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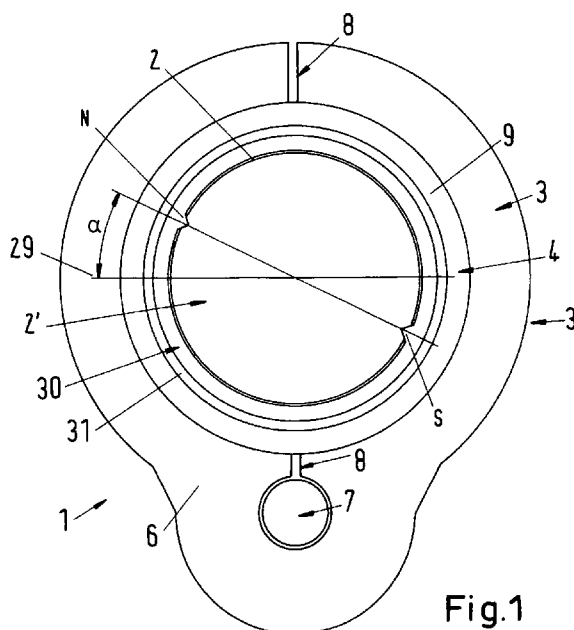
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- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
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(54) **Title:** THERMALLY INDEPENDENT OVERCURRENT TRIPPING DEVICE



(57) **Abstract:** The invention is about an electrical overcurrent tripping device (1) for a circuit breaker (10), said tripping device (1) comprising an actuating member (2) which in case of an overcurrent is driven to interact directly or indirectly with a movable contact piece (13) of the circuit breaker to open a contact point (11) in the circuit breaker if said overcurrent is exceeding a pre-set tripping threshold for a predetermined tripping delay time. Said actuating member (2) is coupled to a magnetic circuit (3) whereby the driving force acting on the actuating member (2) is created by the magnetic field of the magnetic circuit, said magnetic field being induced by the overcurrent, that said actuating member (2) is coupled to an electromagnetic damping arrangement (4) to set the tripping delay time, and that said actuating member (2) is connected to a coupling spring (5) configured to adjust the overcurrent tripping threshold.

Thermally independent overcurrent tripping device

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Specification

The invention relates to an electrical overcurrent tripping device for a circuit breaker, said circuit breaker having at least one contact point with a fixed and a movable contact
10 piece, said tripping device comprising an actuating member which in case of an overcurrent is driven to interact directly or indirectly with the movable contact piece to open the contact point if said overcurrent is exceeding a pre-set tripping threshold for a pre-determined tripping delay time, according to the preamble of claim 1.

15 The invention further relates to an installation switching device with an electrical overcurrent tripping device, said switching device having at least one contact point with a fixed and a movable contact piece, said tripping device comprising an actuating member which in case of an overcurrent is driven to interact directly or indirectly with the movable contact piece to open the contact point if said overcurrent is exceeding a pre-
20 set tripping threshold for a pre-determined tripping delay time, according to the preamble of claim 9.

Overcurrent trip and installation switching devices of the kind mentioned usually are electro- mechanical devices. The point of contact comprises a fixed contact member
25 and a movable contact member which is held by a movable contact arm or contact bridge. In the closed position the movable contact member is pressed against the fixed contact member influenced by the force of a contact spring.

Trip devices and installation switching devices of the kind mentioned usually also comprise a mechanical gear mechanism with a latch and a spring force based energy storage assembly.
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Further on, a tripping device as known in the art in case of a tripping condition acts on the latch, which then releases the energy from the energy storage so that the gear
35 mechanism can act upon the contact lever or contact bridge in order to open the point of contact.

A tripping action of the overcurrent tripping device is triggered if the current flowing through the installation switching device exceeds the nominal current considerably over a given period of time. The time that has to pass by until a tripping event occurs depends on the strength of the overcurrent. The stronger the overcurrent, the shorter is the time until a tripping action occurs. The characteristic dependence between overcurrent and trip time is called the "time invert trip curve". There are standards describing the time invert trip curves, classified in so called trip classes. At an overcurrent which is e.g. 1.5 time the nominal current, for example, typical trip times are between 1 and 10 minutes, for overcurrents 3 times higher than the nominal current trip times are in the range of 2 to 40 seconds, and for overcurrents in the range of 1.1 time the nominal current trip times can be as long as 30 minutes to several hours.

Known overcurrent tripping devices are using metal strips made of a bimetal or a thermal shape memory alloy as actuating member. The bimetal strip is heated up by the current flowing, either directly or indirectly, and heating causes the bimetal strip to bend. The thermal properties of the bimetal strip are designed such that in case of nominal current the bending of the bimetal strip is small enough so that no tripping action occurs. If however an overcurrent flows for some time, the bending becomes large enough to cause an interaction of the bimetal strip, either directly or indirectly via a tripping lever, with the gear mechanism which then causes the contact point to open. Such a device is shown for example in DE 10 2005 020 215 A1.

Such known thermal overcurrent tripping devices suffer from a cross-influence to ambient temperature. Increasing ambient temperature causes a bending that adds to the current-induced bending and would reduce the tripping threshold if not compensated for. Known solutions for compensating the ambient temperature effect are based on the application of a second bi-metal strip, called compensation bimetal, which is not heated by the current flow but only due to ambient temperature and whose bending direction is opposed to that of the tripping bi-metal. The temperature range that can be compensated by such compensation bimetals is however limited.

There are applications where circuit breakers are to be applied in an environment where a high ambient temperature variation might occur, for example up to 70°C, and where the cross-sensitivity of the tripping threshold should be minimal. Today there are no compensation means known to allow the reliable application of an installation switching device like a circuit breaker in applications with such large variations of ambient temperature.

The object of the present invention is to provide an overcurrent tripping device with a very low thermal cross-sensitivity to ambient temperature change.

It is a further objective of the present invention to provide an installation switching device with an overcurrent tripping device with a very low thermal cross-sensitivity to ambient temperature change.

According to the invention, the above object is achieved by an electrical overcurrent tripping device with the features as pointed out in claim 1. In respect to the installation switching device the objective is achieved by an installation switching device according to claim 9.

Advantageous embodiments are described in the characteristic features of the dependent claims.

According to the invention the actuating member is coupled to a magnetic circuit whereby the driving force acting on the actuating member is created by the magnetic field of the overcurrent, and the actuating member is coupled to an electromagnetic damping arrangement to set the tripping delay time, and the actuating member is connected to a coupling spring configured to adjust the overcurrent tripping threshold.

The advantage of the invention is basically that the overcurrent tripping is realised with a magnetic tripping setup, whereby a magnetic tripping device per se has none or only a very small thermal cross-sensitivity. The time invert trip curve is obtained by including an electromagnetically damped actuating member, where the magnetic driving force is created by the load current. Thus the thermomechanical behaviour of a bimetal strip when exposed to an overcurrent is more or less reproduced by the combination of electromagnetic damping and coupling to a coupling spring of a magnetic actuator.

According to an advantageous aspect of the invention the actuating member is an electromagnetically damped rotor in a magnetic circuit where the driving magnetic field is created by the load current.

According to an advantageous aspect of the invention the actuating member is a tubular rotor comprising a permanent magnet, and the magnetic circuit further comprises a tubular stator being part of the magnetic core of the magnetic circuit with at least one winding of a conductor embracing the magnetic core and carrying the load current,

whereby the stator at least partially embraces the rotor and the rotor is rotatably mounted within the stator.

The driving force provided by the current is countered with a spring force. If the current exceeds a certain value, the so called overcurrent threshold, then the driving force will overcome the spring counter force and start to rotate the rotor.

According to an advantageous aspect of the invention the tubular stator comprises soft magnetic and highly permeable material. Radially oriented slots can be used further to control the magnetic flux.

According to an advantageous aspect of the invention the device comprises an eddy-current type electromagnetic damping system for the rotor. The Eddy current is induced in the fixed body, meaning in the stator or in a part being fixedly connected to the stator.

According to an advantageous aspect of the invention the electromagnetic damping arrangement comprises a tube made of electrically conductive material which is located in a gap between the tubular stator and the tubular rotor, so that a damping power loss due to eddy-current generated in the tube is induced when the rotor is turning. In an advantageous embodiment, the tube can consist of copper, silver or other material or combinations with high electrical conductivity. The damping power loss and mass inertia will require time to complete the rotation to a certain angle. This time required sets the tripping delay time.

The opening of the contact point will be triggered when the rotation has completed to a pre-set angle after a time interval which is given by the force, the magnetisation, the eddy-current type damping and the mass inertia.

According to an advantageous aspect of the invention the coupling spring is coupled to the rotation axis of the tubular rotor.

An installation switching device according to the invention is characterized in that the actuating member is coupled to a magnetic circuit whereby the driving force acting on the actuating member is created by the magnetic field of the overcurrent, and that the actuating member is coupled to an electromagnetic damping arrangement to set the tripping delay time, and that the actuating member is connected to a coupling spring configured to adjust the overcurrent tripping threshold.

The invention will be described in greater detail by description of two embodiments with reference to the accompanying drawings, wherein

5 Fig. 1 shows a cross-sectional view of an electrical overcurrent tripping device according to the invention in a first embodiment,

Fig. 2 shows a schematic view of an installation switching device with an electrical overcurrent tripping device according to the invention.

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Same or similar elements or elements with a similar effect have the same reference numerals.

Fig 1 shows a tubular stator 6 made of a soft magnetic and magnetically highly permeable material, e.g. iron. At its lower border area there is an additional bore in which a conductor 7 is held. The conductor carries the current of the current path. The current creates a magnetic field which inside the tubular stator has a direction approximately parallel to the line 29. The tubular stator 6 has one or several slots 8, oriented in radial direction. The purpose of the slots 8 is to prevent the magnetic flux created by the conductor to be completely kept within the iron circuit or magnetic circuit 3 of the stator 6. Inserted into and attached to the inner contour of the iron stator 6 there is a copper tube 9. An actuating member 2 in form of a tubular rotor 2', comprising a permanent magnet, is held inside the inner opening of the tubular stator 6, being rotatably mounted on an axis which is coaxial to the central axis of the tubular stator 6. The tubular rotor 2' is encased by an aluminium tube 30, for mechanical support and protection reasons. Between the outer contour of the aluminium tube 30 and the inner contour of the copper tube 9 there is an air gap 31. The rotor 2' is press-fitted into the aluminium tube 30, additionally being fixed by two noses protruding from the aluminium tube 30 and fitting into two grooves N and S in the rotor 2'. The thought line connecting the grooves N and S may indicate the orientation of the magnetic field of the permanent magnet comprised by the rotor 2', but does not have to. As can be seen in fig. 1, the magnetic field of the permanent magnet from the rotor 2' and the magnetic field generated by the conductor 7 enclose an angle α of between 10° and 40° , preferably about 30° .

35 An increase of the current flow through the conductor 7 will increase its magnetic field, resulting in a driving force turning the rotor 2' in a clockwise direction, increasing the angle α to a value of between 80° and 120° , preferably to approx. 110° . On one side, not shown in fig. 1, but in fig. 3, there is a spring acting on the axis of the rotor 2' apply-

ing a retaining torque. Only after the current in the conductor has exceeded a certain threshold value, the torque created by the magnetic field is sufficient to overcome the retaining torque of the spring and rotation of the rotor 2' will start. The rotation of the permanent magnet in the rotor induces eddy-currents in the copper tube 9, which provide damping by generating counteracting magnetic fields. The copper tube 9 in cooperation with the magnetic field of the permanent magnet in the rotor 2' thus forms an electromagnetic damping arrangement 4 for the rotor. The eddy current is thus induced in the stator. The mass inertia of the rotor mass contributes with a second order time integration effect. The described damping effects have as a result that the rotation of the rotor 2' does not happen immediately, but with a delay time.

Fig. 2 shows in a schematic view an installation switching device 21, e.g. a circuit breaker, having a housing 22 made of an insulating material. The switching device has on one side 23 a first connection terminal 24 for connection of a conductor, and on the opposite side 25 a second connection terminal 26 for connection of another conductor. A current path is flowing between the two connection terminals 24, 26 through the device 21. A contact point 11 comprises a fixed contact piece 12 and a movable contact piece 13, which is mounted on a movable contact lever 14. The circuit breaker 21 comprises a mechanical gear 15 which cooperates along a dotted function line 16 with the movable contact lever for permanent opening of the contact point 11 or closing of the same. The gear 15 can be manually operated by a handle 18 via a dotted function line 17.

An overcurrent trip device 1 as shown and described above in reference to fig. 1 is located inside the device 21 and part of the current path. The stator 6 is schematically shown as a bold bar, for ease of illustration. The axis of the rotor 2' of the overcurrent tripping device 1 has at its free end an excenter disk 19 or any other angular dependent movement which cooperates with a trip lever 20. The trip lever 20 cooperates via a dotted function line 21 with the gear 15 as well. The opposite side of the rotor axis is coupled to a spring 5 which is schematically shown as an arrow indicating the direction of the spring torque that is bears on the rotor 2'. In the case shown here the spring bears a torque directed in a counter-clockwise direction on the rotor axis.

In case of an overcurrent flowing through the device 21, a torque in clockwise direction will be exerted on to the rotor 2'. The damping force due to the electromagnetic damping in the eddy-current tube will exert a counter torque in counter clockwise direction. The arrow 28 in fig. 2 shows the resulting net torque which is directed in clockwise direction. The excenter disk 19 will on clockwise turning lift the trip lever 20, which on be-

ing actuated in such a way by the tripping device 1 will act via a dotted function line 27 with the gear 15 to permanently open the contact point 11.

5 The advantage of the setup according to figures 1 and 2 when used as an overcurrent tripping device in an application as shown in fig. 3 is that the tripping is independent of thermal cross-sensitivity, because tripping is due to electro magnetic effects as function of the line current.

10 Finally, the invention shall not be limited to the embodiments shown, but each equivalent shall certainly be comprised within the range of protection of this specification. For example, the stator could be formed as a single part or as a core assembled from two or more pieces. In another embodiment not shown here, the rotor would not have an aluminium tube. Protection of the permanent magnet could be achieved by other means as well. In yet another embodiment the grooves N and S are not at the North- and
15 South poles of the permanent magnet of the rotor.

List of reference signs

	1	overcurrent tripping device		19	excenter disk
5	2	actuating member		20	trip lever
	2'	rotor	25	21	circuit breaker
	3	magnetic circuit		22	housing
	4	damping arrangement		23	side
	5	coupling spring		24	connection terminal
10	6	stator		25	side
	7	conductor	30	26	connection terminal
	8	slot		27	dotted function line
	9	tube		28	arrow
	10	circuit breaker		29	line
15	11	contact point		30	aluminium tube
	12	fixed contact piece	35	31	air gap
	13	movable contact piece		32	middle bar
	14	contact lever		33	lower bar
	15	mechanical gear		34	fluxlines
20	16	dotted function line		35	solid arrow
	17	dotted function line	40	36	dotted arrow
	18	handle			

Claims

1. Electrical overcurrent tripping device (1) for a circuit breaker (10), said tripping device (1) comprising an actuating member (2) which in case of an overcurrent is driven to interact directly or indirectly with a movable contact piece (13) of the circuit breaker to open a contact point (11) in the circuit breaker if said overcurrent is exceeding a pre-set tripping threshold for a pre-determined tripping delay time,
characterized in that said actuating member (2) is coupled to a magnetic circuit (3) whereby the driving force acting on the actuating member (2) is created by the magnetic field of the magnetic circuit, said magnetic field being induced by the overcurrent, that said actuating member (2) is coupled to an electromagnetic damping arrangement (4) to set the tripping delay time, and that said actuating member (2) is connected to a coupling spring (5) configured to adjust the overcurrent tripping threshold.
2. Electrical overcurrent tripping device (1) according to claim 1, characterized in that the actuating member (2) is an electromagnetically damped rotor (2') in a magnetic circuit where the driving magnetic field is created by the load current.
3. Electrical overcurrent tripping device (1) according to claim 2, characterized in that the actuating member (2) is a tubular rotor (2') comprising a permanent magnet, and that the magnetic circuit further comprises a tubular stator (6) being part of the magnetic core of the magnetic circuit (3) with at least one winding of a conductor (7) embracing the magnetic core and carrying at least partly the load current, whereby the stator (6) at least partially embraces the rotor (2') and that the rotor (2') is rotatably mounted within the stator (6) .
4. Electrical overcurrent tripping device (1) according to claim 3, characterized in that the tubular stator (6) comprises soft magnetic and highly permeable material, and has radially oriented slots (8) to control the magnetic flux.
5. Electrical overcurrent tripping device (1) according to claim 3, characterized in that the device comprises an eddy-current type electromagnetic damping system (4) for the rotor.
6. Electrical overcurrent tripping device (1) according to claim 5, characterized in that the electromagnetic damping arrangement (4) comprises a tube (9) made of

electrically conductive material which is located in a gap between the tubular stator (6) and the tubular rotor (2'), so that a damping power loss due to eddy-current generated in the tube (9) is induced when the rotor (2') is turning .

- 5 7. Electrical overcurrent tripping device (1) according to claim 5, characterized in that the coupling spring is coupled to the rotation axis of the tubular rotor.
8. Circuit breaker (10) with an electrical overcurrent tripping device (1), said circuit breaker (10) having at least one contact point (11) with a fixed and a movable contact piece (12, 13), said tripping device (10) comprising an actuating member (2) which in case of an overcurrent is driven to interact directly or indirectly with the movable contact piece (13) to open the contact point (11) if said overcurrent is exceeding a pre-set tripping threshold for a pre-determined tripping delay time, characterized in that said actuating member (2) is coupled to a magnetic circuit (3) whereby the driving force acting on the actuating member (2) is created by the magnetic field of the overcurrent, that said actuating member (2) is coupled to an electromagnetic damping arrangement (4) to set the tripping delay time, and that said actuating member (2) is connected to a coupling spring (5) configured to adjust the overcurrent tripping threshold.

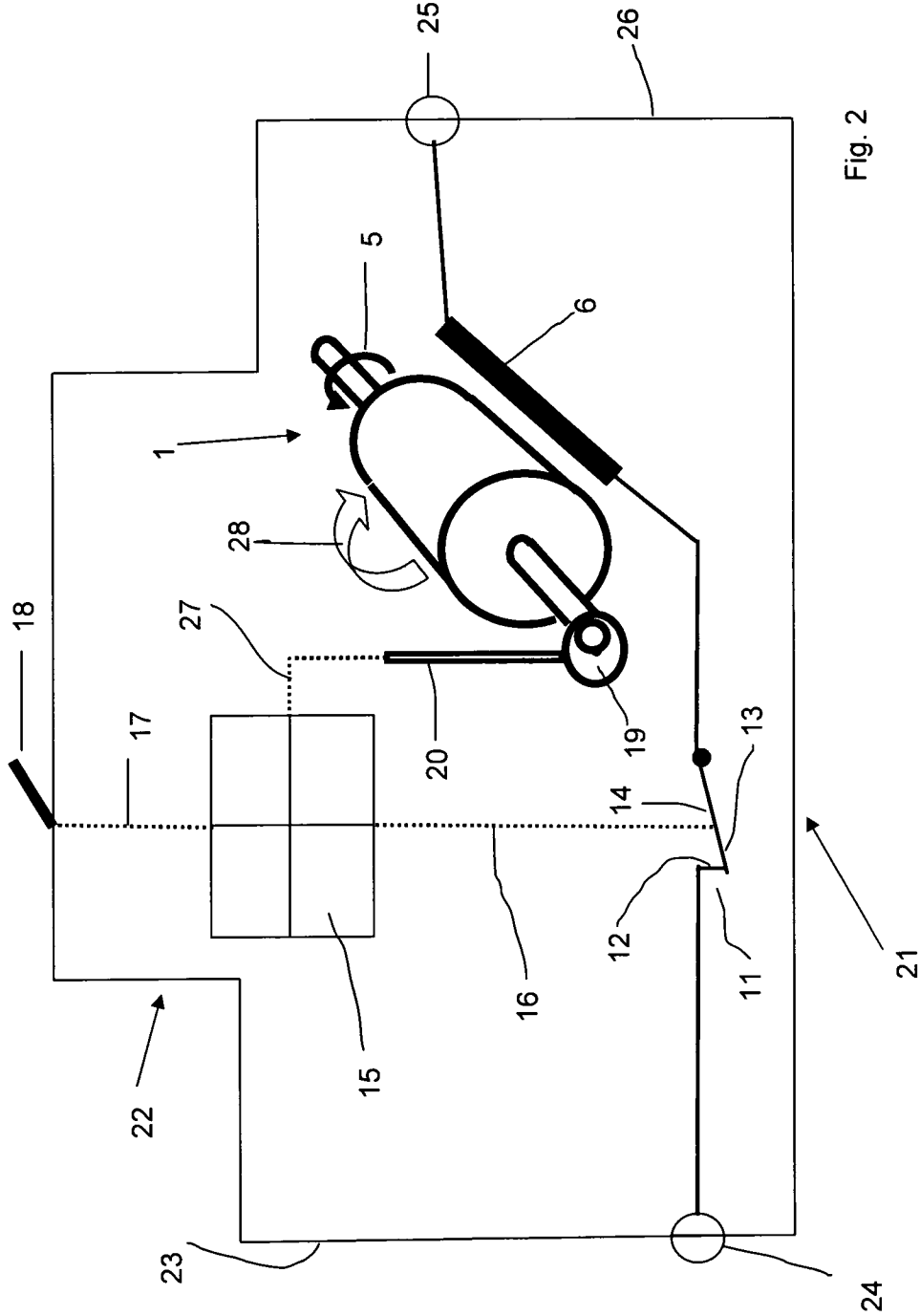


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2010/003045

A. CLASSIFICATION OF SUBJECT MATTER

INV. H01H71/32 H01H71/43

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01H H02H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 252 053 A (ERIC PADDISON) 17 May 1966 (1966-05-17) column 2, line 50 - column 6, line 44; figures 1-3	1,2,8
X	US 3 036 248 A (DAVID NELLIST BRIAN) 22 May 1962 (1962-05-22) columns 2-4; figures 1-3	1,2,8
X	GB 1 062 623 A (ENGLISH ELECTRIC CO LTD) 22 March 1967 (1967-03-22) pages 1-2; figure 1	1,2,8
X	GB 896 124 A (CHAMBERLAIN & HOOKHAM LTD) 9 May 1962 (1962-05-09) page 1; figures 1,2	1,2,8

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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Patent document cited in search report		Publication date	Patent family member(s)		Publication date
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