CLAIMS

1. A method of operating a superconducting channel, the method comprising:

providing a device comprising:

an electrical circuit including: an inductor,

a channel defined by a potentially superconducting material,

wherein the channel is structured as a wire,

a gate electrode positioned adjacent to the channel, such that an end surface of the gate electrode faces a portion of the channel, wherein a gap exists between the end surface of the gate and the portion of the channel, and

an electrically insulating medium arranged at least within the gap so as to electrically insulate the gate electrode from the channel;, and

a control unit connected to the gate and the channel;

rendering the channel superconducting by cooling down the device; and to a cryogenic temperature;

applying, by the control unit, a voltage difference between the gate electrode and the channel to inject electrons infrom the end surface of the gate into the channel through the electrically insulating medium, and thereby generate a gate current between the gate electrode and the channel, wherein the electrons are injected with an average energy sufficient to modify a critical current of the channel. during operation of the device at the cryogenic temperature;

adjusting, by the control unit, a kinetic inductance of the wire so as to adjust one of a resonant frequency or a cut-off frequency of the electrical circuit;

applying, by the control unit, a signal to the channel and altering the signal applied by modifying the critical current during the operation; and

allowing, by the control unit, a property of the channel or a property implied by the property of the channel to be measured during the operation, and the applied voltage difference to be controllably modified according to the measured property so as to adjust the property of the channel or the property implied by the property during the operation.

2. The method according to the preceding claim 1, wherein

the applying the voltage difference lowers the critical current to zero and thereby generates an electrical resistance in the channel at least locally at the portion of the channel.

3. The method according to ~~any of the preceding claims~~claim 2, wherein the method further comprises:

~~-~~switching off the voltage difference applied for the potentially superconducting material to self-reset to a fully superconducting state.

4. The method according to ~~any of the preceding claims and with features of~~ claim 2, wherein the ~~method further comprises:~~ applied voltage difference corresponds to a minimum value required to switch the channel to a normal state thereof, and wherein an impedance of the gate, as determined by the electrically insulating medium, is larger than 1 GΩ.

~~applying a signal to the channel, prior to the applying the voltage difference, whereby generating the electrical resistance in the channel impacts a transmission of the signal applied in the channel.~~

5. The method according to ~~the preceding~~ claim 1, wherein ~~the method further comprises:~~

~~repeatedly applying and switching off the voltage difference so as to modulate the applied signal.~~

~~6. The method according to the preceding claim, wherein~~

~~the applied signal is modulated at a frequency that is larger than 10 MHz and smaller than 10 GHz.~~

~~7. The method according to any of the preceding claims, wherein~~

an intensity of the gate current generated upon applying the voltage difference is at least ten times less than the critical current.

~~8~~6. The method according to ~~any of the preceding claims~~claim 1, wherein

an intensity of the gate current generated upon applying the voltage difference is between 10 pA and 10 nA.

~~9~~7. The method according to ~~any of the preceding claims~~claim 1, wherein

the voltage difference is applied such that the average energy is at least 100 times larger than a superconducting gap of the potentially superconducting material.

~~10. The method according to any of the preceding claims, wherein~~

~~the applied voltage difference corresponds to a minimum value required to switch the channel to a normal state thereof, and wherein an impedance of the gate electrode, as determined by the electrically insulating medium, is larger than 1 GΩ.~~

~~11. The method according to any of the preceding claims and with features of claim 2, wherein the method further comprises:~~

~~altering a strength of the voltage difference so as to controllably grow a region of the channel in which the electrical resistance is generated.~~

~~12. The method according to any of the preceding claims, wherein the method further comprises:~~

~~altering the voltage difference applied so as to adjust a property of the channel or a property implied by this property of the channel.~~

~~13. The method according to the preceding claim, wherein~~

~~the adjusted property of the channel is a kinetic inductance of the channel.~~

~~14. The method according to the preceding claim, wherein~~

~~the device further includes an electrical circuit having an inductor formed by the channel configured as a wire; and~~

~~the kinetic inductance is adjusted so as to adjust one of a resonant frequency or a cut-off frequency of the electrical circuit.~~

~~15. The method according to any of the preceding claims, wherein~~

~~the device is configured as a frequency-tunable coupler connected to quantum circuits of a quantum processing apparatus; and~~

~~the applying the voltage difference adjusts a resonator frequency of the frequency-tunable coupler and thereby modifies a coupling between the quantum circuits.~~

~~16~~8. An apparatus comprising:

~~a device~~ an electrical circuit including~~:~~ an inductor;

a device comprising:

a channel defined by a ~~potentially~~ superconducting material, the device configured to be operated at cryogenic temperatures that render the channel superconducting~~;~~, wherein the channel is structured as a wire,

a gate ~~electrode~~ positioned adjacent to the channel, such that an end surface of the gate ~~electrode~~ faces a portion of the channel, wherein a gap exists between the end surface of the gate and the portion of the channel, and

an electrically insulating medium arranged at least within the gap so as to electrically insulate the gate ~~electrode~~ from the channel; and

a control unit connected to the gate ~~electrode~~and the channel, the control unit being configured to~~:~~:

apply a voltage difference between the gate ~~electrode~~ and the channel so as to inject electrons ~~in~~from the end surface of the gate into the channel through the electrically insulating medium, and thereby generate a gate current between the gate ~~electrode~~ and the channel, wherein an average energy of the electrons is sufficient to modify a critical current of the channel during operation of the device at the cryogenic temperatures~~.~~,

~~17. The apparatus according to the preceding claim, wherein~~

~~the control unit is additionally connected to the channel, and~~

~~the control unit is further configured to both~~ adjust a kinetic inductance of the wire so as to adjust one of a resonant frequency or a cut-off frequency of the electrical circuit,

apply a signal to the channel and alter the signal applied by modifying the critical current during the operation~~.~~, and

~~18. The apparatus according to the preceding claim, wherein the control unit is further configured to~~ allow~~:~~

a property of the channel or a property implied by the property of the channel to be measured during the operation, and

the applied voltage difference to be controllably modified according to the measured property so as to adjust the property of the channel or the property implied by the property during the operation.

~~19~~9. The apparatus according to ~~any of the preceding claims 16 to 18~~claim 8, wherein

~~the channel is structured as a wire.~~

~~20. The apparatus according to the preceding claim wherein~~

~~the apparatus further comprises an electrical circuit including an inductor, and~~

~~the control unit is further configured to adjust a kinetic inductance of the wire so as to adjust one of a resonant frequency or a cut-off frequency of the electrical circuit.~~

~~21. The apparatus according to any of the two preceding claims, wherein~~

the device comprises a substrate forming the electrically insulating medium, and each of the gate ~~electrode~~ and the wire are structured on the substrate.

~~22~~10. The apparatus according to ~~the preceding~~ claim 9, wherein

a width of the wire is between 40 and 300 nm, and

~~a minimal~~the gap between the end surface of the gate ~~electrode~~ and the portion of the channel is between 40 nm and 300 nm, the width and the ~~minimal~~ gap being measured parallel to a main surface of the substrate.

~~23~~11. The apparatus according to ~~any of the preceding claims 16 to 22~~claim 8, wherein the potentially superconducting material comprises at least one member selected from the group consisting of: Ti, TiN, Nb, W, WSi, Al, and Mo.

~~24~~12. The apparatus according to ~~any of the preceding claims 16 to 23~~claim 8, wherein

the apparatus is configured as a quantum processing apparatus, which additionally ~~includes~~include quantum circuits, and

the channel of the device is connected to one or more of the quantum circuits.

~~25. The apparatus according to the preceding claim, wherein the device is configured as one of:~~

~~a switch for switching radio frequency signals applied to the channel; or~~

~~a frequency tunable coupler for modifying a coupling between two or more of the quantum circuits.~~