to emit a secure access signal conveying information dependent upon said accessibility attribute.*** For example, the Secure Enclave emits a signal with ephemerally re-encrypted file keys: "sepOS can then use the ephemeral wrapping key to wrap file keys for use by the Application Processor file-system driver. When the file-system driver reads or writes a file, it sends the wrapped key to the AES Engine."

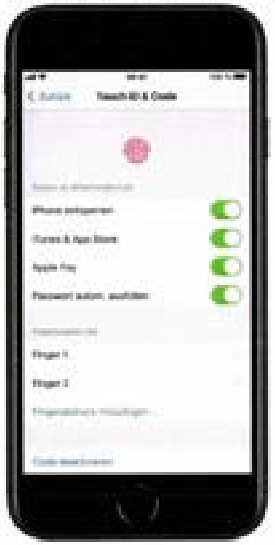
Claim 14	Accused Instrumentalities
	(Ex. A, Apple Platform Security, at 14.) "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. [...] When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and sent back to the Application Processor." (*Id.* at 85.) The signal with the ephemerally re-encrypted file keys is a secure signal because it comes from the Secure Enclave and thus from a secure environment. Furthermore, the signal is secure because the transmitted information is encrypted. The emitted file keys are encrypted with the ephemeral key: "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. At startup, the Secure Enclave negotiates an ephemeral key with the AES Engine. When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and sent back to the Application Processor." (*Id.*)  Filesystem Data Protection Overview File blocks are encrypted using AES-XTS with 128-bit keys Each file on the user partition is encrypted using a unique random key chosen by SEP Raw file keys are never exposed to the AP • Wrapped with a key from the user keybag for long-term storage • Wrapped with an ephemeral key while in use, bound to boot session

Claim 14	Accused Instrumentalities
	(Ex. B, Behind the Scenes with iOS Security, at 29.)  Filesystem Data Protection User Kernel SEP open("foo.txt", ...) 1. Fetch wrapped file_key from metadata HFS Key Store 2. Unwrap file_key using keybag key 4. Send IO command with ephemerally wrapped file_key NVME Driver AES Engine 3. Wrap file_key using ephemeral_key, return ephemerally wrapped file_key to kernel Clear Text Hardware NAND Cipher Text Storage Controller Ephemeral Key established on boot (*Id.*, at 30.) The information transmitted by the emitted signal, i.e., the ephemerally re-encrypted file keys, is dependent on the availability attribute, i.e., the confirmation that a biometric "template match" exists. This confirmation is signaled by the issuance of the random secret (cf. step 3): Only if there is a confirmation of the match and the random secret is issued by the Touch ID or Face ID subsystem within the Secure Enclave, i.e. SBIO, the class key is available for re-encrypting the file keys. The re-encrypted file keys are therefore information which is emitted depending on the fact that the availability attribute has been emitted.

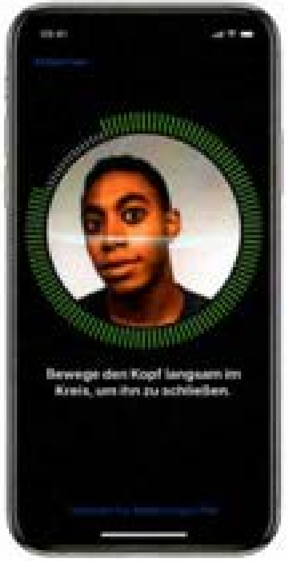
Claim 14	Accused Instrumentalities
14h. provide conditional access to a controlled item dependent upon said information, wherein the controlled item is one of: a locking mechanism of a physical access structure or an electronic lock on an electronic computing device.	***The Accused Instrumentalities are configured to provide conditional access to a controlled item dependent upon said information, wherein the controlled item is one of: a locking mechanism of a physical access structure or an electronic lock on an electronic computing device.*** More specifically, the controlled item is a locking mechanism of the door lock of the user's home. The Accused Instrumentalities are configured to provide secure access to the user's home via Yale Smart Locks when the user provides biometric signal to the Accused Instrumentalities via Touch ID or Face ID. "When the "Secure Remote Access" feature is turned on, the app will use your phone's built-in authentication tools to prompt fingerprint or facial recognition before you can unlock or lock your home remotely (note: if your phone does not have these features, it will prompt you to use your PIN code). This further ensures that your door is only operated by the right people at the time you intend for it." (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

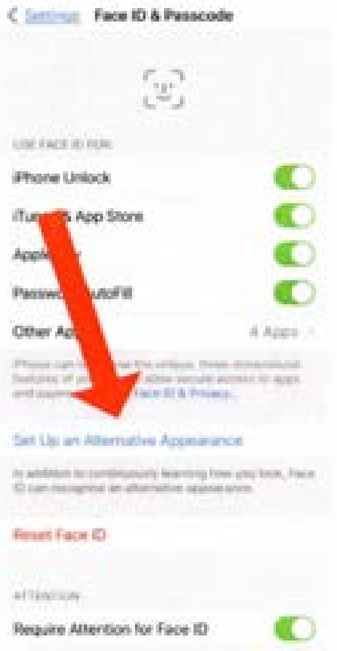
Claim 14	Accused Instrumentalities
	 Open Yale Introducing Biometric Verification for August and Yale Locks (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

Claim 14	Accused Instrumentalities
	 (https://www.apple.com/shop/product/HPAR2ZM/A/yale-assure-lock-sl-touchscreen-deadbolt-black)

Claim 15	Accused Instrumentalities
15. A system for providing secure access to a controlled item, the system comprising:	***The Accused Instrumentalities are non-transitory computer readable storage medium storing a computer program comprising instructions as set forth below.***
15a. a memory comprising a database of biometric signatures;	***The Accused Instrumentalities include a memory comprising a database of biometric signatures.*** More specifically, the iPhone allows multiple biometric signatures to be entered into a database on the iPhone: **Touch ID** The iPhone allows the registration of multiple fingerprints:  Touch ID & Code iPhone entsperren iTunes & App Store Apple Pay Passwort autom. ausfüllen Finger 1 Finger 2 Fig. from https://support.apple.com/en-us/HT201371 under Manage Touch ID Settings. In the second bullet, it literally says:

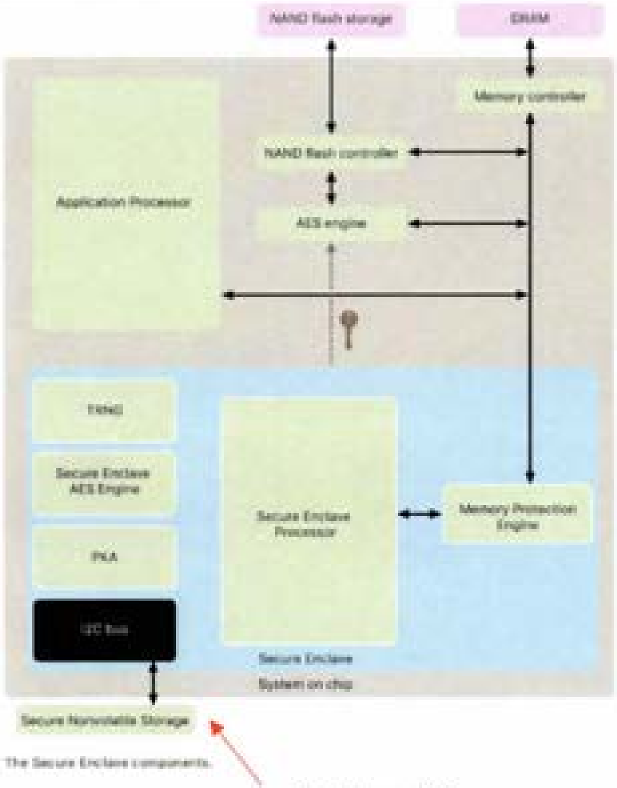
Claim 15	**Accused Instrumentalities**
	"Register up to five fingerprints." "Touch ID can read multiple fingerprints, and it can read fingerprints in 360-degrees of orientation. It then creates a mathematical representation of your fingerprint and compares this to your enrolled fingerprint data to identify a match and unlock your device. " (https://support.apple.com/en-us/HT204587) "Touch ID can read multiple fingerprints and recognize fingerprints at any orientation of the finger. The system then creates a mathematical representation of your fingerprint and compares it to the registered fingerprint data to determine a match and unlock your device." (https://support.apple.com/en-us/HT204587) **Face ID** The iPhone allows the registration of multiple faces:

Claim 15	Accused Instrumentalities
	 Bewege den Kopf langsam im Kreis, um ihn zu schließen. To register a face, the iPhone takes a series of pictures of the user in different poses while circling his head. This is revealed in detail in https://support.apple.com/en-us/HT208109 in the second section "Configure Face ID", there also the figure shown above. To register a second face, the iPhone offers a corresponding option in its settings. If the user selects the option "Set up an alternative appearance" as shown in the figure below (from How To Add A Second Face To Face ID - Macworld UK; https://www.macworld.co.uk/how-to/second-face-id-3803421/), a second face is registered by the iPhone in the same way as the first face. "Set up Face ID or add another face. • Select "Settings" > "Face ID & Code" > "Configure alternate appearance" if you want to configure another face to be recognized by Face ID."

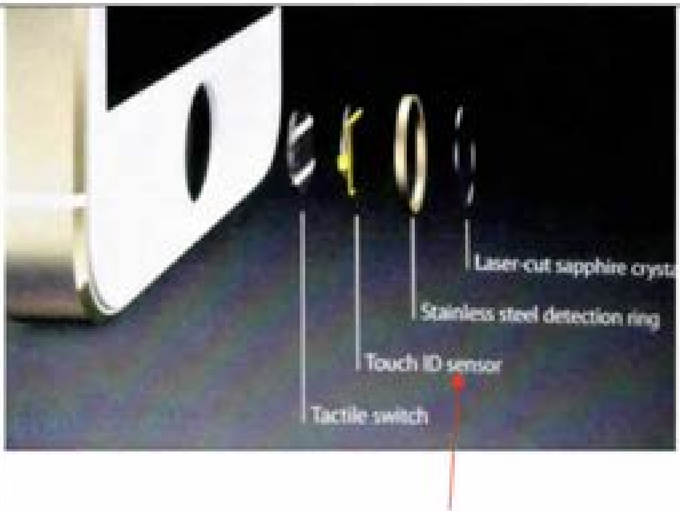
Claim 15	Accused Instrumentalities
	(https://support.apple.com/de-de/guide/iphone/iph6d162927a/ios) Settings Face ID & Passcode USE FACE ID FOR: iPhone Unlock iTu[illegible]s App Store Appl[illegible] Passw[illegible]utoFill Other Ap[illegible] 4 Apps [illegible] Face ID & Privacy... Set Up an Alternative Appearance In addition to continuously learning how you look, Face ID can recognise an alternative appearance. Reset Face ID ATTENTION Require Attention for Face ID The page How To Add A Second Face To Face ID - Macworld UK (https://www.macworld.co.uk/how-to/second-face-id-3803421/) literally states: "Face ID is a fast and secure way to unlock your iPhone or iPad Pro, but you may not know that you can actually set up more than one face to use the feature.

Claim 15	**Accused Instrumentalities**
	This second face could belong to a loved one, enabling your partner or child to access your phone without requiring your smiling mug to unlock it. ” To store the biometric signatures ("template data") from the received biometric signals, the iPhone has a System on Chip (SOC) called a Secure Enclave. A Secure Enclave Processor provides the Secure Enclave with computing power: "The *Secure Enclave* is a system on chip (SoC) that is included on all recent iPhone, ... devices" (Ex. A, Apple Platform Security, at 7.) "The Secure Enclave is a dedicated secure subsystem integrated into Apple systems on chip (SoCs)." (*Id.*, at 9.) The Secure Enclave Processor provides the main computing power for the Secure Enclave." (*Id.*, at 10.) "During enrollment, the Secure Enclave processes, encrypts, and **stores** the corresponding Touch ID and Face ID template data." (*Id.*, at 19.) The Secure Enclave has access to a memory assigned to it and accessible only to it: **Secure nonvolatile storage** “The Secure Enclave is equipped with a dedicated secure nonvolatile storage device. The secure nonvolatile storage is connected to the Secure Enclave using a dedicated I2C bus, so that it can only be accessed by the Secure Enclave.” (*Id.*, at 15.) This memory serves as a database for storing the biometric signatures:

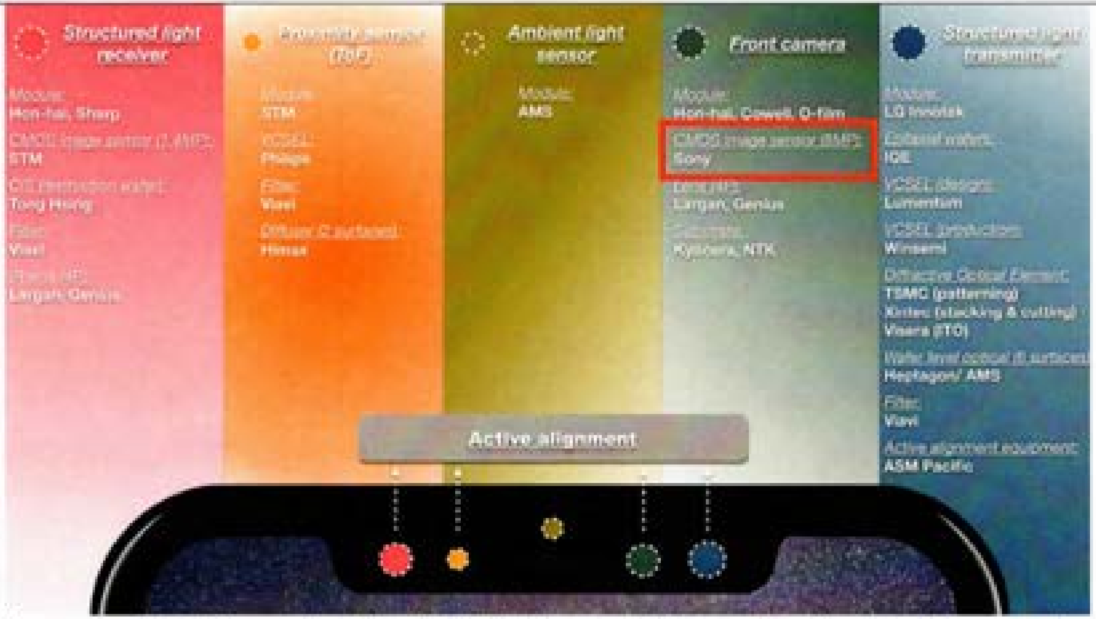
Claim 15	**Accused Instrumentalities**
	"The secure nonvolatile storage is used for all anti-replay services in the Secure Enclave. Anti-replay services on the Secure Enclave are used for revocation of data over events that mark anti-replay boundaries including, but not limited to, the following: ● … ● Adding or removing a Touch ID fingerprint or Face ID face". (*Id.*, at 16.) This database is shown in the figure from Apple Platform Secutiry reproduced below:

Claim 15	Accused Instrumentalities
	 NAND flash storage DRAM Memory controller NAND flash controller Application Processor AES engine TRNG Secure Enclave AES Engine PKA I2C bus Secure Enclave Processor Memory Protection Engine Secure Enclave System on chip Secure Nonvolatile Storage The Secure Enclave components. Database 105 (Ex. A, Apple Platform Security, at 9.)
15b. a transmitter sub-system comprising:	***As set forth in elements 15b1, 15b2, and 15b3 below, the Accused Instrumentalities include a transmitter subsystem***
15b1. a biometric sensor capable of receiving a biometric signal;	***The Accused Instrumentalities include a biometric sensor configured to receive a biometric signal.***

Claim 15	**Accused Instrumentalities**
	More specifically, the iPhone has at least one biometric sensor for capturing a fingerprint or a face (Touch ID and/or Face ID), namely a Touch ID sensor and a camera system with image sensor, respectively. **Touch ID** "Apple devices with a Touch ID sensor can be unlocked using a fingerprint." (Ex. A, Apple Platform Security, at 19.) "Touch ID is the fingerprint sensing system that makes secure access to supported Apple devices faster and easier. This technology reads fingerprint data from any angle and learns more about a user's fingerprint over time, with the **sensor** continuing to expand the fingerprint map as additional overlapping nodes are identified with each use." (*Id.*) "When the fingerprint sensor detects the touch of a finger, it triggers the advanced imaging array to scan the finger and sends the scan to the Secure Enclave." (*Id.*) The biometric sensor for Touch ID is located below the home button: "The Home button is a stack of different materials, capped with a sapphire crystal lens. The surrounding stainless-steel ring works as a ground and detects the user's finger. This action activates a capacitive touch sensor installed underneath the cover: A CMOS chip with small capacitors." (https://appleinsider.com/inside/touch-id)

Claim 15	Accused Instrumentalities
	 Laser-cut sapphire crysta Stainless steel detection ring Touch ID sensor Tactile switch Biometric sensor 121 "Where is the Touch ID sensor located? The Touch ID sensor is located either in the home button or - on the iPad Air (4th generation) - in the top button. (https://support.apple.com/en-us/HT201371) The image sensor captures an 88-by-88-pixel, 500 PPI raster scan: "The 88-by-88-pixel, 500-ppi raster scan is temporarily stored in encrypted memory within the Secure Enclave while being vectorized for analysis, and then it's discarded. The analysis utilizes subdermal ridge flow angle mapping, which is a lossy process that discards minutia data that would be required to reconstruct the user's actual fingerprint. The resulting map of nodes is stored without any identity information in an encrypted format that can only be read by the Secure Enclave, and is never sent to Apple or backed up to iCloud or iTunes. "

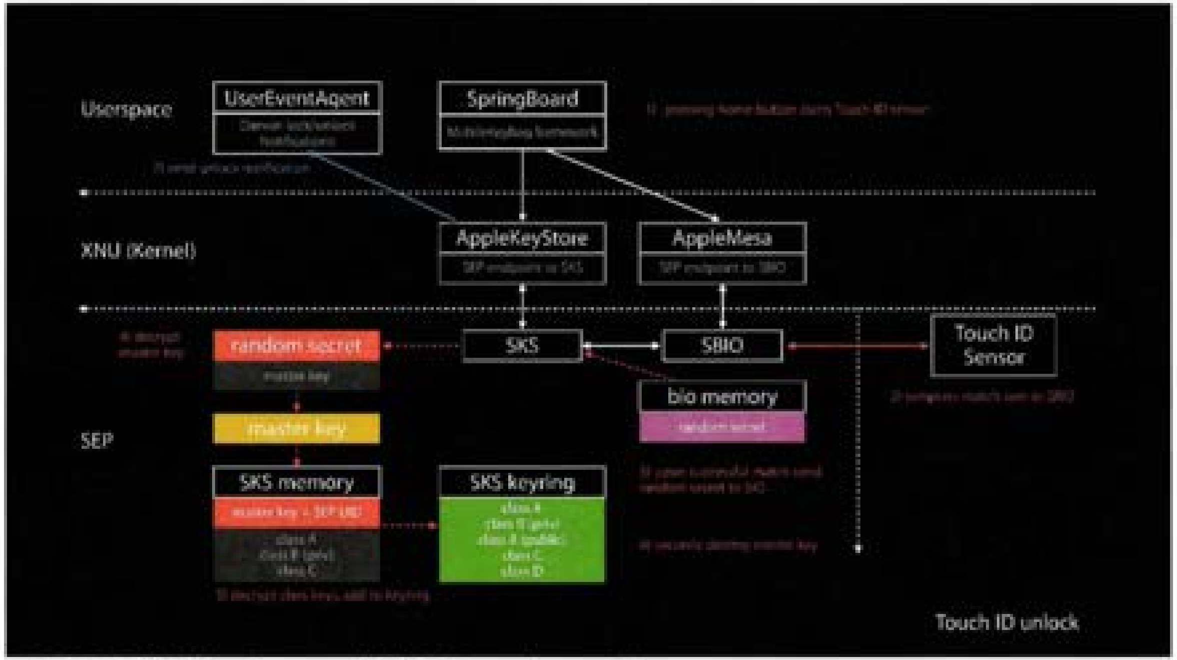
Claim 15	**Accused Instrumentalities**
	(Ex. C, iOS Security white paper, at 8.) **Face ID** The biometric sensor for facial biometrics is a camera system ("**TrueDepth** camera **system**") with an image sensor. "With a simple glance, Face ID securely unlocks supported Apple devices. It provides intuitive and secure authentication enabled by the TrueDepth camera system, which uses advanced technologies to accurately map the geometry of a user's face. " (Ex. A, Apple Platform Security, at 20.) To receive a biometric signal, the camera system with image sensor reads over 30,000 infrared points to capture depth information along with a two-dimensional infrared image. "After the TrueDepth camera confirms the presence of an attentive face, it projects and **reads over 30,000 infrared dots to form a depth map of the face along with a 2D infrared image**. This data is used to **create a sequence of 2D images and depth maps,** which are digitally signed and sent to the Secure Enclave. To counter both digital and physical spoofs, the TrueDepth camera randomizes the sequence of 2D images and depth map captures, and projects a device-specific random pattern. A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (*Id.*) The camera system includes a biometric image sensor, namely a "CMOS image" sensor from Sony, to perform facial biometrics:

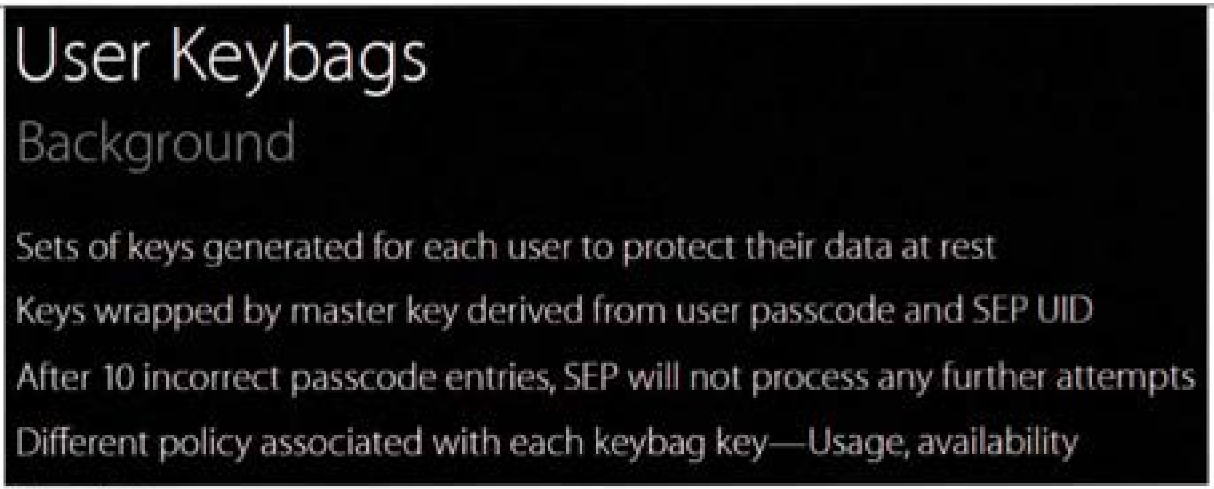
Claim 15	Accused Instrumentalities
	 Structured light receiver Module: Hon-hai, Sharp CMOS image sensor (1.4MP): STM CG (distribution wafer): Tong Hsing Filter: Viavi Lens (4P): Largan, Genius Proximity sensor (ToF) Module: STM VCSEL: Philips Filter: Viavi Diffuser (2 surfaces): Himax Ambient light sensor Module: AMS Front camera Module: Hon-hai, Cowell, O-film CMOS image sensor (8MP): Sony Lens (4P): Largan, Genius Substrate: Kyocera, NTK Structured light transmitter Module: LG Innotek Epitaxial wafers: IQE VCSEL design: Lumentum VCSEL production: Winsemi Diffractive Optical Element: TSMC (patterning) Xintec (stacking & cutting) Visera (ITO) Wafer level optical (6 surfaces): Heptagon/ AMS Filter: Viavi Active alignment equipment: ASM Pacific Active alignment (https://appleinsider.com/articles/17/09/09/inner-workings-of-apples-face-id-camera-detailed-in-report)
15b2. a transmitter sub-system controller capable of matching the biometric signal against members of the database of biometric signatures to thereby output an accessibility attribute; and	***The Accused Instrumentalities include a transmitter controller configured to emit a secure access signal conveying information dependent upon said accessibility attribute.*** More specifically, the iPhone's System on Chip (SOC), i.e. the Secure Enclave with its Secure Enclave Processor (SEP) or a Secure Neural Engine contained therein, is a means (103) to check a match of the biometric signal with elements of the biometric signature database. "The *Secure Enclave* is a system on chip (SoC) that is included on all recent iPhone, ... devices" (Ex. A, Apple Platform Security, at 7.)

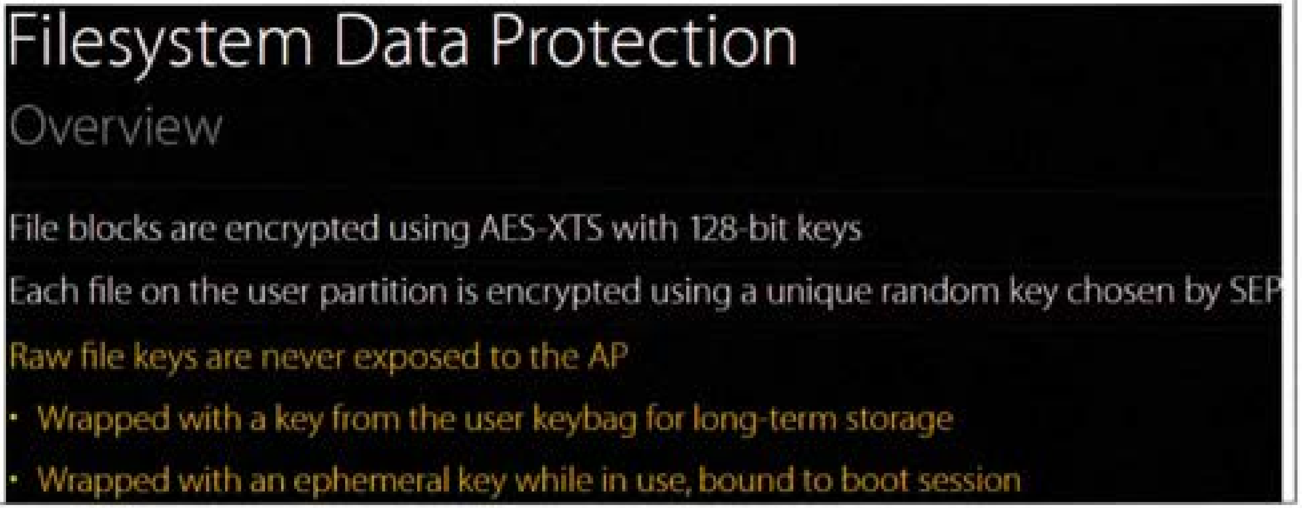
Claim 15	Accused Instrumentalities
	"During **matching**, the Secure Enclave **compares** incoming data from the biometric sensor against the stored templates **to determine whether to unlock the device** or respond that a match is valid (for Apple Pay, in-app, and other uses of Touch ID and Face ID). " (*Id*., at 19.) The biometric signal received from the biometric sensor ("incoming data from the biometric sensor") is thus checked by the Secure Enclave and its SEP with the elements of the database of biometric signatures 105, i.e. the "stored templates", for the presence of a match. For Touch ID, the Secure Enclave match verification is performed as follows: "The Secure Enclave is responsible for processing fingerprint data from the Touch ID sensor, determining if there is a match against registered fingerprints, and then enabling access or purchases on behalf of the user ..." (Ex. C, iOS Security white paper, at 7.) "During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches...." (Ex. A, Apple Platform Security, at 19.) "Touch ID can read multiple fingerprints, and it can read fingerprints in 360-degrees of orientation. It then creates a mathematical representation of your fingerprint and compares this to your enrolled fingerprint data to identify a match and unlock your device. " (https://support.apple.com/en-us/HT204587) "Touch ID can read multiple fingerprints and recognize fingerprints at any orientation of the finger. The system then creates a mathematical representation of your fingerprint and compares it to the registered fingerprint data to determine a match and unlock your device." (https://support.apple.com/de-de/HT204587)

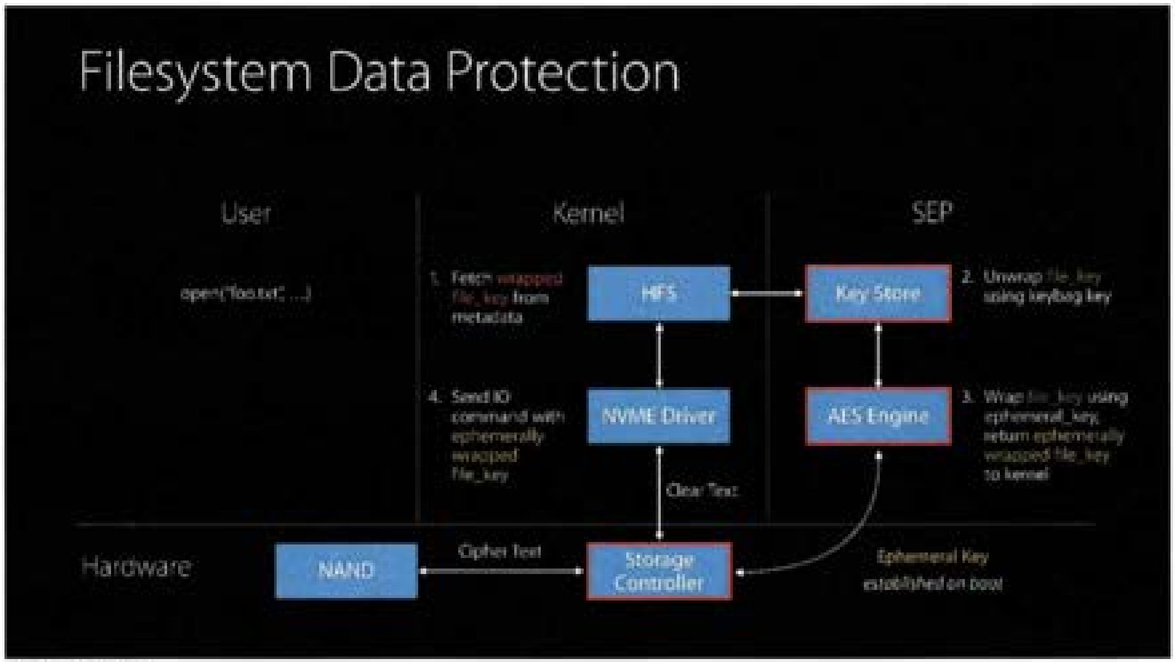
Claim 15	**Accused Instrumentalities**
	For **Face ID,** the Secure Enclave has a neural network protected by it, i.e., a Secure Neural Engine, which is used to verify the match: "Face ID uses neural networks for determining attention, **matching**, and antispoofing, so a user can unlock their phone with a glance." (Ex. A, Apple Platform Security, at 20.) "A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (*Id.*). "Facial matching security Facial matching is performed within the Secure Enclave using neural networks trained specifically for that purpose... Face ID data, including mathematical representations of a user's face, is encrypted and available only to the Secure Enclave. This data never leaves the device." (*Id.* at 23.) When the Secure Enclave, or more precisely the Touch ID or Face ID subsystem within the Secure Enclave, has determined that a match exists, an accessibility attribute is issued by the corresponding Touch ID or Face ID subsystem. This Touch ID or Face ID subsystem is also referred to as the SBIO. The accessibility attribute confirms that there is a match and that the iPhone is to be unlocked ("... determine whether to unlock the device ..."). This confirmation of the match is signaled by the SBIO by issuing a random secret to which only the Touch ID or Face ID subsystem within the Secure Enclave has access: "During matching, the Secure Enclave compares incoming data from the biometric sensor against the stored templates to determine whether to unlock the device [...]." (*Id.* at 19.)

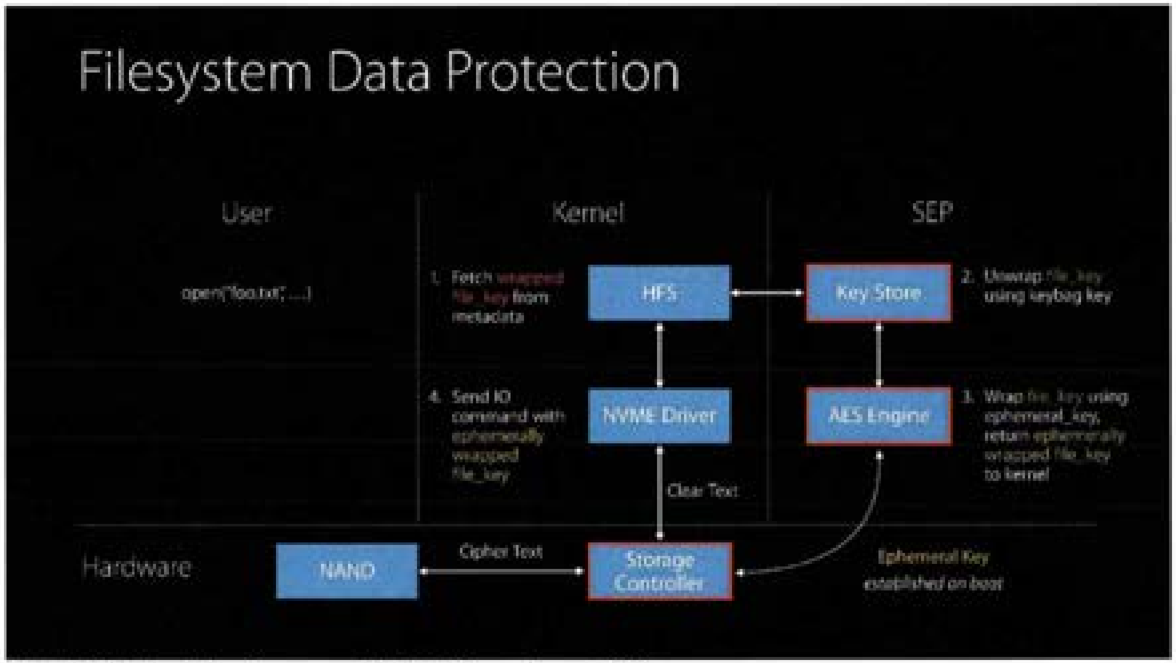
Claim 15	**Accused Instrumentalities**
	"Uses for Touch ID and Face ID **Unlocking a device or user account** [...] **keys for the highest class of Data Protection-which** are **held in the Secure Enclave** [...]. With Touch ID or Face ID enabled, the keys aren't discarded when the device or account locks; instead, **they're wrapped with a key that's given to the Touch ID or Face ID subsystem inside the Secure Enclave**. When a user attempts to unlock the device or account, **if the device detects a successful match, it provides the key for unwrapping the Data Protection keys**, and the device or account is unlocked. This process provides additional protection by requiring cooperation between the Data Protection and Touch ID or Face ID subsystems to unlock the device." (*Id.* at 24.) "The class key is protected with the hardware UID and, for some classes, the user's passcode." (*Id.* at 85.) **"Complete Protection** *(NSFileProtectionComplete):* The class key is protected with a key derived from the user passcode or password and the device UID. Shortly after the user locks a device (10 seconds, if the Require Password setting is Immediately), the decrypted class key is discarded, **rendering all data in this class inaccessible until the user** enters the passcode again or **unlocks** (logs in to) **the device using Touch ID or Face ID.**" (*Id.* at 86.) The Touch ID or Face ID subsystem within the Secure Enclave is the SBIO shown below. SBIO is an application that runs within the Secure Enclave on the SEP and is responsible for checking the match of biometric features. SBIO receives the corresponding biometric data from a biometric sensor, such as the Touch ID sensor. The random secret is stored in a memory ("bio memory") associated with the

Claim 15	Accused Instrumentalities
	SBIO and is output from the bio memory upon match, see step 3 in the diagram below ("3) upon sucessful match send random secret to SKS"):  Userspace UserEventAgent Darwin lock/unlock notifications SpringBoard MultitouchKeyBag framework 1) pressing home button starts Touch ID sensor 7) send unlock notification XNU (Kernel) AppleKeyStore SEP endpoint to SKS AppleMesa SEP endpoint to SBIO 4) decrypt master key random secret master key SKS SBIO Touch ID Sensor bio memory random secret 2) fingerprint match sent to SBIO SEP master key SKS memory master key + SEP UID class A class B (priv) class C SKS keyring class A class B (priv) class B (public) class C class D 3) upon successful match send random secret to SKS 6) securely destroy master key 5) decrypt class keys, add to keyring Touch ID unlock (Ex. B, Behind the Scenes with iOS Security, at 34.) The class keys are encrypted with a master key:

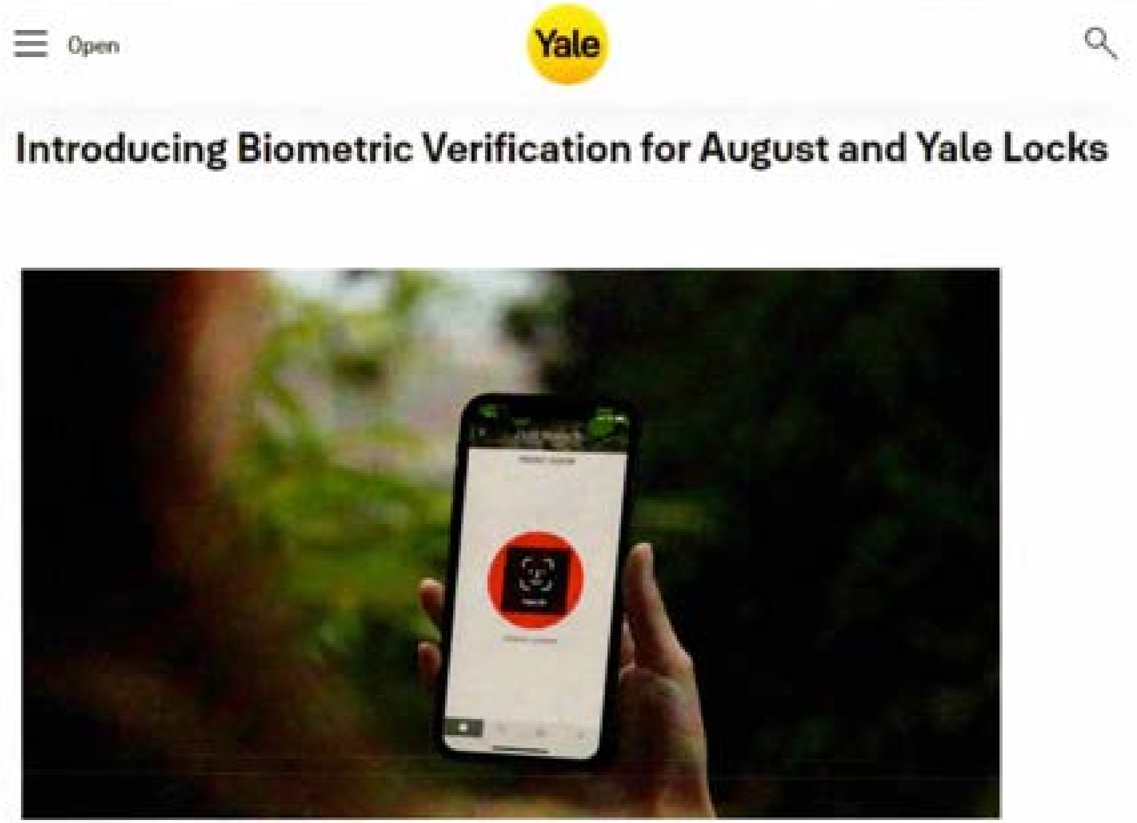
Claim 15	Accused Instrumentalities
	 User Keybags Background Sets of keys generated for each user to protect their data at rest Keys wrapped by master key derived from user passcode and SEP UID After 10 incorrect passcode entries, SEP will not process any further attempts Different policy associated with each keybag key—Usage, availability (*Id.*, at 25.) The random secret is issued to SKS. SKS is a Secure Key Service application which is located within the Secure Enclave on the SEP and is responsible for decrypting class keys. The random secret provided by SBIO is used to decrypt a master key ("4) decrypt master key"). The master key is concatenated with the UID of the SEP and thus class keys are decrypted and added to the SKS keyring ("5) decrypt class keys, add to keyring") for further use by the Secure Enclave. The decrypted class keys include, for example, the class key of class A.
15b3. a transmitter capable of emitting a secure access signal conveying information dependent upon said accessibility attribute; and	***The Accused Instrumentalities include a transmitter configured to emit a secure access signal conveying information dependent upon said accessibility attribute.*** For example, the Secure Enclave emits a signal with ephemerally re-encrypted file keys: "sepOS can then use the ephemeral wrapping key to wrap file keys for use by the Application Processor file-system driver. When the file-system driver reads or writes a file, it sends the wrapped key to the AES Engine."

<u>**Claim 15**</u>	<u>**Accused Instrumentalities**</u>
	(Ex. A, Apple Platform Security, at 14.) "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. [...] When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and sent back to the Application Processor." (*Id.* at 85.) The signal with the ephemerally re-encrypted file keys is a secure signal because it comes from the Secure Enclave and thus from a secure environment. Furthermore, the signal is secure because the transmitted information is encrypted. The emitted file keys are encrypted with the ephemeral key: "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. At startup, the Secure Enclave negotiates an ephemeral key with the AES Engine. When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and sent back to the Application Processor." (*Id.*)  Filesystem Data Protection Overview File blocks are encrypted using AES-XTS with 128-bit keys Each file on the user partition is encrypted using a unique random key chosen by SEP Raw file keys are never exposed to the AP · Wrapped with a key from the user keybag for long-term storage · Wrapped with an ephemeral key while in use, bound to boot session

Claim 15	Accused Instrumentalities
	(Ex. B, Behind the Scenes with iOS Security, at 29.)  Filesystem Data Protection User Kernel SEP open("foo.txt", ...) 1. Fetch wrapped file_key from metadata HFS Key Store 2. Unwrap file_key using keybag key 4. Send IO command with ephemerally wrapped file_key NVME Driver AES Engine 3. Wrap file_key using ephemeral_key, return ephemerally wrapped file_key to kernel Clear Text Hardware NAND Cipher Text Storage Controller Ephemeral Key established on boot (*Id.*, at 30.) The information transmitted by the emitted signal, i.e., the ephemerally re-encrypted file keys, is dependent on the availability attribute, i.e., the confirmation that a biometric "template match" exists. This confirmation is signaled by the issuance of the random secret (cf. step 3): Only if there is a confirmation of the match and the random secret is issued by the Touch ID or Face ID subsystem within the Secure Enclave, i.e. SBIO, the class key is available for re-encrypting the file keys. The re-encrypted file keys are therefore information which is emitted depending on the fact that the availability attribute has been emitted.

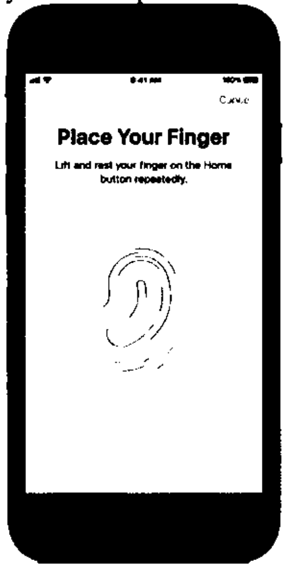
Claim 15	**Accused Instrumentalities**
15c. a receiver sub-system comprising:	***As set forth in elements 15c1 and 15c2 below, the Accused Instrumentalities include a receiver sub-system.***
15c1. a receiver sub-system controller capable of: receiving the transmitted secure access signal; and	***The Accused Instrumentalities include a receiver sub-system controller capable of: receiving the transmitted secure access signal.*** An application processor (118) with file system driver, which receives the ephemerally re-encrypted file key. To read files from the NAND Flash storage, the application processor processes the received signal by creating a read command with the ephemerally wrapped file key ("IO command with ephemerally wrapped file_key") and sends it to the storage controller (109) (NAND Flash controller with AES engine). This read command provides the storage controller with all the information required to read and decrypt the encrypted file from the NAND flash storage:  Filesystem Data Protection User Kernel SEP open("foo.txt", ...) 1. Fetch wrapped file_key from metadata HFS Key Store 2. Unwrap file_key using keybag key 4. Send IO command with ephemerally wrapped file_key NVME Driver AES Engine 3. Wrap file_key using ephemeral_key, return ephemerally wrapped file_key to kernel Clear Text Hardware NAND Cipher Text Storage Controller Ephemeral Key established on boot (Ex. B, Behind the Scenes with iOS Security, at 30.)

Claim 15	Accused Instrumentalities
	"sepOS can then use the ephemeral wrapping key to wrap file keys **for use by the Application Processor file-system driver. When the file-system driver reads or writes a file, it sends the wrapped key to the AES Engine. "** (Ex. A, Apple Platform Security, at 14.) "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. [...] When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and **sent back to the Application Processor.**" (*Id.*, at 85.)
15c2. providing conditional access to the controlled item dependent upon said information;	***The Accused Instrumentalities include a receiver sub-system configured to provide conditional access to the controlled item dependent upon said information.*** More specifically, the controlled item is a locking mechanism of the door lock of the user's home. The Accused Instrumentalities are configured to provide secure access to the user's home via Yale Smart Locks when the user provides biometric signal to the Accused Instrumentalities via Touch ID or Face ID. "When the "Secure Remote Access" feature is turned on, the app will use your phone's built-in authentication tools to prompt fingerprint or facial recognition before you can unlock or lock your home remotely (note: if your phone does not have these features, it will prompt you to use your PIN code). This further ensures that your door is only operated by the right people at the time you intend for it." (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

Claim 15	Accused Instrumentalities
	 Introducing Biometric Verification for August and Yale Locks (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

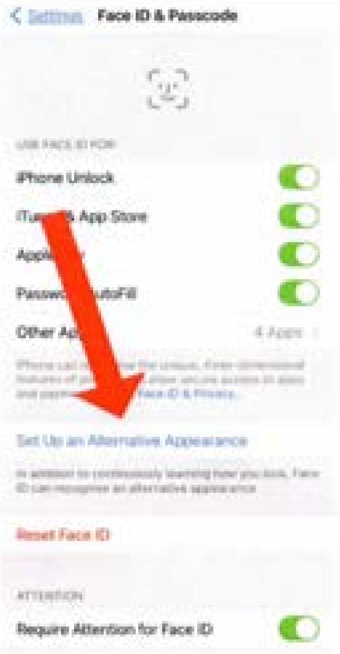
Claim 15	Accused Instrumentalities
	 (https://www.apple.com/shop/product/HPAR2ZM/A/yale-assure-lock-sl-touchscreen-deadbolt-black)
15d. wherein the transmitter sub-system controller is further capable of:	***The Accused Instrumentalities include a transmitter sub-system controller that is configured to be used as set forth in elements 15d1, 15d2, and 15d3 below.***

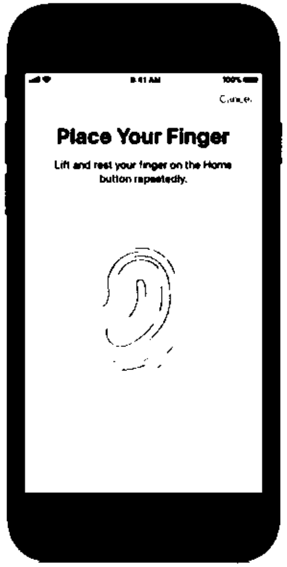
Claim 15	Accused Instrumentalities
15d1. receiving a series of entries of the biometric signal, said series being characterised according to at least one of the number of said entries and a duration of each said entry;	***The Accused Instrumentalities include a transmitter sub-system controller configured to receive a series of entries of the biometric signal, said series being characterized according to at least one of the number of said entries and a duration of each said entry.*** More specifically, the Secure Enclave of the iPhone with the Secure Enclave Processor forms the means for receiving a series of entries of the biometric signal. "Apple's biometric security architecture relies on a strict separation of responsibilities between the biometric sensor and the Secure Enclave, and a secure connection between the two. The sensor captures the biometric image and securely transmits it to the Secure Enclave." (Ex. A, Apple Platform Security, at 19.) **Touch ID** When a finger is placed on the biometric sensor, the finger is scanned and the corresponding biometric signal entry is received by the Secure Enclave. "When the fingerprint sensor detects the touch of a finger, it triggers the advanced imaging array to scan the finger and sends the scan to the Secure Enclave." (*Id.*) To enroll a fingerprint in the database, the iPhone's fingerprint sensor records an entry of a biometric signal when the user places his finger on the sensor. This is done multiple times, resulting in a series of entries of such biometric signals. Receiving a series of entries of the biometric signal by repeatedly placing a finger on the Touch ID sensor will use Touch ID on iPhone. **Set up Touch ID** Before you can set up Touch ID, you must first create a code for your device,* then follow these steps:

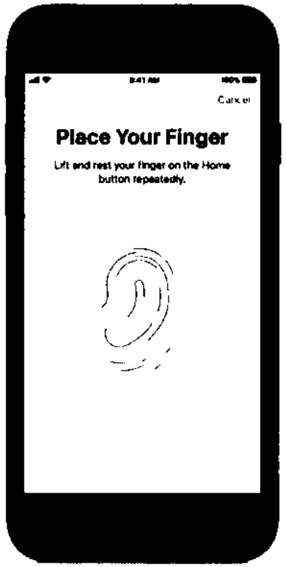
Claim 15	**Accused Instrumentalities**
	19. Make sure the Touch ID sensor and your finger are clean and dry. 20. Tap Settings > Touch ID & Code, and then enter your code. 21. Tap "Add fingerprint" and hold the device as you normally would when touching the Touch ID sensor. 22. Touch the Touch ID sensor with one finger, but do not press. Keep your finger on the button until you feel a quick vibration or are prompted to lift your finger.  Place Your Finger Lift and rest your finger on the Home button repeatedly. 23. Continue by raising and slowly lowering your finger over and over again, changing the position of your finger just a tiny bit at a time. 24. The next screen will ask you to change your finger position. Hold your device as you normally would when unlocking it. Touch the Touch ID sensor with the outer edges of your fingertip instead of the middle part as you would during the first scan." (https://support.apple.com/en-us/HT201371)

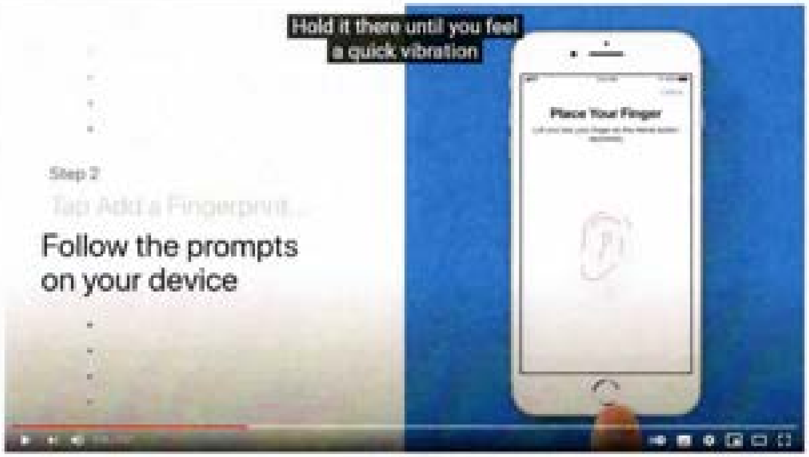
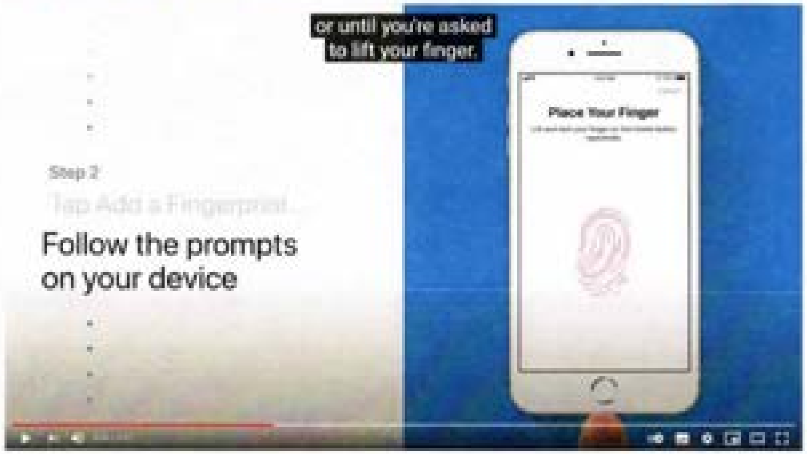
Claim 15	**Accused Instrumentalities**
	Accordingly, the user is prompted to place his finger on the sensor several times, in particular in accordance with step 5. Each time the finger is placed on the sensor, a corresponding biometric entry is generated, i.e. a series of such entries. All these entries, which result from placing the same finger on the sensor, form a series. **Face ID** The means for receiving a series of entries of the biometric signal includes a Secure Neural Engine, which is protected by the Secure Enclave. The Secure Neural Engine transforms the series of entries of the biometric signal received by the Secure Enclave into a biometric signature ("mathematical representation"). "After the TrueDepth camera confirms the presence of an attentive face, it projects and reads over 30,000 infrared dots to form a depth map of the face along with a 2D infrared image. This data is used to create **a sequence of 2D images and depth maps**, which are digitally signed and **sent to the Secure Enclave**. To counter both digital and physical spoofs, the TrueDepth camera randomizes the sequence of 2D images and depth map captures, and projects a device-specific random pattern. A portion of the **Secure Neural Engine-protected** within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (Ex. A, Apple Platform Security, at 20.) Each entry of the biometric signal thus contains a two-dimensional infrared image with 30,000 infrared points for capturing depth information. By continuously capturing such infrared images into a Face ID scan while the user moves his head into different poses, a series of entries of the biometric signal results. Two such Face ID scans are required to generate a biometric signature of a single face, so that two series of entries of the biometric signal are received accordingly. Using Face ID on iPhone 1. Tap Settings > Face ID & Code. Enter your code when prompted. 2. Tap on "Configure Face ID".

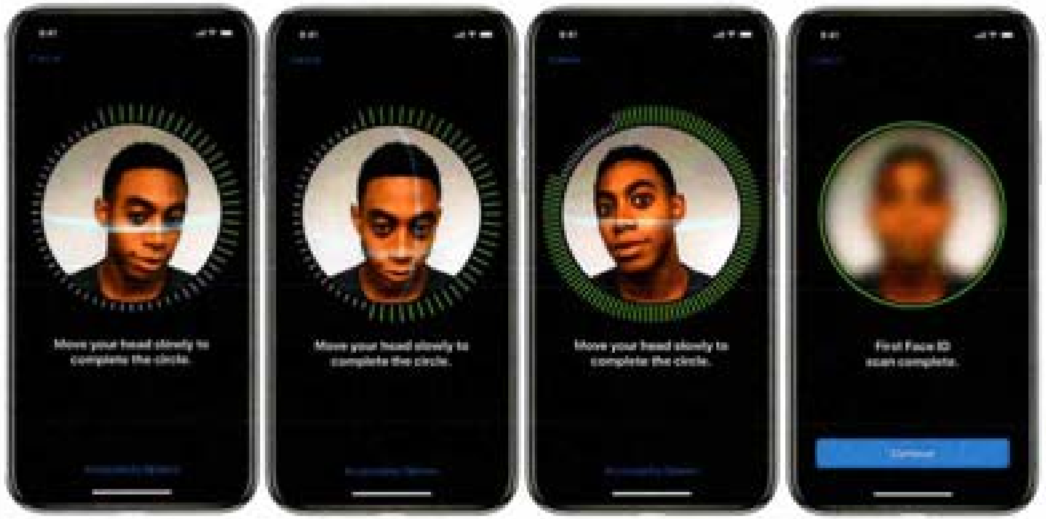
Claim 15	Accused Instrumentalities
	3. Hold the device in portrait mode in front of your face and tap "Let's go". 4. Make sure your face is inside the frame and slowly move your head until the circle shown is completed. If you can't move your head, tap on "Options for operating aids". 5. After performing the first Face ID scan, tap "Next". 6. Again, slowly describe a circle with your head until it is completed. 7. Tap "Done." (https://support.apple.com/en-us/HT208109) The biometric signature of a single face is thus determined by two successive Face ID scans, each of which receives a series of entries of the biometric signal (compare steps 4. and 6. above). To register a second face, the iPhone offers a corresponding option in its settings. If the user selects the option "Set up an alternative appearance" as shown in the figure below on https://www.macworld.co.uk/how-to/second-face-id-3803421/, a second face is registered by the iPhone in the same way as the first face.

<u>**Claim 15**</u>	<u>**Accused Instrumentalities**</u>
	 < Settings Face ID & Passcode USE FACE ID FOR: iPhone Unlock iTu s App Store Appl Passw utoFill Other Ap 4 Apps > Face ID & Privacy... Set Up an Alternative Appearance In addition to continuously learning how you look, Face ID can recognise an alternative appearance. Reset Face ID ATTENTION Require Attention for Face ID The series of entries of the biometric signal is identified on the iPhone by both the number and duration of each such entry. **Touch ID** According to step 5 of the instructions https://support.apple.com/en-us/HT201371, for the enrollment of a single finger, the user has to repeatedly place the respective finger on the sensor and thus a number of entries in a row predetermined via the user guidance are captured by the iPhone. Each one of the entries must also be of a predetermined duration given to the user via the iPhone display, i.e. the user's finger must remain on the sensor for a predetermined duration for each entry of the biometric signal in order to capture the biometric signal during this time.

Claim 15	Accused Instrumentalities
	Receiving a series of entries of the biometric signal by repeatedly placing a finger on the Touch ID sensor will use Touch ID on iPhone and iPad. **Set up Touch ID** … 4. Touch the Touch ID sensor with one finger, but do not press. Keep your finger on the button until you feel a quick vibration or are prompted to lift your finger.  Place Your Finger Lift and rest your finger on the Home button repeatedly. 5. Continue by raising and slowly lowering your finger over and over again, changing the position of your finger just a tiny bit at a time. 6. The next screen will ask you to change your finger position. Hold your device as you normally would when unlocking it. Touch the Touch ID sensor with the outer edges of your fingertip instead of the middle part as you did during the first scan. (https://support.apple.com/en-us/HT201371)

Claim 15	**Accused Instrumentalities**
	After placing a finger on the home button, a fingerprint appears on the display with red progress bars spreading along some of the papillary bars until the capture of the biometric entry in question is complete:  Place Your Finger Lift and rest your finger on the Home button repeatedly. When the required duration is reached, the iPhone vibrates after an entry of the biometric signal is received or it issues a prompt to the user to lift the finger. The user then lifts the finger in question and replaces the same finger so that the iPhone receives a series of biometric signal entries of sufficient duration for that finger. The process is repeated for the same finger for as long as required according to the iPhone's user guidance. This is shown in the Apple You Tube video (32) How to set up Touch ID on your iPhone or iPad - Apple Support - YouTube (https://www.youtube.com/watch?v=xTZ2LALWZlg):

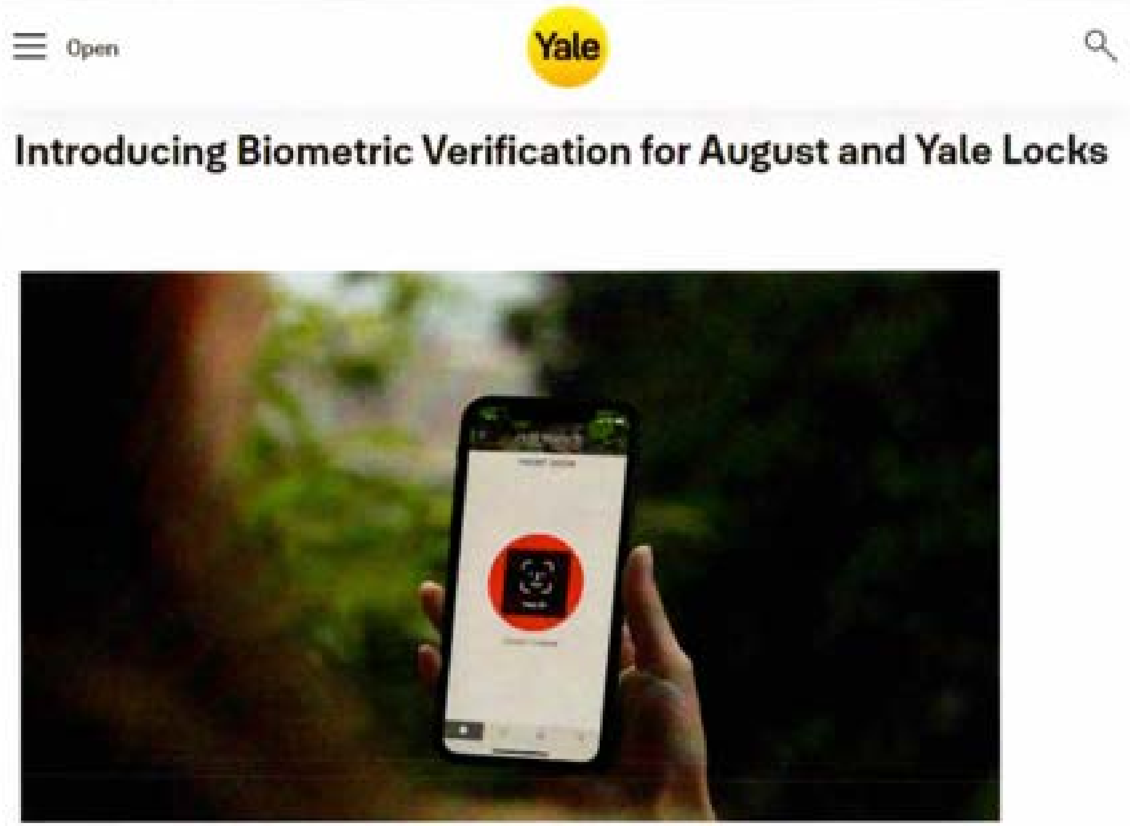
Claim 15	Accused Instrumentalities
	 Hold it there until you feel a quick vibration Step 2 Tap Add a Fingerprint... Follow the prompts on your device Place Your Finger  or until you're asked to lift your finger. Step 2 Tap Add a Fingerprint... Follow the prompts on your device Place Your Finger Both the number of entries, i.e. the number of repetitions for placing the finger on the screen, and their respective duration are specified by the iPhone via the user guidance.

Claim 15	Accused Instrumentalities
	Face ID The user moves his face in front of the camera to strike different poses, and the camera system with image sensor continuously captures a large number of biometric entries, i.e. here the 2D images with depth information, in a row. "This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (Ex. A, Apple Platform Security, at 20.) The sufficient duration of an entry for a pose, i.e. an angular position of the head specified via the user interface of the iPhone, is indicated to the user by the transformation of a gray line into a green line:  Move your head slowly to complete the circle. Move your head slowly to complete the circle. Move your head slowly to complete the circle. First Face ID scan complete. (Individual images taken from: https://support.apple.com/en-us/HT208109)
15d2. mapping said series into an instruction; and	***The Accused Instrumentalities include a transmitter sub-system controller configured to map said series into an instruction.***

Claim 15	Accused Instrumentalities
	More specifically, the Secure Enclave of the iPhone contains means to assign the received row to an instruction: The Secure Enclave, after receiving the full set of entries of the biometric signal, assigns this set to an instruction for processing, encrypting and storing the biometric signature ("Touch ID and Face ID template data"). "The sensor captures the biometric image and securely transmits it to the Secure Enclave. During enrollment, the Secure Enclave processes, encrypts, and stores the corresponding Touch ID and Face ID template data." (Ex. A, Apple Platform Security, at 19.) To carry out this instruction, the Secure Enclave has its own processor: "The Secure Enclave Processor provides the main computing power for the Secure Enclave." (*Id.*, at 10.) **Touch ID** The instruction here involves the processing of under-the-skin fingerprint characteristics and their encrypted storage. "The analysis uses subdermal ridge flow angle mapping, a lossy process that discards "finger minutiae data" that would be required to reconstruct the user's actual fingerprint. During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches, but without any identity information." (*Id.*, at 19.) **Face ID** The instruction involves the transformation of the set of entries of the biometric signal captured via the Face ID scans into a mathematical representation, i.e. the biometric signature of the face in question by the Secure Neural Engine of the Secure Enclave, as well as its encryption and storage.

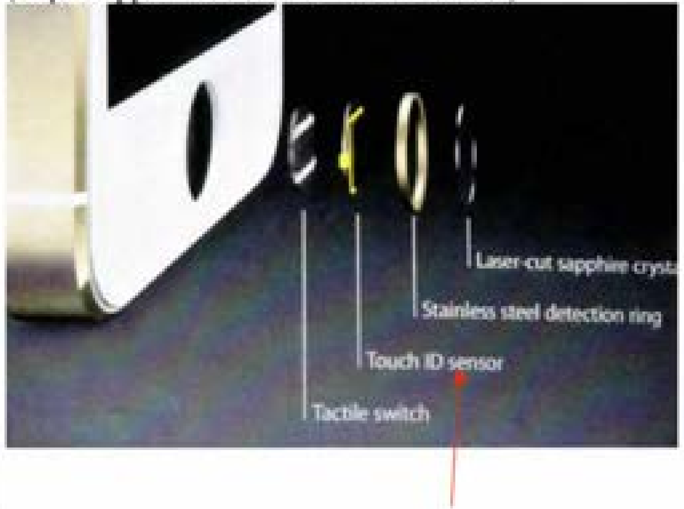
Claim 15	**Accused Instrumentalities**
	"A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's facc captured across a variety of poses. " (*Id.*, at 20.) "Face ID data, including mathematical representations of a user's face, is encrypted and available only to the Secure Enclave. This data never leaves the device. It's not sent to Apple, nor is it included in device backups. The following Face ID data is saved, encrypted only for use by the Secure Enclave, during normal operation: • The mathematical representations of a user's face calculated during enrollment • …" (*Id.*, at 23.)
15d3. populating the data base according to the instruction,	***The Accused Instrumentalities include a transmitter sub-system controller configured to populate the database according to the instruction.*** More specifically, the Secure Enclave stores the biometric signature, i.e. the encrypted mathematical representation of the fingerprint or face, in the database 105, i.e. the "secure nonvolatile storage": "The secure nonvolatile storage is used for all anti-replay services in the Secure Enclave. Anti-replay services on the Secure Enclave are used for revocation of data over events that mark anti-replay boundaries including, but not limited to, the following: • … • … • Adding or removing a Touch ID fingerprint or Face ID face". (Ex. A, Apple Platform Security, at 16.) "During enrollment, the Secure Enclave processes, encrypts, and stores the corresponding Touch ID and Face ID template data." (*Id.*, at 19.)

Claim 15	Accused Instrumentalities
	Touch ID "During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches...." (*Id.*) **Face ID** The following Face ID data is saved, encrypted only for use by the Secure Enclave, during normal operation: • The mathematical representations of a user's face calculated during enrollment". (*Id.*, at 23.)
wherein the controlled item is one of: a locking mechanism of a physical access structure or an electronic lock on an electronic computing device.	***The Accused Instrumentalities are configured to provide access to the controlled item, wherein the controlled item is one of: a locking mechanism of a physical access structure or an electronic lock on an electronic computing device.*** More specifically, the controlled item is a locking mechanism of the door lock of the user's home. The Accused Instrumentalities are configured to provide secure access to the user's home via Yale Smart Locks when the user provides biometric signal to the Accused Instrumentalities via Touch ID or Face ID. "When the "Secure Remote Access" feature is turned on, the app will use your phone's built-in authentication tools to prompt fingerprint or facial recognition before you can unlock or lock your home remotely (note: if your phone does not have these features, it will prompt you to use your PIN code). This further ensures that your door is only operated by the right people at the time you intend for it." (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

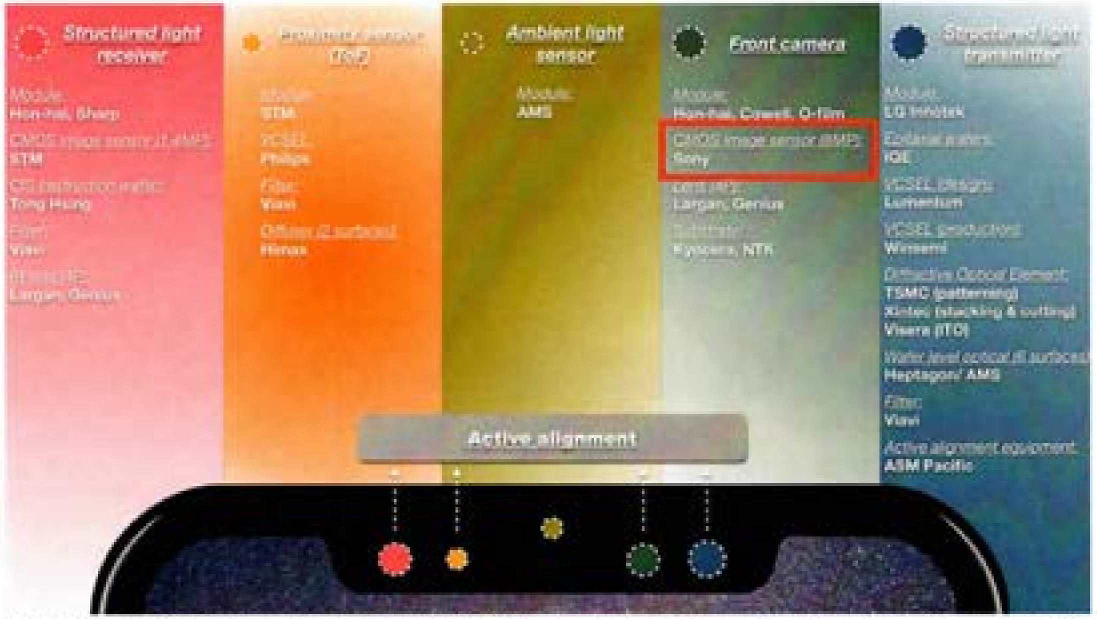
Claim 15	Accused Instrumentalities
	 Introducing Biometric Verification for August and Yale Locks (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

Claim 15	Accused Instrumentalities
	 (https://www.apple.com/shop/product/HPAR2ZM/A/yale-assure-lock-sl-touchscreen-deadbolt-black)

Claim 16	**Accused Instrumentalities**
16. A transmitter sub-system for operating in a system for providing secure access to a controlled item, wherein the transmitter sub-system comprises:	***To the extent that the preamble is deemed to be a limitation, the Accused Instrumentalities include a transmitter sub-system for operating in a system for providing secure access to a controlled item in accordance with this claim.***
16a. a biometric sensor capable of receiving a biometric signal;	***The Accused Instrumentalities include a biometric sensor configured to receive a biometric signal.*** More specifically, the iPhone has at least one biometric sensor for capturing a fingerprint or a face (Touch ID and/or Face ID), namely a Touch ID sensor and a camera system with image sensor, respectively. **Touch ID** "Apple devices with a Touch ID sensor can be unlocked using a fingerprint." (Ex. A, Apple Platform Security, at 19.) "Touch ID is the fingerprint sensing system that makes secure access to supported Apple devices faster and easier. This technology reads fingerprint data from any angle and learns more about a user's fingerprint over time, with the **sensor** continuing to expand the fingerprint map as additional overlapping nodes are identified with each use." (*Id.*) "When the fingerprint sensor detects the touch of a finger, it triggers the advanced imaging array to scan the finger and sends the scan to the Secure Enclave." (*Id.*) The biometric sensor for Touch ID is located below the home button:

Claim 16	Accused Instrumentalities
	"The Home button is a stack of different materials, capped with a sapphire crystal lens. The surrounding stainless-steel ring works as a ground and detects the user's finger. This action activates a capacitive touch sensor installed underneath the cover: A CMOS chip with small capacitors." (https://appleinsider.com/inside/touch-id)  Laser-cut sapphire crysta Stainless steel detection ring Touch ID sensor Tactile switch Biometric sensor 121 "Where is the Touch ID sensor located? The Touch ID sensor is located either in the home button or - on the iPad Air (4th generation) - in the top button. (https://support.apple.com/en-us/HT201371) The image sensor captures an 88-by-88-pixel, 500 PPI raster scan: "The 88-by-88-pixel, 500-ppi raster scan is temporarily stored in encrypted memory within the Secure Enclave while being vectorized for analysis, and then it's discarded. The analysis utilizes subdermal

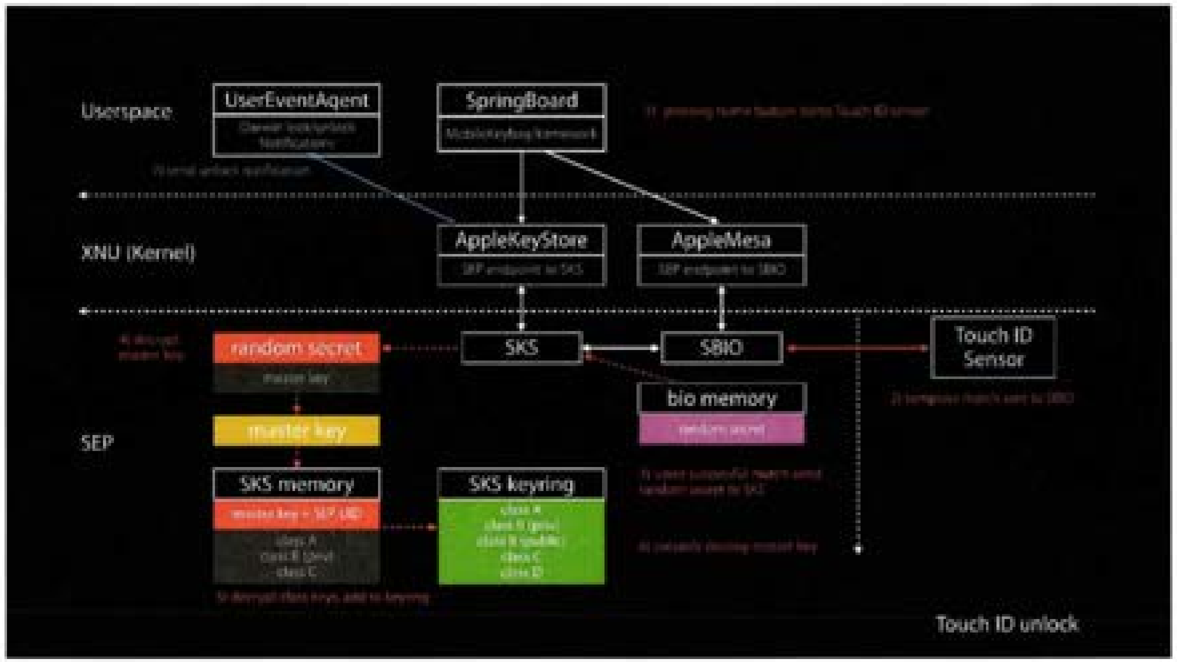
<u>**Claim 16**</u>	<u>**Accused Instrumentalities**</u>
	ridge flow angle mapping, which is a lossy process that discards minutia data that would be required to reconstruct the user's actual fingerprint. The resulting map of nodes is stored without any identity information in an encrypted format that can only be read by the Secure Enclave, and is never sent to Apple or backed up to iCloud or iTunes. " (Ex. C, iOS Security white paper, at 8.) **Face ID** The biometric sensor for facial biometrics is a camera system ("**TrueDepth** camera **system"**) with an image sensor. "With a simple glance, Face ID securely unlocks supported Apple devices. It provides intuitive and secure authentication enabled by the TrueDepth camera system, which uses advanced technologies to accurately map the geometry of a user's face. " (Ex. A, Apple Platform Security, at 20.) To receive a biometric signal, the camera system with image sensor reads over 30,000 infrared points to capture depth information along with a two-dimensional infrared image. "After the TrueDepth camera confirms the presence of an attentive face, it projects and **reads over 30,000 infrared dots to form a depth map of the face along with a 2D infrared image**. This data is used to **create a sequence of 2D images and depth maps**, which are digitally signed and sent to the Secure Enclave. To counter both digital and physical spoofs, the TrueDepth camera randomizes the sequence of 2D images and depth map captures, and projects a device-specific random pattern. A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (*Id.*)

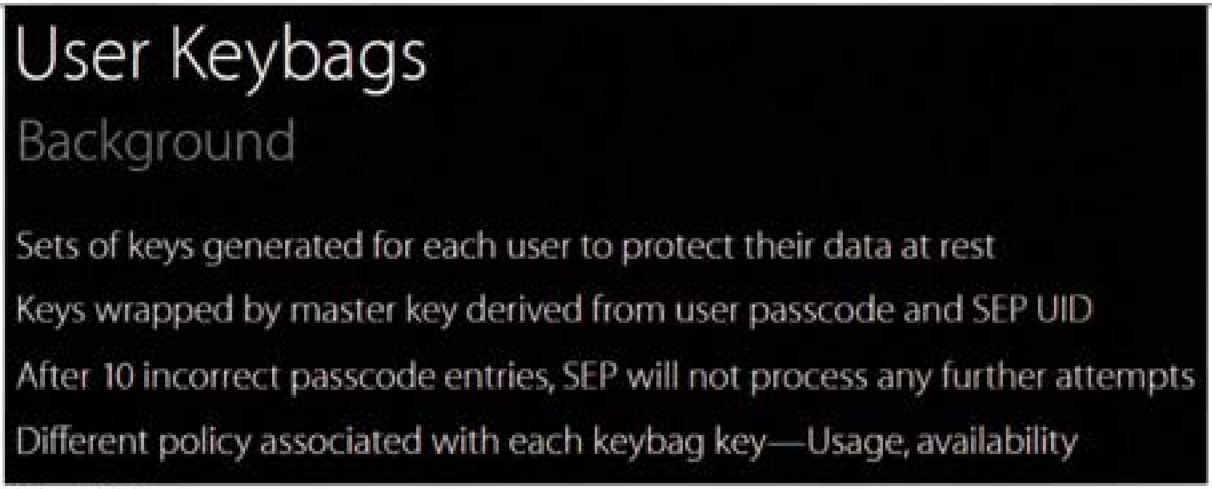
Claim 16	Accused Instrumentalities
	The camera system includes a biometric image sensor, namely a "CMOS image" sensor from Sony, to perform facial biometrics:  Structured light receiver Module: Hon-hai, Sharp CMOS image sensor (1.4MP): STM Tong Hsing Viavi Largan, Genius Proximity sensor (ToF) Module: STM VCSEL: Philips Filter: Viavi Diffuser (2 surfaces): Himax Ambient light sensor Module: AMS Front camera Module: Hon-hai, Cowell, O-film CMOS image sensor (8MP): Sony Lens (4P): Largan, Genius Substrate: Kyocera, NTK Structured light transmitter Module: LG Innotek Epitaxial wafers: IQE VCSEL design: Lumentum VCSEL production: Winsemi Diffractive Optical Element: TSMC (patterning) Xintec (stacking & cutting) Visera (ITO) Wafer level optical (fl surfaces): Heptagon/ AMS Filter: Viavi Active alignment equipment: ASM Pacific Active alignment (https://appleinsider.com/articles/17/09/09/inner-workings-of-apples-face-id-camera-detailed-in-report)
16b. a controller capable of matching the biometric signal against members of a database of biometric signatures to thereby output an accessibility attribute; and	***The Accused Instrumentalities include a transmitter controller configured to emit a secure access signal conveying information dependent upon said accessibility attribute.*** More specifically, the iPhone's System on Chip (SOC), i.e. the Secure Enclave with its Secure Enclave Processor (SEP) or a Secure Neural Engine contained therein, is a means (103) to check a match of the biometric signal with elements of the biometric signature database.

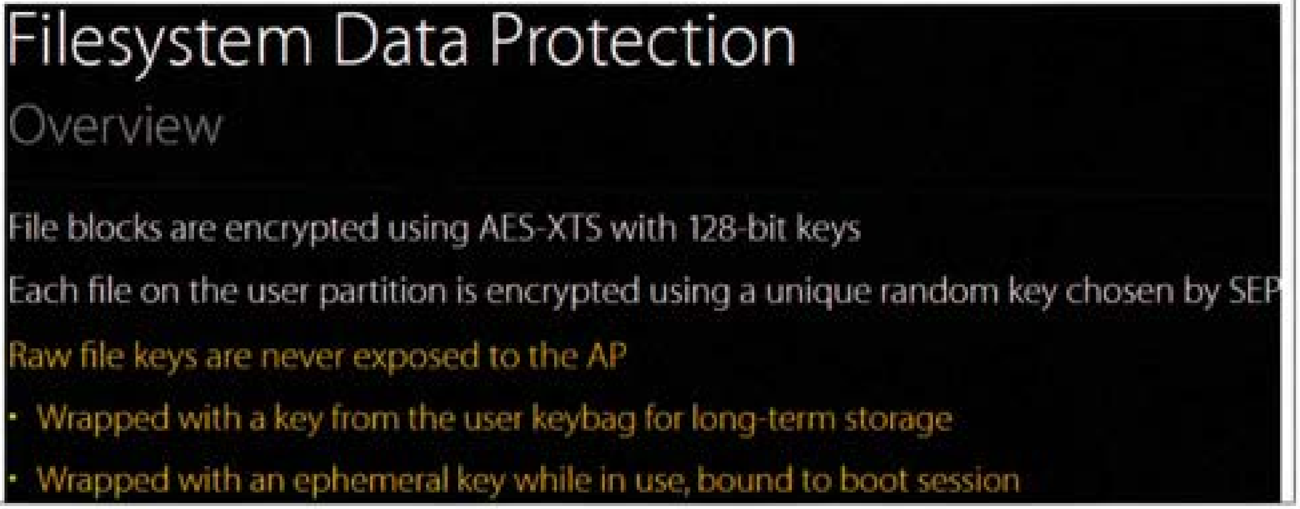
Claim 16	**Accused Instrumentalities**
	"The *Secure Enclave* is a system on chip (SoC) that is included on all recent iPhone, ... devices" (Ex. A, Apple Platform Security, at 7.) "During **matching**, the Secure Enclave **compares** incoming data from the biometric sensor against the stored templates **to determine whether to unlock the device** or respond that a match is valid (for Apple Pay, in-app, and other uses of Touch ID and Face ID). " (*Id.*, at 19.) The biometric signal received from the biometric sensor ("incoming data from the biometric sensor") is thus checked by the Secure Enclave and its SEP with the elements of the database of biometric signatures 105, i.e. the "stored templates", for the presence of a match. For Touch ID, the Secure Enclave match verification is performed as follows: "The Secure Enclave is responsible for processing fingerprint data from the Touch ID sensor, determining if there is a match against registered fingerprints, and then enabling access or purchases on behalf of the user ..." (Ex. C, iOS Security white paper, at 7.) "During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches...." (Ex. A, Apple Platform Security, at 19.) "Touch ID can read multiple fingerprints, and it can read fingerprints in 360-degrees of orientation. It then creates a mathematical representation of your fingerprint and compares this to your enrolled fingerprint data to identify a match and unlock your device. " (https://support.apple.com/en-us/HT204587) "Touch ID can read multiple fingerprints and recognize fingerprints at any orientation of the finger. The system then creates a mathematical representation of your fingerprint and compares it to the registered fingerprint data to determine a match and unlock your device."

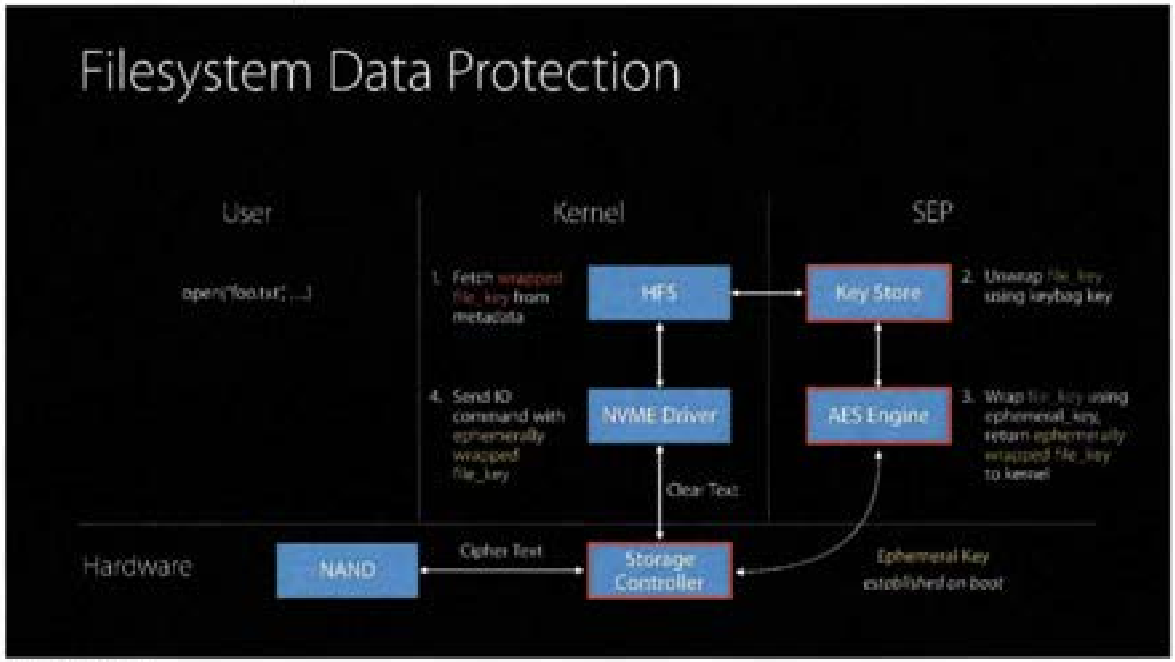
Claim 16	**Accused Instrumentalities**
	(https://support.apple.com/de-de/HT204587) For **Face ID,** the Secure Enclave has a neural network protected by it, i.e., a Secure Neural Engiñe, which is used to verify the match: "Face ID uses neural networks for determining attention, **matching**, and antispoofing, so a user can unlock their phone with a glance." (Ex. A, Apple Platform Security, at 20.) "A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (*Id.*). "Facial matching security Facial matching is performed within the Secure Enclave using neural networks trained specifically for that purpose... Face ID data, including mathematical representations of a user's face, is encrypted and available only to the Secure Enclave. This data never leaves the device." (*Id.* at 23.) When the Secure Enclave, or more precisely the Touch ID or Face ID subsystem within the Secure Enclave, has determined that a match exists, an accessibility attribute is issued by the corresponding Touch ID or Face ID subsystem. This Touch ID or Face ID subsystem is also referred to as the SBIO. The accessibility attribute confirms that there is a match and that the iPhone is to be unlocked ("... determine whether to unlock the device ..."). This confirmation of the match is signaled by the SBIO by issuing a random secret to which only the Touch ID or Face ID subsystem within the Secure Enclave has access:

Claim 16	Accused Instrumentalities
	"During matching, the Secure Enclave compares incoming data from the biometric sensor against the stored templates to determine whether to unlock the device [...]." (*Id.* at 19.) "Uses for Touch ID and Face ID **Unlocking a device or user account** [...] **keys for the highest class of Data Protection-which** are **held in the Secure Enclave** [...]. With Touch ID or Face ID enabled, the keys aren't discarded when the device or account locks; instead, **they're wrapped with a key that's given to the Touch ID or Face ID subsystem inside the Secure Enclave**. When a user attempts to unlock the device or account, **if the device detects a successful match, it provides the key for unwrapping the Data Protection keys**, and the device or account is unlocked. This process provides additional protection by requiring cooperation between the Data Protection and Touch ID or Face ID subsystems to unlock the device." (*Id.* at 24.) "The class key is protected with the hardware UID and, for some classes, the user's passcode." (*Id.* at 85.) **"Complete Protection** *(NSFileProtectionComplete):* The class key is protected with a key derived from the user passcode or password and the device UID. Shortly after the user locks a device (10 seconds, if the Require Password setting is Immediately), the decrypted class key is discarded, **rendering all data in this class inaccessible until the user** enters the passcode again or **unlocks** (logs in to) **the device using Touch ID or Face ID.**" (*Id.* at 86.) The Touch ID or Face ID subsystem within the Secure Enclave is the SBIO shown below. SBIO is an application that runs within the Secure Enclave on the SEP and is responsible for checking the match

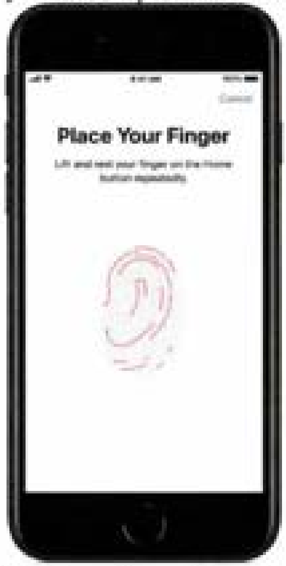
Claim 16	Accused Instrumentalities
	of biometric features. SBIO receives the corresponding biometric data from a biometric sensor, such as the Touch ID sensor. The random secret is stored in a memory ("bio memory") associated with the SBIO and is output from the bio memory upon match, see step 3 in the diagram below ("3) upon sucessful match send random secret to SKS"):  Userspace UserEventAgent Darwin lock/unlock Notifications SpringBoard MobileKeyBag framework 1) pressing home button wakes Touch ID sensor 6) send unlock notification XNU (Kernel) AppleKeyStore SEP endpoint to SKS AppleMesa SEP endpoint to SBIO 4) decrypt master key random secret master key SKS SBIO Touch ID Sensor bio memory random secret 2) template match sent to SBIO SEP master key SKS memory master key + SEP UID class A class B (priv) class C SKS keyring class A class B (priv) class B (public) class C class D 3) upon successful match send random secret to SKS 6) cancels deleting master key 5) decrypt class keys, add to keyring Touch ID unlock (Ex. B, Behind the Scenes with iOS Security, at 34.) The class keys are encrypted with a master key:

Claim 16	Accused Instrumentalities
	 User Keybags Background Sets of keys generated for each user to protect their data at rest Keys wrapped by master key derived from user passcode and SEP UID After 10 incorrect passcode entries, SEP will not process any further attempts Different policy associated with each keybag key—Usage, availability (*Id.*, at 25.) The random secret is issued to SKS. SKS is a Secure Key Service application which is located within the Secure Enclave on the SEP and is responsible for decrypting class keys. The random secret provided by SBIO is used to decrypt a master key ("4) decrypt master key"). The master key is concatenated with the UID of the SEP and thus class keys are decrypted and added to the SKS keyring ("5) decrypt class keys, add to keyring") for further use by the Secure Enclave. The decrypted class keys include, for example, the class key of class A.
16c. a transmitter capable of emitting a secure access signal conveying said information dependent upon said accessibility attribute;	***The Accused Instrumentalities include a transmitter configured to emit a secure access signal conveying information dependent upon said accessibility attribute.*** For example, the Secure Enclave emits a signal with ephemerally re-encrypted file keys: "sepOS can then use the ephemeral wrapping key to wrap file keys for use by the Application Processor file-system driver. When the file-system driver reads or writes a file, it sends the wrapped key to the AES Engine."

Claim 16	**Accused Instrumentalities**
	(Ex. A, Apple Platform Security, at 14.) "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. [...] When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and sent back to the Application Processor." (*Id.* at 85.) The signal with the ephemerally re-encrypted file keys is a secure signal because it comes from the Secure Enclave and thus from a secure environment. Furthermore, the signal is secure because the transmitted information is encrypted. The emitted file keys are encrypted with the ephemeral key: "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. At startup, the Secure Enclave negotiates an ephemeral key with the AES Engine. When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and sent back to the Application Processor." (*Id.*)  Filesystem Data Protection Overview File blocks are encrypted using AES-XTS with 128-bit keys Each file on the user partition is encrypted using a unique random key chosen by SEP Raw file keys are never exposed to the AP - Wrapped with a key from the user keybag for long-term storage - Wrapped with an ephemeral key while in use, bound to boot session

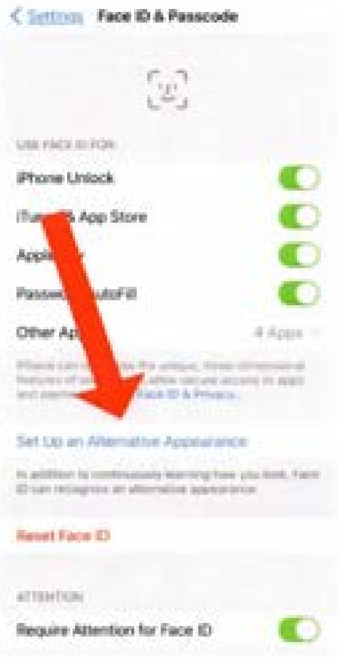
Claim 16	Accused Instrumentalities
	(Ex. B, Behind the Scenes with iOS Security, at 29.)  Filesystem Data Protection User Kernel SEP open("foo.txt", ...) 1. Fetch wrapped file_key from metadata HFS Key Store 2. Unwrap file_key using keybag key 4. Send IO command with ephemerally wrapped file_key NVME Driver AES Engine 3. Wrap file_key using ephemeral_key, return ephemerally wrapped file_key to kernel Clear Text Hardware NAND Cipher Text Storage Controller Ephemeral Key established on boot (*Id.*, at 30.) The information transmitted by the emitted signal, i.e., the ephemerally re-encrypted file keys, is dependent on the availability attribute, i.e., the confirmation that a biometric "template match" exists. This confirmation is signaled by the issuance of the random secret (cf. step 3): Only if there is a confirmation of the match and the random secret is issued by the Touch ID or Face ID subsystem within the Secure Enclave, i.e. SBIO, the class key is available for re-encrypting the file keys. The re-encrypted file keys are therefore information which is emitted depending on the fact that the availability attribute has been emitted.

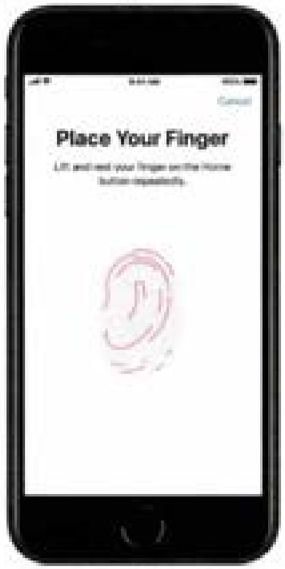
Claim 16	**Accused Instrumentalities**
16d. wherein the controller is further capable of:	***The Accused Instrumentalities include a controller that has capabilities as set forth in elements 16d1, 16d2, and 16d3 below.***
16d1. receiving a series of entries of the biometric signal, said series being characterised according to at least one of the number of said entries and a duration of each said entry;	***The Accused Instrumentalities include a transmitter sub-system controller configured to receive a series of entries of the biometric signal, said series being characterized according to at least one of the number of said entries and a duration of each said entry.*** More specifically, the Secure Enclave of the iPhone with the Secure Enclave Processor forms the means for receiving a series of entries of the biometric signal. "Apple's biometric security architecture relies on a strict separation of responsibilities between the biometric sensor and the Secure Enclave, and a secure connection between the two. The sensor captures the biometric image and securely transmits it to the Secure Enclave." (Ex. A, Apple Platform Security, at 19.) **Touch ID** When a finger is placed on the biometric sensor, the finger is scanned and the corresponding biometric signal entry is received by the Secure Enclave. "When the fingerprint sensor detects the touch of a finger, it triggers the advanced imaging array to scan the finger and sends the scan to the Secure Enclave." (*Id.*) To enroll a fingerprint in the database, the iPhone's fingerprint sensor records an entry of a biometric signal when the user places his finger on the sensor. This is done multiple times, resulting in a series of entries of such biometric signals. Receiving a series of entries of the biometric signal by repeatedly placing a finger on the Touch ID sensor will use Touch ID on iPhone.

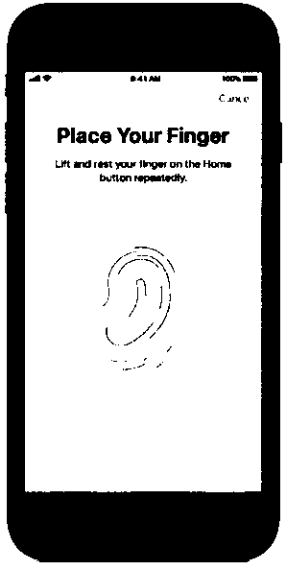
Claim 16	Accused Instrumentalities
	Set up Touch ID Before you can set up Touch ID, you must first create a code for your device,* then follow these steps: 25. Make sure the Touch ID sensor and your finger are clean and dry. 26. Tap Settings > Touch ID & Code, and then enter your code. 27. Tap "Add fingerprint" and hold the device as you normally would when touching the Touch ID sensor. 28. Touch the Touch ID sensor with one finger, but do not press. Keep your finger on the button until you feel a quick vibration or are prompted to lift your finger.  Place Your Finger Lift and rest your finger on the Home button repeatedly. 29. Continue by raising and slowly lowering your finger over and over again, changing the position of your finger just a tiny bit at a time.

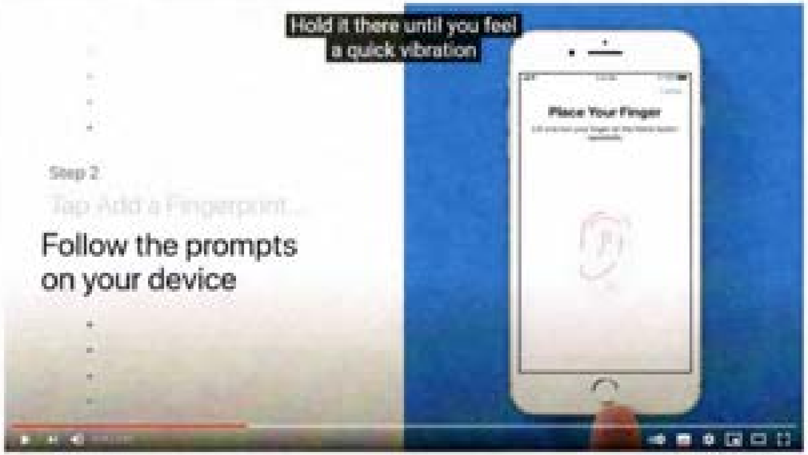
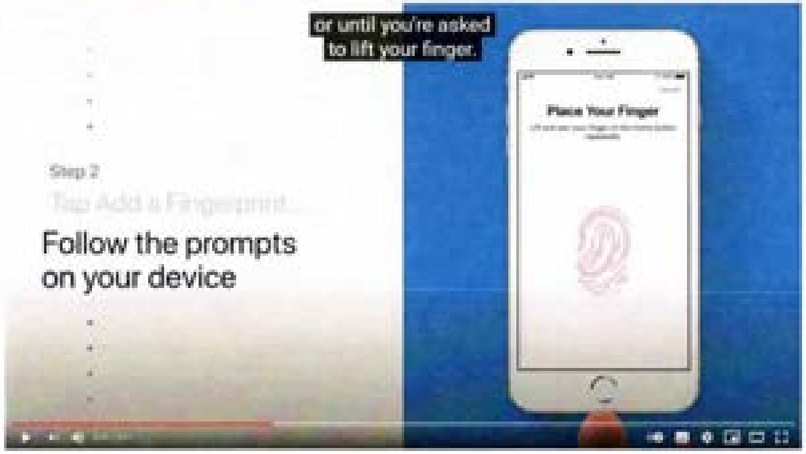
Claim 16	Accused Instrumentalities
	30. The next screen will ask you to change your finger position. Hold your device as you normally would when unlocking it. Touch the Touch ID sensor with the outer edges of your fingertip instead of the middle part as you would during the first scan." (https://support.apple.com/en-us/HT201371) Accordingly, the user is prompted to place his finger on the sensor several times, in particular in accordance with step 5. Each time the finger is placed on the sensor, a corresponding biometric entry is generated, i.e. a series of such entries. All these entries, which result from placing the same finger on the sensor, form a series. **Face ID** The means for receiving a series of entries of the biometric signal includes a Secure Neural Engine, which is protected by the Secure Enclave. The Secure Neural Engine transforms the series of entries of the biometric signal received by the Secure Enclave into a biometric signature ("mathematical representation"). "After the TrueDepth camera confirms the presence of an attentive face, it projects and reads over 30,000 infrared dots to form a depth map of the face along with a 2D infrared image. This data is used to create **a sequence of 2D images and depth maps**, which are digitally signed and **sent to the Secure Enclave**. To counter both digital and physical spoofs, the TrueDepth camera randomizes the sequence of 2D images and depth map captures, and projects a device-specific random pattern. A portion of the **Secure Neural Engine-protected** within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (Ex. A, Apple Platform Security, at 20.) Each entry of the biometric signal thus contains a two-dimensional infrared image with 30,000 infrared points for capturing depth information. By continuously capturing such infrared images into a Face ID scan while the user moves his head into different poses, a series of entries of the biometric signal

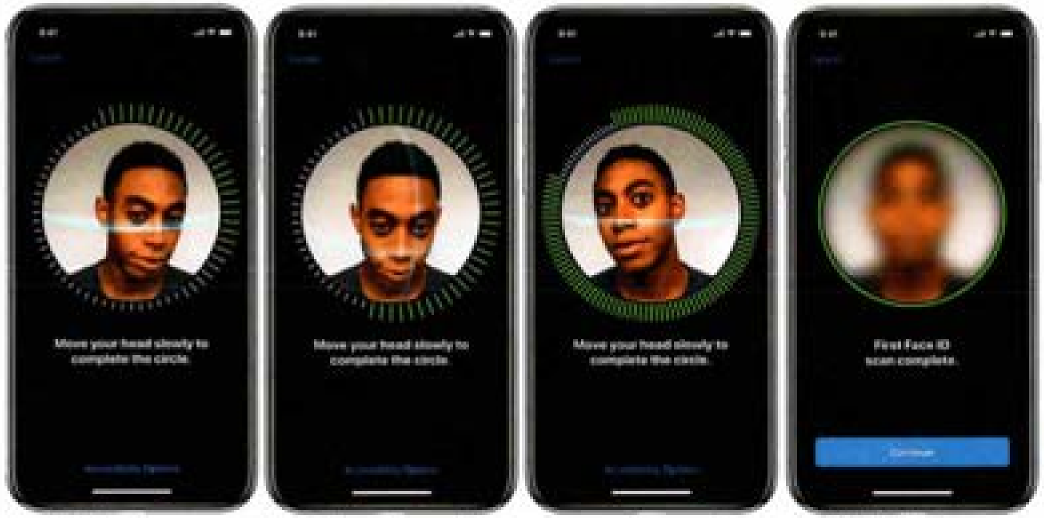
Claim 16	**Accused Instrumentalities**
	results. Two such Face ID scans are required to generate a biometric signature of a single face, so that two series of entries of the biometric signal are received accordingly. Using Face ID on iPhone 1. Tap Settings > Face ID & Code. Enter your code when prompted. 2. Tap on "Configure Face ID". 3. Hold the device in portrait mode in front of your face and tap "Let's go". 4. Make sure your face is inside the frame and slowly move your head until the circle shown is completed. If you can't move your head, tap on "Options for operating aids". 5. After performing the first Face ID scan, tap "Next". 6. Again, slowly describe a circle with your head until it is completed. 7. Tap "Done." (https://support.apple.com/en-us/HT208109) The biometric signature of a single face is thus determined by two successive Face ID scans, each of which receives a series of entries of the biometric signal (compare steps 4. and 6. above). To register a second face, the iPhone offers a corresponding option in its settings. If the user selects the option "Set up an alternative appearance" as shown in the figure below on https://www.macworld.co.uk/how-to/second-face-id-3803421/, a second face is registered by the iPhone in the same way as the first face.

Claim 16	Accused Instrumentalities
	 Settings Face ID & Passcode USE FACE ID FOR: iPhone Unlock iTu S App Store Appl Passw utoFill Other Ap 4 Apps Set Up an Alternative Appearance In addition to continuously learning how you look, Face ID can recognize an alternative appearance. Reset Face ID ATTENTION Require Attention for Face ID The series of entries of the biometric signal is identified on the iPhone by both the number and duration of each such entry. **Touch ID** According to step 5 of the instructions https://support.apple.com/en-us/HT201371, for the enrollment of a single finger, the user has to repeatedly place the respective finger on the sensor and thus a number of entries in a row predetermined via the user guidance are captured by the iPhone. Each one of the entries must also be of a predetermined duration given to the user via the iPhone display, i.e. the user's finger must remain on the sensor for a predetermined duration for each entry of the biometric signal in order to capture the biometric signal during this time.

Claim 16	Accused Instrumentalities
	Receiving a series of entries of the biometric signal by repeatedly placing a finger on the Touch ID sensor will use Touch ID on iPhone and iPad. **Set up Touch ID** … 4. Touch the Touch ID sensor with one finger, but do not press. Keep your finger on the button until you feel a quick vibration or are prompted to lift your finger.  Place Your Finger Lift and rest your finger on the Home button repeatedly. 5. Continue by raising and slowly lowering your finger over and over again, changing the position of your finger just a tiny bit at a time. 6. The next screen will ask you to change your finger position. Hold your device as you normally would when unlocking it. Touch the Touch ID sensor with the outer edges of your fingertip instead of the middle part as you did during the first scan. (https://support.apple.com/en-us/HT201371)

Claim 16	**Accused Instrumentalities**
	After placing a finger on the home button, a fingerprint appears on the display with red progress bars spreading along some of the papillary bars until the capture of the biometric entry in question is complete:  Place Your Finger Lift and rest your finger on the Home button repeatedly. When the required duration is reached, the iPhone vibrates after an entry of the biometric signal is received or it issues a prompt to the user to lift the finger. The user then lifts the finger in question and replaces the same finger so that the iPhone receives a series of biometric signal entries of sufficient duration for that finger. The process is repeated for the same finger for as long as required according to the iPhone's user guidance. This is shown in the Apple You Tube video (32) How to set up Touch ID on your iPhone or iPad - Apple Support - YouTube (https://www.youtube.com/watch?v=xTZ2LALWZlg):

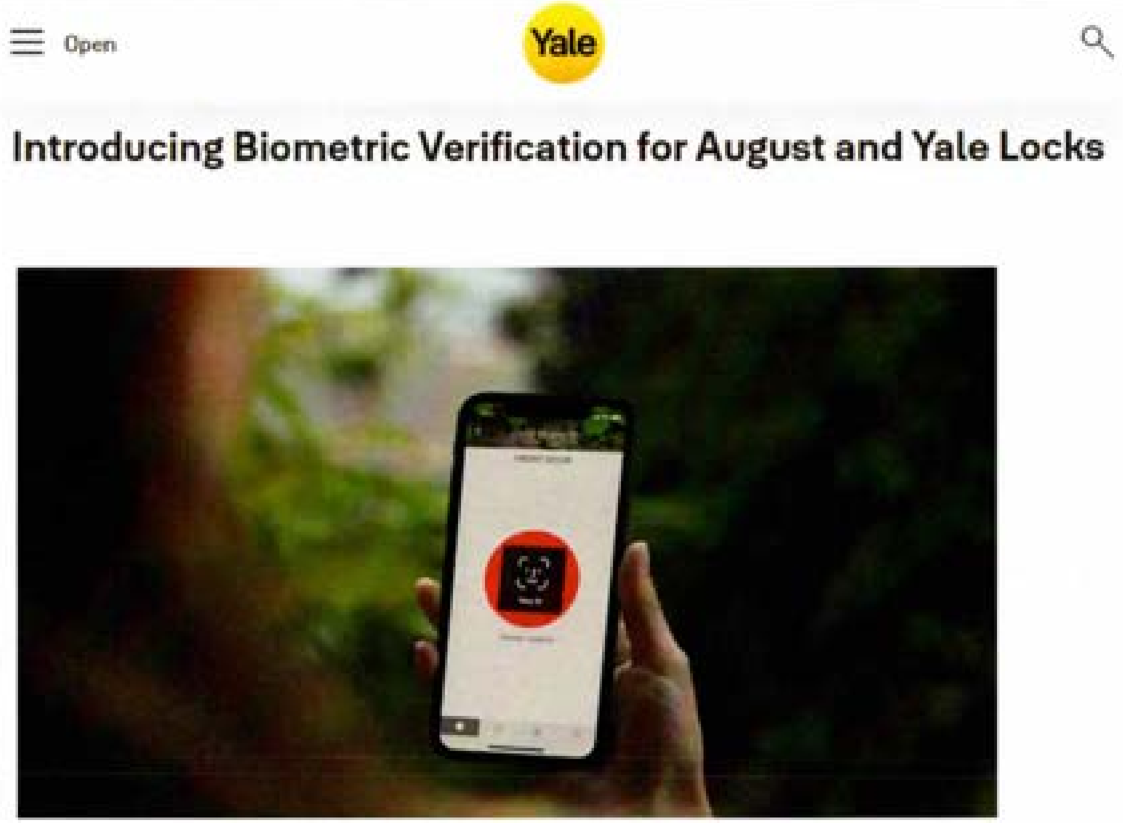
Claim 16	Accused Instrumentalities
	 Hold it there until you feel a quick vibration Step 2 Tap Add a Fingerprint... Follow the prompts on your device Place Your Finger  or until you're asked to lift your finger. Step 2 Tap Add a Fingerprint... Follow the prompts on your device Place Your Finger Both the number of entries, i.e. the number of repetitions for placing the finger on the screen, and their respective duration are specified by the iPhone via the user guidance.

Claim 16	Accused Instrumentalities
	Face ID The user moves his face in front of the camera to strike different poses, and the camera system with image sensor continuously captures a large number of biometric entries, i.e. here the 2D images with depth information, in a row. "This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (Ex. A, Apple Platform Security, at 20.) The sufficient duration of an entry for a pose, i.e. an angular position of the head specified via the user interface of the iPhone, is indicated to the user by the transformation of a gray line into a green line:  Move your head slowly to complete the circle. Move your head slowly to complete the circle. Move your head slowly to complete the circle. First Face ID scan complete. Continue (Individual images taken from: https://support.apple.com/en-us/HT208109)
16d2. mapping said series into an instruction; and	***The Accused Instrumentalities include a transmitter sub-system controller configured to map said series into an instruction.***

Claim 16	**Accused Instrumentalities**
	More specifically, the Secure Enclave of the iPhone contains means to assign the received row to an instruction: The Secure Enclave, after receiving the full set of entries of the biometric signal, assigns this set to an instruction for processing, encrypting and storing the biometric signature ("Touch ID and Face ID template data"). "The sensor captures the biometric image and securely transmits it to the Secure Enclave. During enrollment, the Secure Enclave processes, encrypts, and stores the corresponding Touch ID and Face ID template data." (Ex. A, Apple Platform Security, at 19.) To carry out this instruction, the Secure Enclave has its own processor: "The Secure Enclave Processor provides the main computing power for the Secure Enclave." (*Id.*, at 10.) **Touch ID** The instruction here involves the processing of under-the-skin fingerprint characteristics and their encrypted storage. "The analysis uses subdermal ridge flow angle mapping, a lossy process that discards "finger minutiae data" that would be required to reconstruct the user's actual fingerprint. During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches, but without any identity information." (*Id.*, at 19.) **Face ID** The instruction involves the transformation of the set of entries of the biometric signal captured via the Face ID scans into a mathematical representation, i.e. the biometric signature of the face in question by the Secure Neural Engine of the Secure Enclave, as well as its encryption and storage.

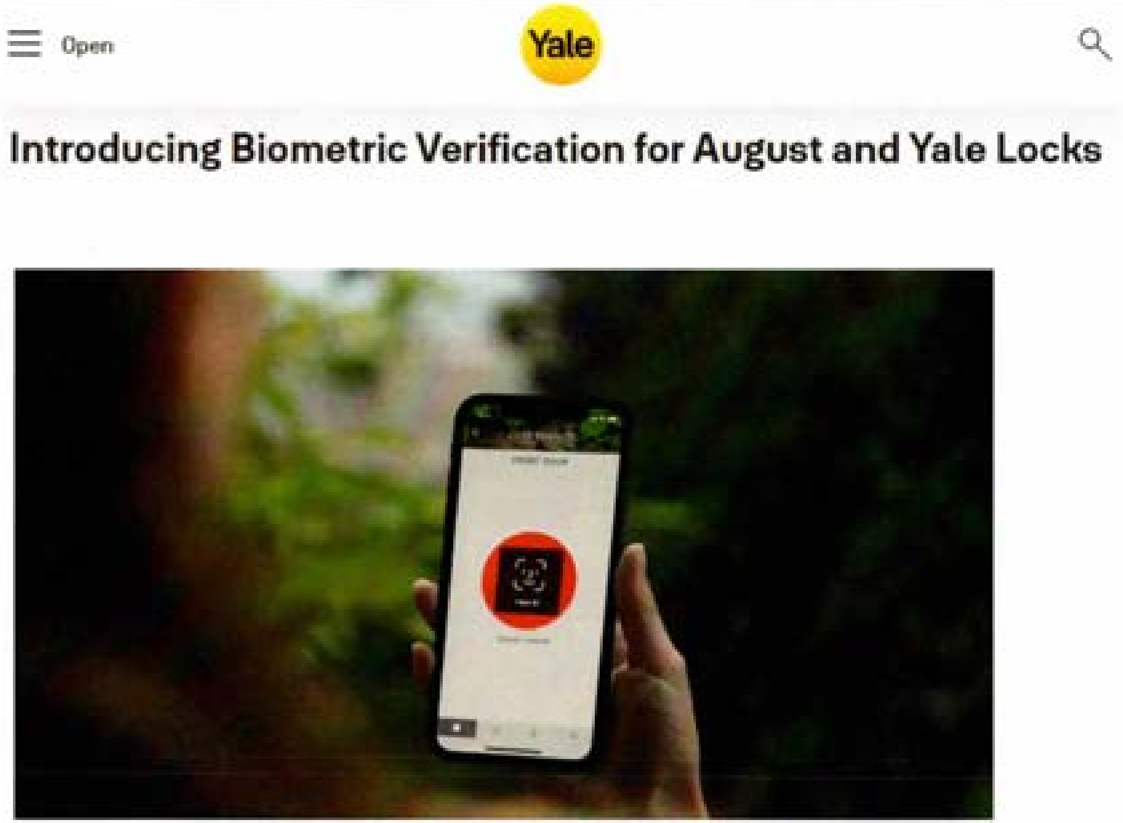
Claim 16	**Accused Instrumentalities**
	"A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses. " (*Id.*, at 20.) "Face ID data, including mathematical representations of a user's face, is encrypted and available only to the Secure Enclave. This data never leaves the device. It's not sent to Apple, nor is it included in device backups. The following Face ID data is saved, encrypted only for use by the Secure Enclave, during normal operation: • The mathematical representations of a user's face calculated during enrollment • …" (*Id.*, at 23.)
16d3. populating the database according to the instruction,	***The Accused Instrumentalities include a transmitter sub-system controller configured to populate the database according to the instruction.*** More specifically, the Secure Enclave stores the biometric signature, i.e. the encrypted mathematical representation of the fingerprint or face, in the database 105, i.e. the "secure nonvolatile storage": "The secure nonvolatile storage is used for all anti-replay services in the Secure Enclave. Anti-replay services on the Secure Enclave are used for revocation of data over events that mark anti-replay boundaries including, but not limited to, the following: • … • … • Adding or removing a Touch ID fingerprint or Face ID face". (Ex. A, Apple Platform Security, at 16.) "During enrollment, the Secure Enclave processes, encrypts, and stores the corresponding Touch ID and Face ID template data." (*Id.*, at 19.)

Claim 16	Accused Instrumentalities
	Touch ID "During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches...." (*Id.*) **Face ID** The following Face ID data is saved, encrypted only for use by the Secure Enclave, during normal operation: • The mathematical representations of a user's face calculated during enrollment". (*Id.*, at 23.)
wherein the controlled item is one of: a locking mechanism of a physical access structure or an electronic lock on an electronic computing device.	***The Accused Instrumentalities include a controller capable of: populating the database according to the instruction, wherein the controlled item is one of: a locking mechanism of a physical access structure or an electronic lock on an electronic computing device.*** More specifically, the controlled item is a locking mechanism of the door lock of the user's home. The Accused Instrumentalities are configured to provide secure access to the user's home via Yale Smart Locks when the user provides biometric signal to the Accused Instrumentalities via Touch ID or Face ID. "When the "Secure Remote Access" feature is turned on, the app will use your phone's built-in authentication tools to prompt fingerprint or facial recognition before you can unlock or lock your home remotely (note: if your phone does not have these features, it will prompt you to use your PIN code). This further ensures that your door is only operated by the right people at the time you intend for it." https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/

Claim 16	Accused Instrumentalities
	 Open Yale Introducing Biometric Verification for August and Yale Locks https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/

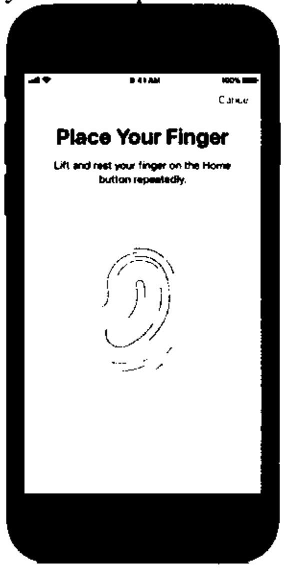
Claim 16	Accused Instrumentalities
	 https://www.apple.com/shop/product/HPAR2ZM/A/yale-assure-lock-sl-touchscreen-deadbolt-black

Claim 17	Accused Instrumentalities
17. A method for providing secure access to a controlled item in a system comprising a database of biometric signatures, a transmitter sub-system comprising a biometric sensor capable of receiving a biometric signal, and a transmitter capable of emitting a secure access signal capable of granting access to the controlled item, and a receiver sub-system comprising a receiver sub-system controller capable of receiving the transmitted secure access signal, and providing conditional access to the controlled item dependent upon information in said secure access signal, the method comprising:	***To the extent that the preamble is deemed to be a limitation, the Accused Instrumentalities are configured to use a method in accordance with this claim.*** More specifically, the controlled item is a locking mechanism of the door lock of the user's home. The Accused Instrumentalities are configured to provide secure access to the user's home via Yale Smart Locks when the user provides biometric signal to the Accused Instrumentalities via Touch ID or Face ID. "When the "Secure Remote Access" feature is turned on, the app will use your phone's built-in authentication tools to prompt fingerprint or facial recognition before you can unlock or lock your home remotely (note: if your phone does not have these features, it will prompt you to use your PIN code). This further ensures that your door is only operated by the right people at the time you intend for it." (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

Claim 17	Accused Instrumentalities
	 Introducing Biometric Verification for August and Yale Locks (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

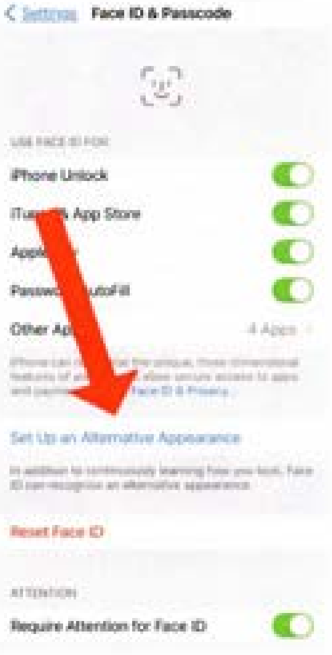
Claim 17	Accused Instrumentalities
	 (https://www.apple.com/shop/product/HPAR2ZM/A/yale-assure-lock-sl-touchscreen-deadbolt-black)
17a. populating the database of biometric signatures by:	***The Accused Instrumentalities are configured to populate the database of biometric signatures as set forth in elements 17a1 to 17a4 below.***

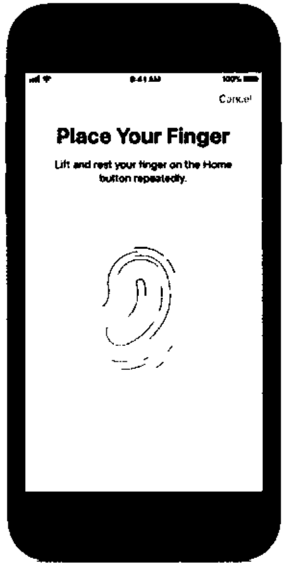
Claim 17	**Accused Instrumentalities**
17a1. receiving a series of entries of the biometric signal;	***The Accused Instrumentalities are configured to populate the database of biometric signatures by: receiving a series of entries of the biometric signal.*** More specifically, the Secure Enclave of the iPhone with the Secure Enclave Processor forms the means for receiving a series of entries of the biometric signal. "Apple's biometric security architecture relies on a strict separation of responsibilities between the biometric sensor and the Secure Enclave, and a secure connection between the two. The sensor captures the biometric image and securely transmits it to the Secure Enclave." (Ex. A, Apple Platform Security, at 19.) **Touch ID** When a finger is placed on the biometric sensor, the finger is scanned and the corresponding biometric signal entry is received by the Secure Enclave. "When the fingerprint sensor detects the touch of a finger, it triggers the advanced imaging array to scan the finger and sends the scan to the Secure Enclave." (Ex. A, Apple Platform Security, at 19.) To enroll a fingerprint in the database, the iPhone's fingerprint sensor records an entry of a biometric signal when the user places his finger on the sensor. This is done multiple times, resulting in a series of entries of such biometric signals. Receiving a series of entries of the biometric signal by repeatedly placing a finger on the Touch ID sensor will use Touch ID on iPhone and iPad here - Apple Support ; https://support.apple.com/en-us/HT201371 literally described as follows: **Set up Touch ID**

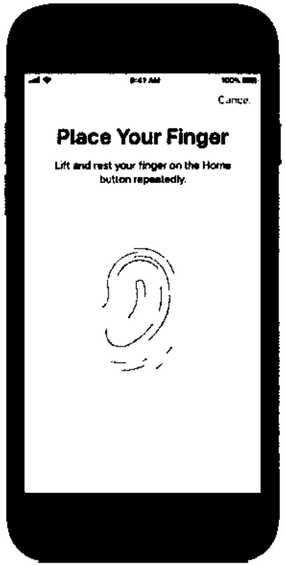
Claim 17	**Accused Instrumentalities**
	Before you can set up Touch ID, you must first create a code for your device,* then follow these steps: 1. Make sure the Touch ID sensor and your finger are clean and dry. 2. Tap Settings > Touch ID & Code, and then enter your code. 3. Tap "Add fingerprint" and hold the device as you normally would when touching the Touch ID sensor. 4. Touch the Touch ID sensor with one finger, but do not press. Keep your finger on the button until you feel a quick vibration or are prompted to lift your finger.  9:41 AM 100% Cancel Place Your Finger Lift and rest your finger on the Home button repeatedly. 5. Continue by raising and slowly lowering your finger over and over again, changing the position of your finger just a tiny bit at a time. 6. The next screen will ask you to change your finger position. Hold your device as you normally would when unlocking it. Touch the Touch ID sensor with the outer edges of your fingertip instead of the middle part as you would during the first scan."

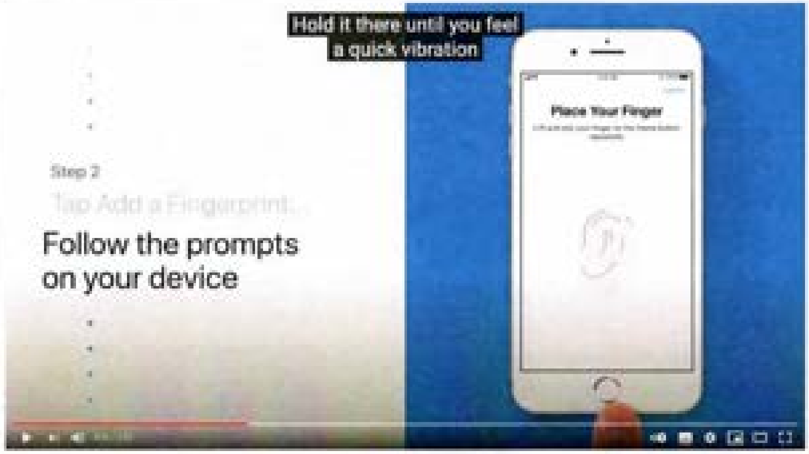
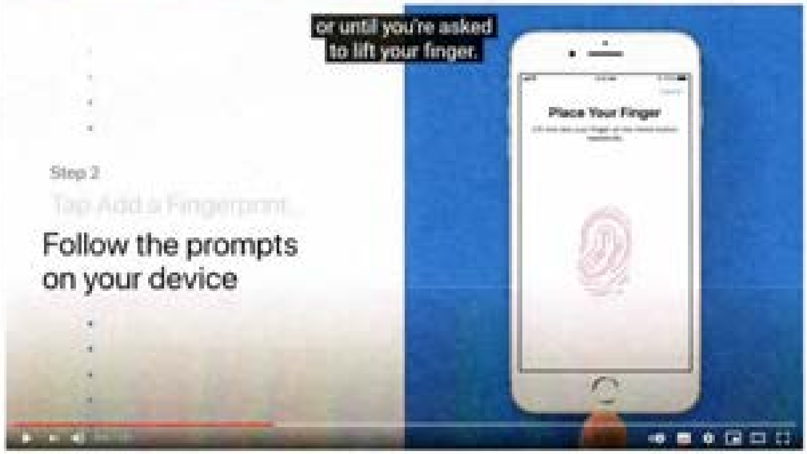
Claim 17	**Accused Instrumentalities**
	Accordingly, the user is prompted to place his finger on the sensor several times, in particular in accordance with step 5. Each time the finger is placed on the sensor, a corresponding biometric entry is generated, i.e. a series of such entries. All these entries, which result from placing the same finger on the sensor, form a series. **Face ID** The means for receiving a series of entries of the biometric signal includes a Secure Neural Engine, which is protected by the Secure Enclave. The Secure Neural Engine transforms the series of entries of the biometric signal received by the Secure Enclave into a biometric signature ("mathematical representation"). "After the TrueDepth camera confirms the presence of an attentive face, it projects and reads over 30,000 infrared dots to form a depth map of the face along with a 2D infrared image. This data is used to create **a sequence of 2D images and depth maps**, which are digitally signed and **sent to the Secure Enclave**. To counter both digital and physical spoofs, the TrueDepth camera randomizes the sequence of 2D images and depth map captures, and projects a device-specific random pattern. A portion of the **Secure Neural Engine-protected** within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (Ex. A, Apple Platform Security, at 20.) Each entry of the biometric signal thus contains a two-dimensional infrared image with 30,000 infrared points for capturing depth information. By continuously capturing such infrared images into a Face ID scan while the user moves his head into different poses, a series of entries of the biometric signal results. Two such Face ID scans are required to generate a biometric signature of a single face, so that two series of entries of the biometric signal are received accordingly. Under Using Face ID on iPhone or iPad Pro - Apple Support; https://support.apple.com/en-us/HT208109, the creation of a set of entries is described as follows:

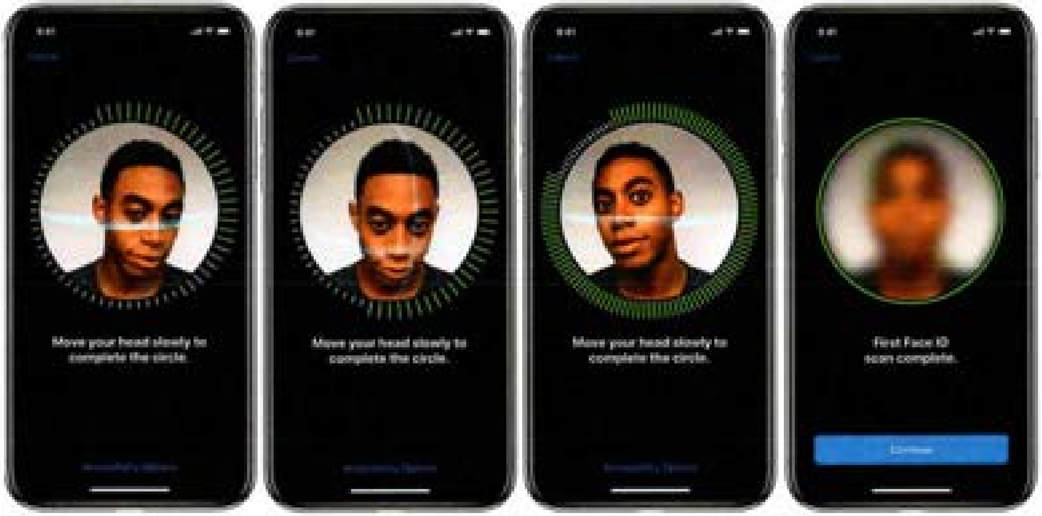
Claim 17	**Accused Instrumentalities**
	Configure Face ID Before configuring Face ID, make sure that neither the TrueDepth camera nor your face are covered by anything.... Follow the steps below to configure Face ID: 1. Tap Settings > Face ID & Code. Enter your code when prompted. 2. Tap on "Configure Face ID". 3. Hold the device in portrait mode in front of your face and tap "Let's go". 4. Make sure your face is inside the frame and slowly move your head until the circle shown is completed. If you can't move your head, tap on "Options for operating aids". 5. After performing the first Face ID scan, tap "Next". 6. Again, slowly describe a circle with your head until it is completed. 7. Tap "Done." The biometric signature of a single face is thus determined by two successive Face ID scans, each of which receives a series of entries of the biometric signal (compare steps 4. and 6. above). To register a second face, the iPhone offers a corresponding option in its settings. If the user selects the option "Set up an alternative appearance" as shown in the figure below on https://www.macworld.co.uk/how-to/second-face-id-3803421/, a second face is registered by the iPhone in the same way as the first face.

<u>Claim 17</u>	<u>Accused Instrumentalities</u>
	 Settings Face ID & Passcode USE FACE ID FOR: iPhone Unlock iTu[illegible] App Store Appl[illegible] Passwo[illegible]utoFill Other Ap[illegible] 4 Apps Set Up an Alternative Appearance In addition to continuously learning how you look, Face ID can recognize an alternative appearance. Reset Face ID ATTENTION Require Attention for Face ID The series of entries of the biometric signal is identified on the iPhone by both the number and duration of each such entry. **Touch ID** According to step 5 of the instructions https://support.apple.com/en-us/HT201371, for the enrollment of a single finger, the user has to repeatedly place the respective finger on the sensor and thus a number of entries in a row predetermined via the user guidance are captured by the iPhone. Each one of the entries must also be of a predetermined duration given to the user via the iPhone display, i.e. the user's finger must remain on the sensor for a predetermined duration for each entry of the biometric signal in order to capture the biometric signal during this time.

Claim 17	**Accused Instrumentalities**
	Receiving a series of entries of the biometric signal by repeatedly placing a finger on the Touch ID sensor will use Touch ID on iPhone and iPad here - Apple Support (https://support.apple.com/en-us/HT201371) literally described as follows: **Set up Touch ID** … 4. Touch the Touch ID sensor with one finger, but do not press. Keep your finger on the button until you feel a quick vibration or are prompted to lift your finger.  Place Your Finger Lift and rest your finger on the Home button repeatedly. 5. Continue by raising and slowly lowering your finger over and over again, changing the position of your finger just a tiny bit at a time. 6. The next screen will ask you to change your finger position. Hold your device as you normally would when unlocking it. Touch the Touch ID sensor with the outer edges of your fingertip instead of the middle part as you did during the first scan.

Claim 17	**Accused Instrumentalities**
	After placing a finger on the home button, a fingerprint appears on the display with red progress bars spreading along some of the papillary bars until the capture of the biometric entry in question is complete:  Place Your Finger Lift and rest your finger on the Home button repeatedly. When the required duration is reached, the iPhone vibrates after an entry of the biometric signal is received or it issues a prompt to the user to lift the finger. The user then lifts the finger in question and replaces the same finger so that the iPhone receives a series of biometric signal entries of sufficient duration for that finger. The process is repeated for the same finger for as long as required according to the iPhone's user guidance. This is shown in the Apple You Tube video (32) How to set up Touch ID on your iPhone or iPad - Apple Support - YouTube (https://www.youtube.com/watch?v=xTZ2LALWZlg):

Claim 17	Accused Instrumentalities
	 Hold it there until you feel a quick vibration Step 2 Tap Add a Fingerprint. Follow the prompts on your device Place Your Finger  or until you're asked to lift your finger. Step 2 Tap Add a Fingerprint. Follow the prompts on your device Place Your Finger Both the number of entries, i.e. the number of repetitions for placing the finger on the screen, and their respective duration are specified by the iPhone via the user guidance.

Claim 17	Accused Instrumentalities
	Face ID The user moves his face in front of the camera to strike different poses, and the camera system with image sensor continuously captures a large number of biometric entries, i.e. here the 2D images with depth information, in a row. "This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (Ex. A, Apple Platform Security, at 20.) The sufficient duration of an entry for a pose, i.e. an angular position of the head specified via the user interface of the iPhone, is indicated to the user by the transformation of a gray line into a green line:  Move your head slowly to complete the circle. Move your head slowly to complete the circle. Move your head slowly to complete the circle. First Face ID scan complete. (Individual images taken from: https://support.apple.com/en-us/HT208109)

Claim 17	**Accused Instrumentalities**
17a2. determining at least one of the number of said entries and a duration of each said entry;	***The Accused instrumentalities are configured to populate the database of biometric signatures by: determining at least one of the number of said entries and a duration of each said entry.*** More specifically, as discussed above, both Face ID and Touch ID require a specific number of entries to enroll a Touch ID or Face ID. The Accused Instrumentalities must determine that the specific number of entries have been input. Likewise, while not necessary for the claim, upon information and belief, the Accused Instrumentalities determine that each input of either facial or fingerprint data is of a sufficient duration. Again, when setting up Touch ID in the Accused Instrumentalities, the users are required to touch the home button with their finger several times for a certain duration. Similarly, the users need to scan their face twice, and each scan requires the users to move their head in a circle for a certain duration for Face ID. Touch ID: Register a fingerprint for Apple Touch ID by the user tapping a finger several times on the home button to record the fingerprint data. (https://video.search.yahoo.com/yhs/search?fr=yhs-pty-pty_ converter&hsimp=yhs-pty_converter&hspart=pty&p=registering+ fingerprint+apple+touch+id+on+screen+instructions#id=1&vid= 156de65ae06ca453643009fc0ea9cf79&action=click) Touch ID: The user's finger must remain on the home button long enough for the data to be recorded. "Touch the Touch ID sensor with your finger, but don't press it. Hold it there until you feel a quick vibration, or until you're asked to lift your finger." "Continue to lift and rest your finger slowly, making small adjustments to the position of your finger each time." (https://support.apple.com/en-au/HT201371) Touch ID: "you shouldn't tap too quickly or move your finger around" (https://support.apple.com/en-us/HT207537) Face ID: Setting up Face ID requires two scans of the user's face. Each scan asks users to move their head slowly in a circle to register different angles of the user's face. (https://www.imore.com/how-set-face-id-iphone)

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17a3. mapping said series into an instruction; and	***The Accused Instrumentalities include a transmitter sub-system controller configured to map said series into an instruction.*** More specifically, the Secure Enclave of the iPhone contains means to assign the received row to an instruction: The Secure Enclave, after receiving the full set of entries of the biometric signal, assigns this set to an instruction for processing, encrypting and storing the biometric signature ("Touch ID and Face ID template data"). "The sensor captures the biometric image and securely transmits it to the Secure Enclave. During enrollment, the Secure Enclave processes, encrypts, and stores the corresponding Touch ID and Face ID template data." (Ex. A, Apple Platform Security, at 19.) To carry out this instruction, the Secure Enclave has its own processor: "The Secure Enclave Processor provides the main computing power for the Secure Enclave." (*Id.*, at 10.) **Touch ID** The instruction here involves the processing of under-the-skin fingerprint characteristics and their encrypted storage. "The analysis uses subdermal ridge flow angle mapping, a lossy process that discards "finger minutiae data" that would be required to reconstruct the user's actual fingerprint. During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches, but without any identity information." (*Id.*, at 19.) **Face ID**

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	The instruction involves the transformation of the set of entries of the biometric signal captured via the Face ID scans into a mathematical representation, i.e. the biometric signature of the face in question by the Secure Neural Engine of the Secure Enclave, as well as its encryption and storage. "A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses. " (*Id.*, at 20.) "Face ID data, including mathematical representations of a user's face, is encrypted and available only to the Secure Enclave. This data never leaves the device. It's not sent to Apple, nor is it included in device backups. The following Face ID data is saved, encrypted only for use by the Secure Enclave, during normal operation: • The mathematical representations of a user's face calculated during enrollment • …" (*Id.*, at 23.)
17a4. populating the database according to the instruction;	***The Accused Instrumentalities include a transmitter sub-system controller configured to populate the database according to the instruction.*** More specifically, the Secure Enclave stores the biometric signature, i.e. the encrypted mathematical representation of the fingerprint or face, in the database 105, i.e. the "secure nonvolatile storage": "The secure nonvolatile storage is used for all anti-replay services in the Secure Enclave. Anti-replay services on the Secure Enclave are used for revocation of data over events that mark anti-replay boundaries including, but not limited to, the following: • … • … • Adding or removing a Touch ID fingerprint or Face ID face". (Ex. A, Apple Platform Security, at 16.)

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	"During enrollment, the Secure Enclave processes, encrypts, and stores the corresponding Touch ID and Face ID template data." (*Id.*, at 19.) **Touch ID** "During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches...." (*Id.*) **Face ID** The following Face ID data is saved, encrypted only for use by the Secure Enclave, during normal operation: • The mathematical representations of a user's face calculated during enrollment". (*Id.*, at 23.)
17b. receiving the biometric signal;	***The Accused Instrumentalities are configured to receive the biometric signal.*** More specifically, the iPhone has at least one biometric sensor for capturing a fingerprint or a face (Touch ID and/or Face ID), namely a Touch ID sensor and a camera system with image sensor, respectively. **Touch ID** "Apple devices with a Touch ID sensor can be unlocked using a fingerprint." (Ex. A, Apple Platform Security, at 19.) "Touch ID is the fingerprint sensing system that makes secure access to supported Apple devices faster and easier. This technology reads fingerprint data from any angle and learns more about a user's fingerprint over time, with the **sensor** continuing to expand the fingerprint map as additional overlapping nodes are identified with each use."

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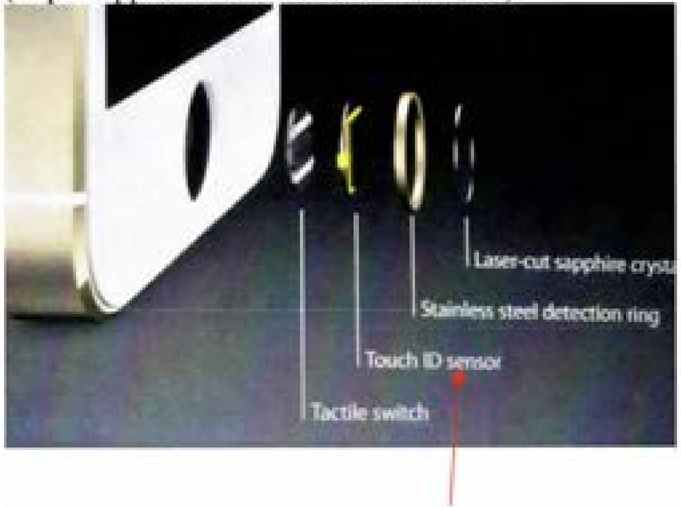
	(*Id.*) "When the fingerprint sensor detects the touch of a finger, it triggers the advanced imaging array to scan the finger and sends the scan to the Secure Enclave." (*Id.*) The biometric sensor for Touch ID is located below the home button: "The Home button is a stack of different materials, capped with a sapphire crystal lens. The surrounding stainless-steel ring works as a ground and detects the user's finger. This action activates a capacitive touch sensor installed underneath the cover: A CMOS chip with small capacitors." (https://appleinsider.com/inside/touch-id)  Laser-cut sapphire crysta Stainless steel detection ring Touch ID sensor Tactile switch Biometric sensor 121 "Where is the Touch ID sensor located?

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	The Touch ID sensor is located either in the home button or - on the iPad Air (4th generation) - in the top button. (https://support.apple.com/en-us/HT201371) The image sensor captures an 88-by-88-pixel, 500 PPI raster scan: "The 88-by-88-pixel, 500-ppi raster scan is temporarily stored in encrypted memory within the Secure Enclave while being vectorized for analysis, and then it's discarded. The analysis utilizes subdermal ridge flow angle mapping, which is a lossy process that discards minutia data that would be required to reconstruct the user's actual fingerprint. The resulting map of nodes is stored without any identity information in an encrypted format that can only be read by the Secure Enclave, and is never sent to Apple or backed up to iCloud or iTunes. " (Ex. C, iOS Security white paper, at 8.) **Face ID** The biometric sensor for facial biometrics is a camera system ("TrueDepth camera system") with an image sensor. "With a simple glance, Face ID securely unlocks supported Apple devices. It provides intuitive and secure authentication enabled by the TrueDepth camera system, which uses advanced technologies to accurately map the geometry of a user's face. " (Ex. A, Apple Platform Security, at 20.) To receive a biometric signal, the camera system with image sensor reads over 30,000 infrared points to capture depth information along with a two-dimensional infrared image. "After the TrueDepth camera confirms the presence of an attentive face, it projects and **reads over 30,000 infrared dots to form a depth map of the face along with a 2D infrared image**. This data is

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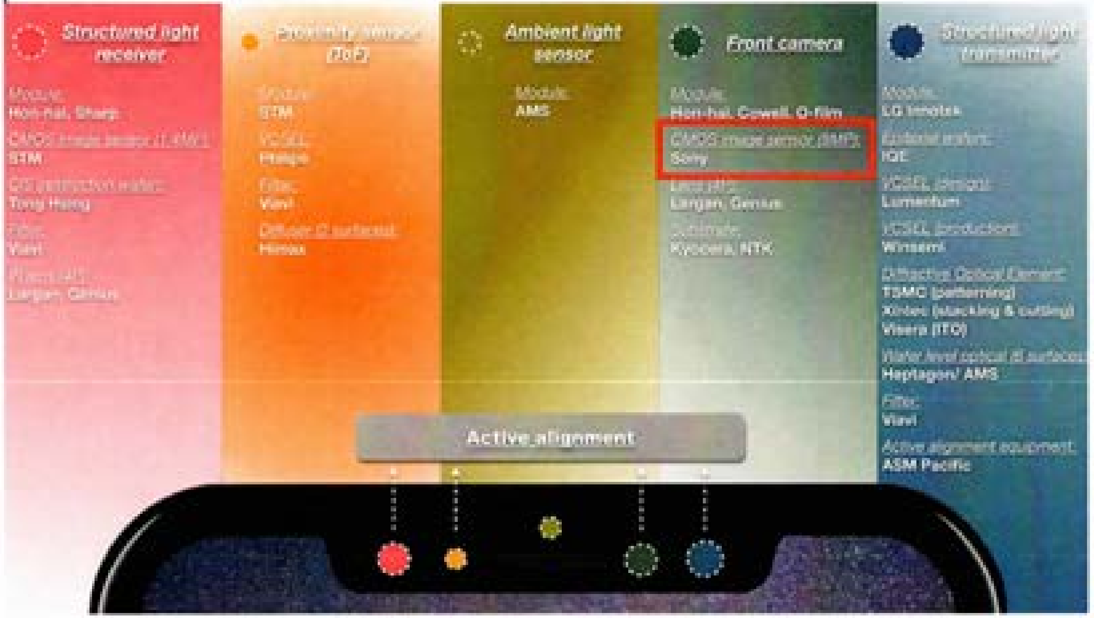
	used to **create a sequence of 2D images and depth maps**, which are digitally signed and sent to the Secure Enclave. To counter both digital and physical spoofs, the TrueDepth camera randomizes the sequence of 2D images and depth map captures, and projects a device-specific random pattern. A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (*Id.*, at 20.) The camera system includes a biometric image sensor, namely a "CMOS image" sensor from Sony, to perform facial biometrics:  Structured light receiver Module: Hon-hai, Sharp CMOS image sensor (1.4MP): STM CIS reconstruction wafer: Tong Hsing Filter: Viavi Lens (4P): Largan, Genius Proximity sensor (ToF) Module: STM VCSEL: Philips Filter: Viavi Diffuser (2 surfaces): Himax Ambient light sensor Module: AMS Front camera Module: Hon-hai, Cowell, O-film CMOS image sensor (8MP): Sony Lens (4P): Largan, Genius Substrate: Kyocera, NTK Structured light transmitter Module: LG Innotek Epitaxial wafers: IQE VCSEL (design): Lumentum VCSEL (production): Winsemi Diffractive Optical Element: TSMC (patterning) Xintec (stacking & cutting) Visera (ITO) Wafer level optical (6 surfaces): Heptagon/ AMS Filter: Viavi Active alignment equipment: ASM Pacific Active alignment (https://appleinsider.com/articles/17/09/09/inner-workings-of-apples-face-id-camera-detailed-in-report)

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17c. matching the biometric signal against members of the database of biometric signatures to thereby output an accessibility attribute;	***The Accused Instrumentalities include a transmitter controller configured to emit a secure access signal conveying information dependent upon said accessibility attribute.*** More specifically, the iPhone's System on Chip (SOC), i.e. the Secure Enclave with its Secure Enclave Processor (SEP) or a Secure Neural Engine contained therein, is a means (103) to check a match of the biometric signal with elements of the biometric signature database. "The *Secure Enclave* is a system on chip (SoC) that is included on all recent iPhone, ... devices" (Ex. A, Apple Platform Security, at 7.) "During **matching**, the Secure Enclave **compares** incoming data from the biometric sensor against the stored templates **to determine whether to unlock the device** or respond that a match is valid (for Apple Pay, in-app, and other uses of Touch ID and Face ID). " (*Id.*, at 19.) The biometric signal received from the biometric sensor ("incoming data from the biometric sensor") is thus checked by the Secure Enclave and its SEP with the elements of the database of biometric signatures 105, i.e. the "stored templates", for the presence of a match. For Touch ID, the Secure Enclave match verification is performed as follows: "The Secure Enclave is responsible for processing fingerprint data from the Touch ID sensor, determining if there is a match against registered fingerprints, and then enabling access or purchases on behalf of the user ..." (Ex. C, iOS Security white paper, at 7.) "During enrollment, the resulting map of nodes is stored in an encrypted format that can be read only by the Secure Enclave as a template to compare against for future matches...." (Ex. A, Apple Platform Security, at 19.)

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	"Touch ID can read multiple fingerprints, and it can read fingerprints in 360-degrees of orientation. It then creates a mathematical representation of your fingerprint and compares this to your enrolled fingerprint data to identify a match and unlock your device. " (https://support.apple.com/en-us/HT204587) "Touch ID can read multiple fingerprints and recognize fingerprints at any orientation of the finger. The system then creates a mathematical representation of your fingerprint and compares it to the registered fingerprint data to determine a match and unlock your device." (https://support.apple.com/de-de/HT204587) For **Face ID,** the Secure Enclave has a neural network protected by it, i.e., a Secure Neural Engine, which is used to verify the match: "Face ID uses neural networks for determining attention, **matching**, and antispoofing, so a user can unlock their phone with a glance." (Ex. A, Apple Platform Security, at 20.) "A portion of the Secure Neural Engine-protected within the Secure Enclave-transforms this data into a mathematical representation and compares that representation to the enrolled facial data. This enrolled facial data is itself a mathematical representation of the user's face captured across a variety of poses." (*Id.*). "Facial matching security Facial matching is performed within the Secure Enclave using neural networks trained specifically for that purpose... Face ID data, including mathematical representations of a user's face, is encrypted and available only to the Secure Enclave. This data never leaves the device." (*Id.* at 23.) When the Secure Enclave, or more precisely the Touch ID or Face ID subsystem within the Secure Enclave, has determined that a match exists, an accessibility attribute is issued by the corresponding

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	Touch ID or Face ID subsystem. This Touch ID or Face ID subsystem is also referred to as the SBIO. The accessibility attribute confirms that there is a match and that the iPhone is to be unlocked ("... determine whether to unlock the device ..."). This confirmation of the match is signaled by the SBIO by issuing a random secret to which only the Touch ID or Face ID subsystem within the Secure Enclave has access: "During matching, the Secure Enclave compares incoming data from the biometric sensor against the stored templates to determine whether to unlock the device [...]." (*Id.* at 19.) "Uses for Touch ID and Face ID **Unlocking a device or user account** [...] **keys for the highest class of Data Protection-which** are **held in the Secure Enclave** [...]. With Touch ID or Face ID enabled, the keys aren't discarded when the device or account locks; instead, **they're wrapped with a key that's given to the Touch ID or Face ID subsystem inside the Secure Enclave**. When a user attempts to unlock the device or account, **if the device detects a successful match, it provides the key for unwrapping the Data Protection keys**, and the device or account is unlocked. This process provides additional protection by requiring cooperation between the Data Protection and Touch ID or Face ID subsystems to unlock the device." (*Id.* at 24.) "The class key is protected with the hardware UID and, for some classes, the user's passcode." (*Id.* at 85.) **"Complete Protection** *(NSFileProtectionComplete):* The class key is protected with a key derived from the user passcode or password and the device UID. Shortly after the user locks a device (10 seconds, if the Require

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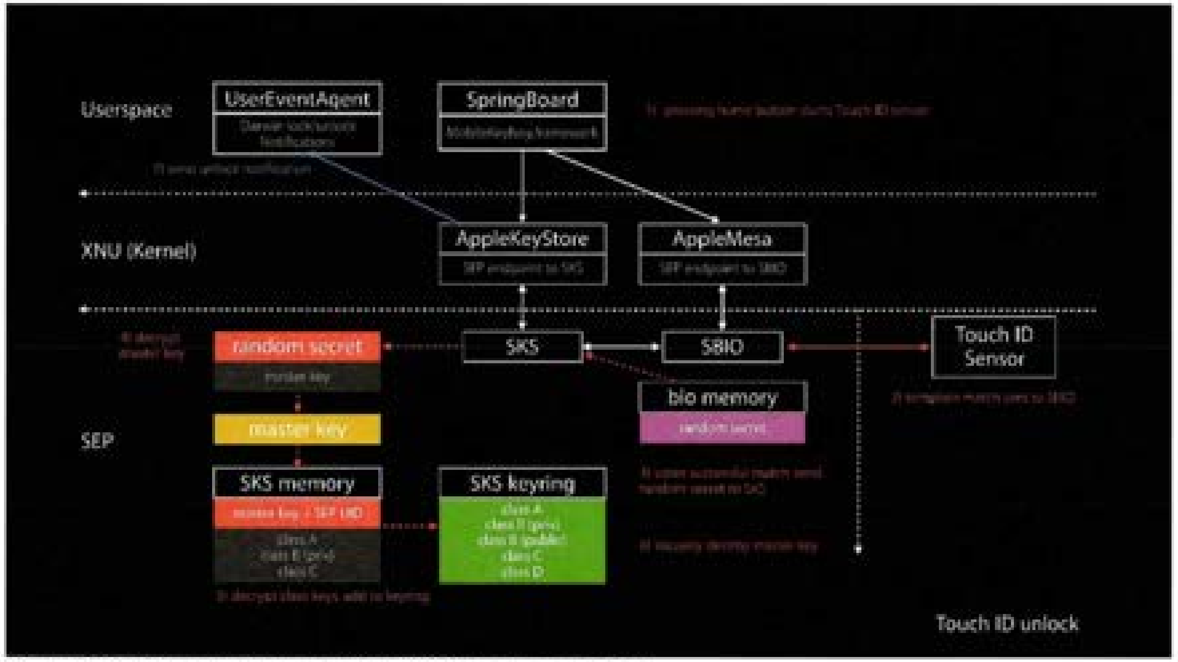
	Password setting is Immediately), the decrypted class key is discarded, **rendering all data in this class inaccessible until the user** enters the passcode again or **unlocks** (logs in to) **the device using Touch ID or Face ID."** (*Id.* at 86.) The Touch ID or Face ID subsystem within the Secure Enclave is the SBIO shown below. SBIO is an application that runs within the Secure Enclave on the SEP and is responsible for checking the match of biometric features. SBIO receives the corresponding biometric data from a biometric sensor, such as the Touch ID sensor. The random secret is stored in a memory ("bio memory") associated with the SBIO and is output from the bio memory upon match, see step 3 in the diagram below ("3) upon sucessful match send random secret to SKS"):  (Ex. B, Behind the Scenes with iOS Security, at 34.)

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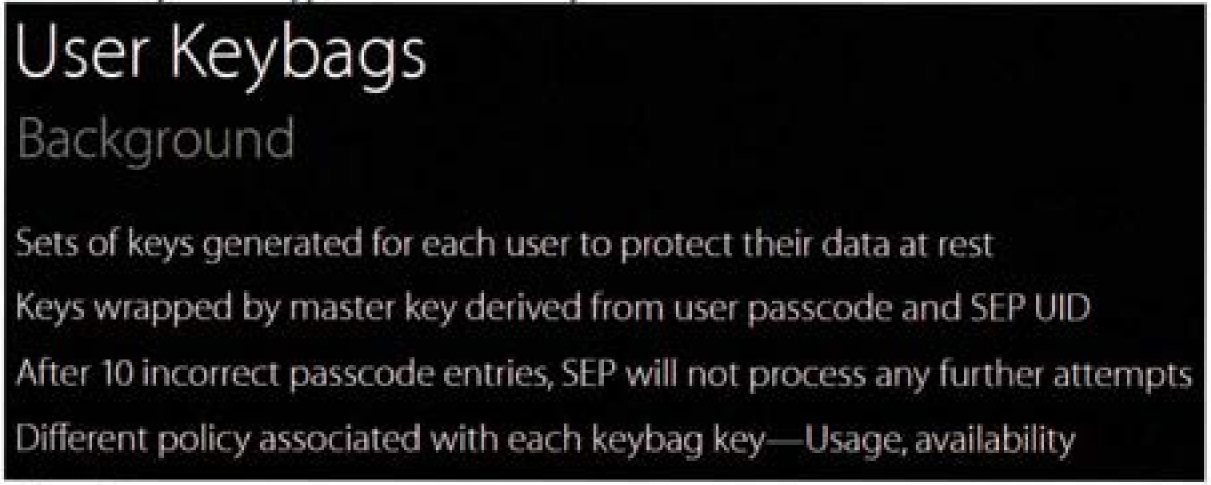
	The class keys are encrypted with a master key:  User Keybags Background Sets of keys generated for each user to protect their data at rest Keys wrapped by master key derived from user passcode and SEP UID After 10 incorrect passcode entries, SEP will not process any further attempts Different policy associated with each keybag key—Usage, availability (*Id.*, at 25.) The random secret is issued to SKS. SKS is a Secure Key Service application which is located within the Secure Enclave on the SEP and is responsible for decrypting class keys. The random secret provided by SBIO is used to decrypt a master key ("4) decrypt master key"). The master key is concatenated with the UID of the SEP and thus class keys are decrypted and added to the SKS keyring ("5) decrypt class keys, add to keyring") for further use by the Secure Enclave. The decrypted class keys include, for example, the class key of class A.
17d. emitting a secure access signal conveying information dependent upon said accessibility attribute; and	***The Accused Instrumentalities include a transmitter configured to emit a secure access signal conveying information dependent upon said accessibility attribute.*** For example, the Secure Enclave emits a signal with ephemerally re-encrypted file keys:

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	"sepOS can then use the ephemeral wrapping key to wrap file keys for use by the Application Processor file-system driver. When the file-system driver reads or writes a file, it sends the wrapped key to the AES Engine." (Ex. A, Apple Platform Security, at 14.) "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. [...] When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and sent back to the Application Processor." (*Id.* at 85.) The signal with the ephemerally re-encrypted file keys is a secure signal because it comes from the Secure Enclave and thus from a secure environment. Furthermore, the signal is secure because the transmitted information is encrypted. The emitted file keys are encrypted with the ephemeral key: "All wrapped file key handling occurs in the Secure Enclave; the file key is never directly exposed to the Application Processor. At startup, the Secure Enclave negotiates an ephemeral key with the AES Engine. When the Secure Enclave unwraps a file's keys, they're rewrapped with the ephemeral key and sent back to the Application Processor." (*Id.*)

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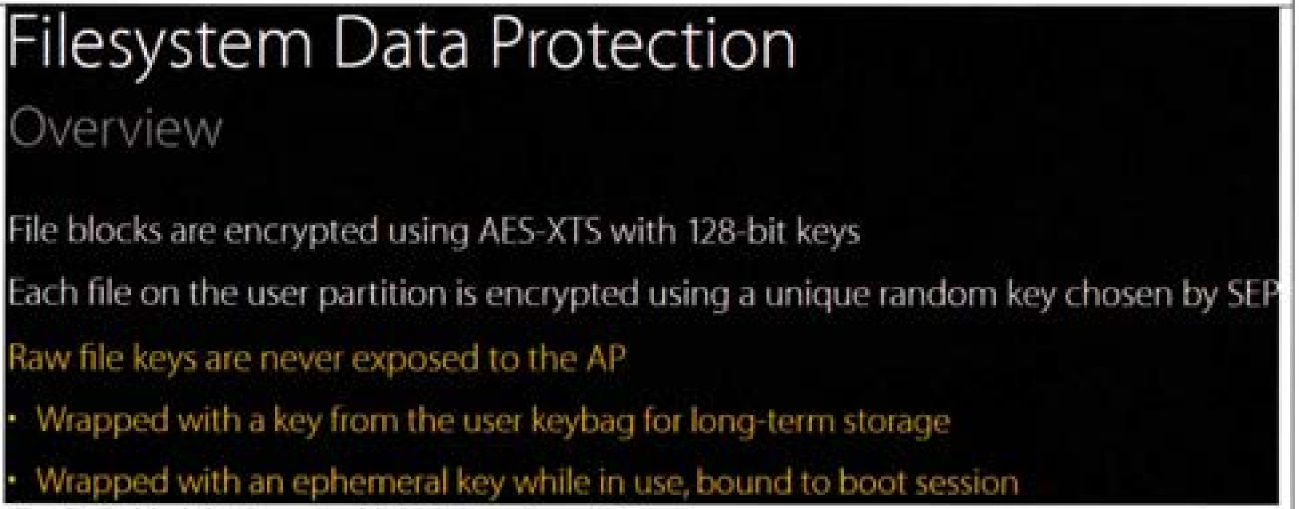
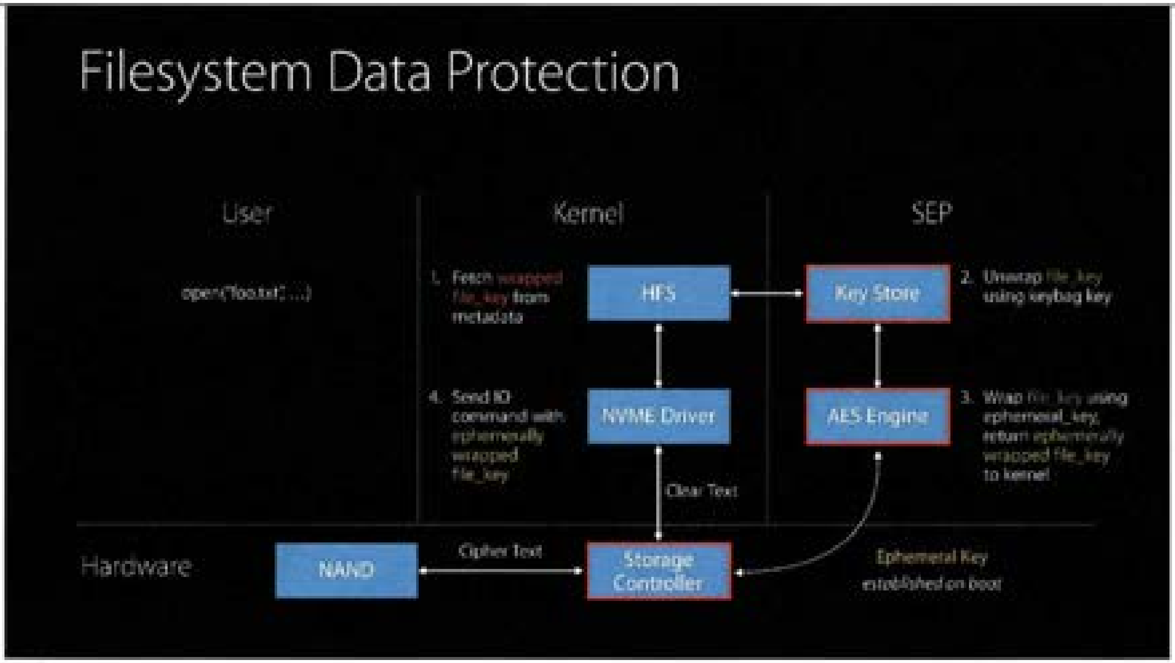
	 Filesystem Data Protection Overview File blocks are encrypted using AES-XTS with 128-bit keys Each file on the user partition is encrypted using a unique random key chosen by SEP Raw file keys are never exposed to the AP • Wrapped with a key from the user keybag for long-term storage • Wrapped with an ephemeral key while in use, bound to boot session (Ex. B, Behind the Scenes with iOS Security, at 29.)

<u>**Claim 17**</u>	<u>**Accused Instrumentalities**</u>
	 Filesystem Data Protection User Kernel SEP open("foo.txt", ...) 1. Fetch wrapped file_key from metadata HFS Key Store 2. Unwrap file_key using keybag key 4. Send IO command with ephemerally wrapped file_key NVME Driver AES Engine 3. Wrap file_key using ephemeral_key, return ephemerally wrapped file_key to kernel Clear Text Hardware NAND Cipher Text Storage Controller Ephemeral Key established on boot (*Id.*, at 30.) The information transmitted by the emitted signal, i.e., the ephemerally re-encrypted file keys, is dependent on the availability attribute, i.e., the confirmation that a biometric "template match" exists. This confirmation is signaled by the issuance of the random secret (cf. step 3): Only if there is a confirmation of the match and the random secret is issued by the Touch ID or Face ID subsystem within the Secure Enclave, i.e. SBIO, the class key is available for re-encrypting the file keys. The re-encrypted file keys are therefore information which is emitted depending on the fact that the availability attribute has been emitted.
17e. providing conditional access to the controlled	***The Accused Instrumentalities are configured to provide conditional access to the controlled item dependent upon said information.***

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item dependent upon said information, wherein the controlled item is one of: a locking mechanism of a physical access structure or an electronic lock on an electronic computing device.	More specifically, the controlled item is a locking mechanism of the door lock of the user's home. The Accused Instrumentalities are configured to provide secure access to the user's home via Yale Smart Locks when the user provides biometric signal to the Accused Instrumentalities via Touch ID or Face ID. "When the "Secure Remote Access" feature is turned on, the app will use your phone's built-in authentication tools to prompt fingerprint or facial recognition before you can unlock or lock your home remotely (note: if your phone does not have these features, it will prompt you to use your PIN code). This further ensures that your door is only operated by the right people at the time you intend for it." (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

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	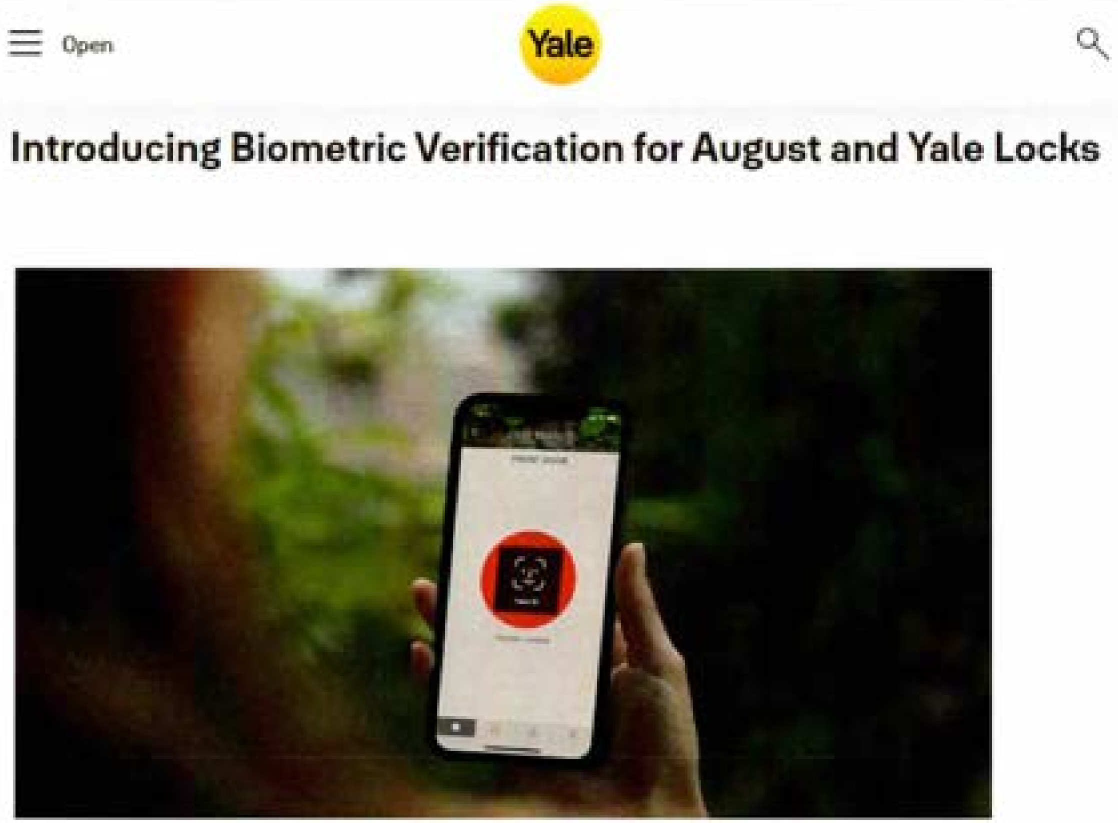 Introducing Biometric Verification for August and Yale Locks (https://us.yalehome.com/en/yale-news/blog/latest-blog-posts/introducing-biometric-verification-for-august-and-yale-locks1/)

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	(https://www.apple.com/shop/product/HPAR2ZM/A/yale-assure-lock-sl-touchscreen-deadbolt-black)