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CIRCUIT BREAKER HAVING IMPROVED ARCING CONTACT STRUCTURE

3,345,485

Filed Dec. 30, 1964

2 Sheets-Sheet 1

FIG. 1

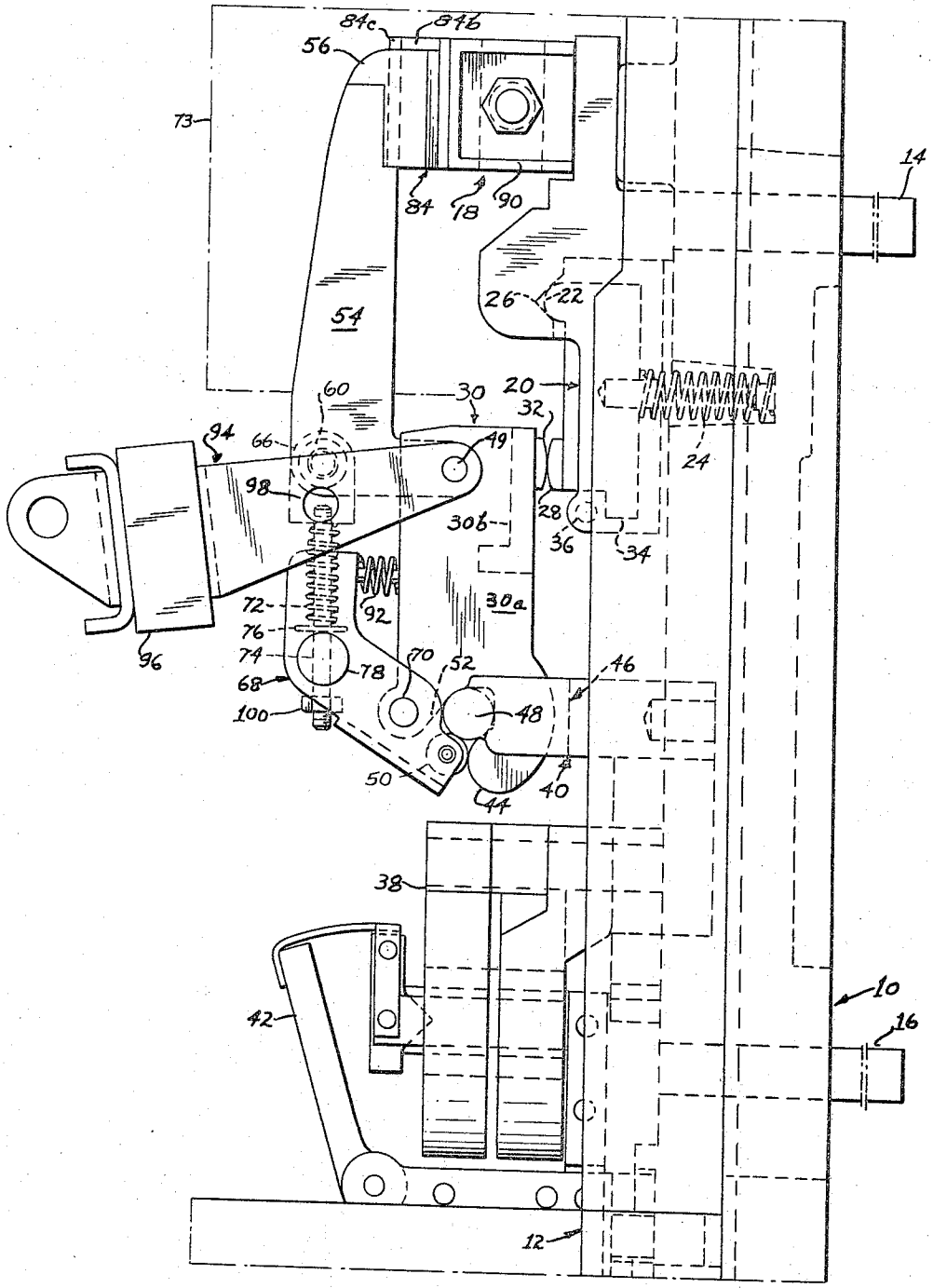

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FIG. 2

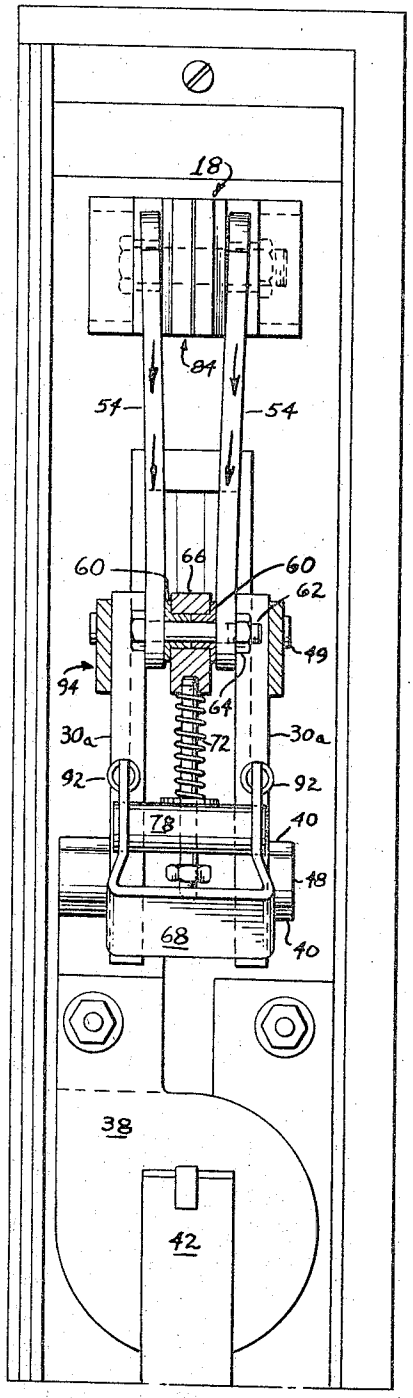


FIG. 4

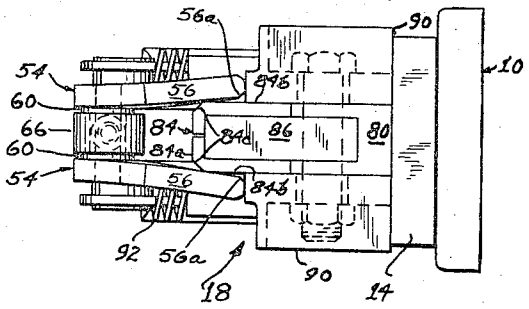
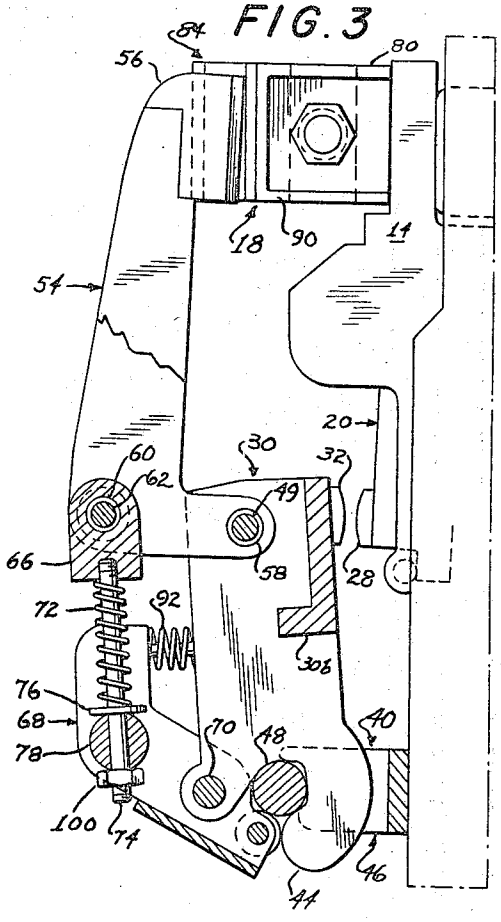


FIG. 3



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CIRCUIT BREAKER HAVING IMPROVED ARCING CONTACT STRUCTURE

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7 Claims. (Cl. 200—146)

ABSTRACT OF THE DISCLOSURE

A circular breaker of the type having face-to-face main contacts and laterally engaging arcing contacts. The arcing contacts momentarily by-pass the main contacts immediately after the main contacts move open for avoiding arcs at the main contacts. The arcing contacts include a pair of physically parallel elongated conductors pivoted to the moving main contact and biased together electrodynamically by the current flowing therein when the main contacts move open and a companion contact in lateral face engagement with both said conductors and disposed between them to be gripped forcibly during moments when high currents flow in the elongated conductors.

This invention relates generally to power circuit breakers and more particularly to the moving arcing contact assembly for such apparatus.

Each pole of an illustrative circuit breaker that is described in detail below includes a moving contact arm that carries main and arcing contacts into and out of contact engagement with companion stationary contacts. The main contacts are in substantially normal contact engagement with companion stationary contact and the arcing contacts are in substantially lateral face engagement with their companion contact. The arcing contacts are designed to part from companion stationary arcing contact only after the main moving contact arm has separated from its companion contact. Similarly, the arcing contacts engage their companion contact before the main contacts touch each other during the closing operation. The arcing contact assembly herein described may advantageously be employed together with a moving main contact assembly such as that shown and described in U.S. Patent No. 3,158,720 which is assigned to the assignee of the present invention.

An object of the present invention resides in the provision of an improved arrangement of the arcing contact assembly wherein retransfer of current from the arcing contact assembly to the main contact assembly is avoided during the breaker opening operation.

Yet another object of this invention is a provision of an arcing contact assembly wherein the "blow-off" effects due to the electrodynamic forces is minimized and the contact pressure between the moving arcing contacts and the stationary arcing contact is enhanced without additional structure or mechanism.

A further object of this invention relates to improvements in arcing contact assemblies wherein increased resistance to "blow-off" effects are achieved without developing excessive contact pressure such as would impose an excessive mechanical load on the contact-closing mechanism.

The illustrative embodiment of the invention which has been generally referred to above as incorporating the various novel features of the invention, is more fully described in the remainder of this specification, from which further novel features, objects and advantages will become apparent. In the following description reference is made to the accompanying drawings forming part of this disclosure.

In the drawings:

FIG. 1 is a side elevation of an illustrative circuit breaker embodying features of the invention;

FIG. 2 is a front elevation of the apparatus in FIG. 1 viewed from the left thereof, showing one pole with portions omitted and other portions broken away, this structure being similar to that shown and described in U.S. Patent No. 3,158,720 cited above;

FIG. 3 is a view similar to FIG. 1, of the moving contact assembly of a single pole, including main and arcing contact arms, the parts being shown with the arcing contacts in lateral face engagement with the stationary arcing contact and the main contacts parted; and

FIG. 4 is a plan view of a portion of the apparatus of FIG. 1 showing the moving arcing contacts in lateral face engagement of the stationary arcing contact.

It should be understood that although only one pole is illustrated in the drawings, the invention is particularly applicable to multi-pole circuit breakers of the type shown and described in U.S. Patent No. 3,097,275 which is assigned to the same assignee as the present invention. It is also contemplated that the operating mechanism of that patent will be employed in operating the contact structure herein described.

Referring now to the drawings, the illustrative pole comprises a block of insulation **10** which is carried by the frame **12**. Each block **10** supports the stationary and movable contacts in the pole. Each pole has a pair of rearwardly projecting terminals **14** and **16**. Terminal **14** extends through the block of insulating to the front thereof where it bears the stationary arcing contact **18**. A number of side-by-side main contact members **20** have hinge ends **22** that are biased by springs **24** into a groove **26** in terminal **14**. Contact segments **28** are brazed to the exposed faces of members **20**.

When the circuit breaker is closed as illustrated in FIG. 1, main contact members **20** are forcibly displaced to the right against their compression springs **24** by the cooperating movable main contact arm **30** which has contact segment **32** secured thereto. The contacts **28, 32** are in face or butt engagement. When contact arm **30** is operated to the left (as described in further detail below) so as to open the circuit breaker, compression springs **24** drive main contact members **20** clockwise about their hinge ends **22**. Ears **34** of contact members **20** limit their counterclockwise movement by engagement with stationary pin **36** (FIG. 3) supported between portions of the main contact assembly. In this way the main contacts **28, 32** are under substantial spring bias from the instant of engagement of contact arm **30** with the contact members **20**.

Terminal member **16** provide a conductive path through block **10** and through a two-turn over-current coil **38**, forward through a hinge block **40** to movable contact arm **30**. Cooperating with the over-current coil **38** is movable armature **42** and associated structure whose details are unnecessary to an understanding of the present invention.

As described in the aforementioned Patent 3,158,720 movable contact arm **30** is formed of a pair of vertical bars **30*a*** brazed to and thus united by horizontal part **30*b***. Contact arm **30** has a pair of laterally spaced hooks **44** (see also FIG. 3) that are received in slots **46** formed in block **40**, one for each hook **44**. A shaft **48** is united to block **40** and extends across the slots **46** in which hooks **44** are received. Members **30, 40** and **48** are of copper advantageously silver-plated, and form a hinge connection with extremely low resistance and high current capacity. Contact pressure is maintained between moving contact arm **30** and shaft **48** by a pressure roll **50** and a spring bias means to be described.

The conductivity of the hinge joint is excellent during normal conditions when currents of the order of 800 or 1,000 amperes may be carried. However, when short-circuit current of the order of 50,000 amperes are to be carried, the pressure between moving contact arm **30** and the hinge shaft **48** is greatly increased by virtue of the geometry of the conductors providing the main current path through the circuit breaker. There is a broad current loop extending horizontally through terminal **14** downward through the main contacts **20** and contact arm **30**, and horizontally through terminal **16**. This loop provides electrodynamic force tending to shift moving contact arm **30** to the left. Contact arm **30** thus tends to pivot clockwise about a mechanical operating pivot **49** (described below) building up the contact pressure of moving contact arm **30** against shaft **48**. This tendency of member **30** to move to the left in FIG. 1 is resisted by the hooks **44** extending about shafts **48**. Consequently, it is safe for notches defined by hooks **44** and the opposite portion **52** of arm **30** to open outwardly of the current loop through parts **14**, **20** and **16**.

The movable contact arm **30** bears a pair of laterally separated movable arcing contact arms **54** having contact portions **56** which cooperate with the stationary arcing contact **18**. The movable arcing contact arms **54** are pivoted on the main contact arm **30** on a conductive bushing **58** (FIG. 3) at the mechanical operating pivot **49**. The lateral separation between the arcing contact arms **54** is determined by a pair of opposed spacers **60** (FIG. 2) which are positioned therebetween about a bolt **62**. The spacers and the moving contacts **54** are tightly clamped together by a nut **64** on the bolt. A connecting block **66** is interposed between the moving contact arm **30** and arcing contact arms **54** and is adapted to pivot on the spacers **60**. Rocker member or lever **68** is carried on a pivot pin **70** which passes through moving contact arm **30**. In the closed condition of the circuit breaker, as illustrated in FIG. 1, and even when main contacts **28** and **32** are parted (FIG. 3) the arcing contact arms **54** are biased toward the stationary arcing contact **18** by compression spring **72** which acts against the block **66**. The coil spring is guided on rod **74** which is secured at one end to the block **66**. An insulated bushing **76** is interposed between the spring **72** and the block **66** to inhibit the flow of current through the spring. Rod **74** works slidably in a suitable bore in a shaft **78** that is rotatably mounted in rocker member **68**. The arcing contact arms **54** are biased clockwise, as a unit, by the spring **72** and pivot about the bushing **58** through which pin **49** is received in the moving contact arm **30**. Arcing contacts **18** and **54** engage at a point spaced vertically about the main contacts **28** and **32**, the arcing contact arms extending well up into an arc chute **73**, only part of which is shown by phantomed lines in FIG. 1. Paired movable arcing contacts and arc chutes of the type contemplated for use herein are shown and described in U.S. Patent No. 2,429,846.

Referring to FIG. 4 the stationary arcing contact **18** includes a substantially U-shaped member **80** which is secured to the terminal member **14**. The stationary arcing contact **18** has an arcing tip portion **84** which comprises a block **86** having arcing contact material applied to the end **84***a* and lateral faces **84***b* thereof. Block **86** is received between the legs of the U-shaped member **80**. Insulator members **90** are positioned on the lateral faces **84***b*. The block **86** and the insulators **90** are secured to the U-shaped member by a bolt and nut which provide a joint of good electrical conductivity and high mechanical strength. The leading edge of the arcing contact material is chamfered at **84***c* to cooperate with the beveled portions **56***a* of the arcing contact arms during the contact closing operation.

In a typical circuit breaker fabricated according to the teachings of the present invention, the spacers **60** between the arcing contact arms **54** provide a separation of three-eighths of an inch at that point. The contact arms are substantially parallel and measure four inches in length from the block **66** to the portions **56** which engage the stationary arcing contact **18**. The width of the tip **84** of the stationary arcing contact **18** is one-half inch where it is in lateral face engagement with the arcing contact **56**. The arms **54** are fabricated from a high-strength modified copper alloy such as Olin No. 605 and therefore although they have a typical cross section of one-quarter inch by seven-eighths of an inch and have been work hardened, they are still sufficiently resilient to be deflected so as to accommodate the interposition of the stationary contact **18** therebetween. Measurements have shown that a force of forty pounds must be applied to the arcing contact arms **54** laterally of the engaged face **84***b* of the arcing contact **18** in order to cause it to separate therefrom.

The reaction of the upward pressure by spring **72** against the arcing contact arms **54** is applied to rocker member **68** in a manner that also develops heavy bias of roller **50** against shaft **48**. The short lever arm between roller **50** and pivot pin **70** provides mechanical advantage that magnifies the force applied to shaft **48** by the spring **72** which acts on the longer lever arm between the axis of shaft **74** and pivot pin **70**. The bias on roller **50** provides normal operating contact pressure at the main hinge contact **44**, **48** of the movable contact arm **30**, this pressure being at its maximum in the contact "closed" or "on" position.

Compression springs **92** act between portions of members **30** and **68** well above the pivot pin **70** to augment the pressure developed by spring **72** between elements **44** and **48** when the circuit breaker is closed, and to provide hinge contact pressure when the circuit breaker is open and spring **72** no longer applies bias to rocker **68**. The pressure of springs **92** assures proper mechanical pivoting operation of the contact arm in times when the arcing contacts **54**, **18** are disengaged and it also provides good electrical contact at hinge **44**, **48** when the contacts are being opened. This is an important concern in the event that the circuit breaker is tripped open to interrupt the currents of short-circuit magnitude, 50,000 amperes for example. This augmented hinge-contact pressure is produced without correspondingly increasing the clockwise bias acting on the arcing contacts **54**. Any excessive increase in the arcing-contact bias beyond the value needed for establishing normal operating contact pressure would unnecessarily increase the force required to close the circuit breaker.

Shaft **49** extends laterally beyond both side faces of moving contact arm **30** and into the U-shaped member **94** carried by the common bar **96** which operates all the main contact arms and the arcing contacts of all the poles of the circuit breaker. The bar **96** and U-shaped member **94** form a driving link for moving the contact arms **30** between the open and closed position thereof. A pair of oppositely disposed holes **98** are provided in each of the U-shaped members **94** to provide access to the nut and bolt **62**, **64** which secure the arcing contact arms **54** together. Upon removal of pivot pin **49** and this nut and bolt, the arcing contact arms may be replaced.

When the circuit breaker is open, the movable arcing contacts **54** are spaced well away from the stationary arcing contact **18**. At this time, clockwise displacement of the arcing contacts **54** relative to the contact arm **30** due to the clockwise bias of spring **72** is adjustably limited by nut **100**. When the circuit breaker is in its closed configuration as illustrated in FIG. 1, nut or stop **100** has a small but definite separation from shaft **78**. This spacing is made large enough to insure counterclockwise travel of moving contact arm **30** to a sufficient angle in an opening stroke to allow ear **34** of the main contact members **20** to be arrested by pin **36** and for a definite separation to be developed between the main contacts represented by members **20** and contact arm **30**. When the main contacts **20**, **30** separate, the current flowing there-

through is transferred to the arcing contacts **54** and **18**. The arcing contact arm **54**, main contact arm **30** and the terminals **14** and **16** also form a broad current loop which tends to expand and which could result in "blowing-off" the arcing contact arms **54** from the stationary arcing contact **18**. However, the arcing contact arms **54** are in lateral face engagement with the arcing contact **18** and the current flowing through the arms **54** is flowing in the same direction as indicated by the arrows in FIG. 2 resulting in a mutual attraction between the arms. This mutual attraction enhances the contact pressure between the arms and the stationary contact at a time when maximum current is flowing therethrough. Any tendency of the contacts **56** to lift from the faces **84***b* of stationary arcing contact **18** is resisted by the already stressed arms **54** in a direction transverse to their normal pivotal path. The "pinch effect" aforedescribed prevents restrike of the arc between the main contacts **28**, **32** due to blowing off of the arcing contact arms **54** from the companion contact **18** but does prevent opening of the breaker.

During continued contact-opening travel of moving contact arm **30**, shaft **78** comes into engagement with stop **100**, as shown in FIG. 3. From this point on, operation of tie bar **96** in the opening direction provides positive drive to separate the arcing contacts **56** from the stationary arcing contact **18**.

It may now be considered that the circuit breaker is open or in an intermediate position with the main and arcing contacts parted rather than in the closed position shown. In the parted-contact condition springs **72** and **92** bias rocker member **68** counterclockwise about pivot **70** and thereby develop relatively heavy pressure of roller **50** against shaft **48**. The reaction force resulting at shaft **70** and contact arm **30** acts to force hooks **44** of the moving contact arm **30** against the face of shaft **48** opposite roller **50**.

When the circuit breaker is open and is to be closed, tie bar **96** is shifted to the right and the pivots **49** of the several poles are swung clockwise in unison about the common axis of the respective shafts **48**. Moving arcing contact arms in each pole wipe across and engage the companion contacts **18** as the complementary camming surfaces **56***a*, **84***c* formed thereon cooperate to deflect the moving arms **54** to each side of the stationary contact. The continued movement of the arcing contact arms **54** is arrested by the engagement of the ends of the arms and the insulators **90** (FIG. 3). During the inward movement the moving arcing contacts **56** in each pole engage the companion contacts and nuts **100** lift from shaft **78** as pivot shafts **49** continue their travel to the right. Thereafter, the moving contact arm **30** engages its companion contact members **20** in each of the poles of the breaker. Drive or tie bar **96** continues for a short distance after initial engagement of the main contacts **28** and **32**, building the contact pressure up by shifting the main contact **28** to the right, and increasing the compression that is maintained initially in springs **24** by ears **34** and pin **36**.

The aforedescribed construction of the moving contact and stationary arcing contact results in the elimination of the problems attributable to blow-off of the arcing contacts at the time that the short-circuit current is transferred from the main contacts to the arcing contacts without a substantial increase in the normal operating force required to close the circuit breaker. The pinch-effect enhances the contact pressure between the moving arcing contacts and stationary arcing contact at a critical time during the opening of the breaker without requiring the addition of complex structures to the moving or stationary assemblies.

The term "circuit breaker" as used in this application applies to apparatus intended to carry high currents and to interrupt currents of short-circuit magnitude; and accordingly the term "circuit breaker" is used in a generic sense, to apply also to switches having similar duty requirements.

The foregoing represents the presently preferred form in which the various aspects of the invention may be applied. However, various modifications will readily occur to those skilled in the art and, therefore, the invention should be broadly construed in accordance with its full spirit and scope.

What I claim is:

1. A circuit breaker including first and second terminal members, a movable main contact arm, a pair of relatively elongated slender resilient arcing contact arms pivotally mounted on said main contact arm, companion main contacts and a companion arcing contact electrically connected to said first terminal member, means pivotally mounting said main contact arm for movement from a closed position wherein said main contact arm abuts said companion main contacts and said arcing contact arms straddle said stationary arcing contact and are in lateral face engagement therewith to an open position, a driving link connected to said main contact arm for moving said main contact arm and said arcing contact arms between said open position and said closed position, means electrically connecting said main contact arm to said second terminal member, said resilient arcing contact arms being urged toward one another against the lateral faces of said companion arcing contact to enhance the contact pressure therebetween by electrodynamic forces due to high currents flowing through said arcing contact arms when said main contacts part.

2. A circuit breaker according to claim **1** wherein the portions of said arcing contact arms that engage the stationary arcing contact are spaced apart a given distance in the open position and are biased further apart by the interposition of said stationary arcing contact therebetween to thereby build contact pressure between the arcing contact arms and said stationary arcing contact.

3. A circuit breaker according to claim **2** wherein said portions of said arcing contact arms that engage said stationary arcing contact and the leading edge of said stationary arcing contact are provided with complementary camming surfaces for interposing said stationary arcing contact between said pair of arcing contact arms.

4. A circuit breaker according to claim **1** wherein means are provided adjacent the lateral surfaces of said stationary arcing contact for limiting the extent of engagement between said arcing contact arms and said stationary contact.

5. A circuit breaker according to claim **4** wherein said contact engagement limiting means are formed of insulation.

6. A circuit breaker including first and second terminal members, a movable main contact arm, a pair of relatively long slender resilient arcing contact arms pivotally mounted at one end of said main contact arm, spacer means cooperating with said arcing contact arms adjacent said main contact arm, said spacer means constraining the arcing contact arms to a given separation, companion main contacts and a companion stationary arcing contact electrically connected to said first terminal member, means pivotally mounting said main contact arm for movement from a closed position wherein said main contact arm abuts said companion main contacts and said arcing contact arms straddle said stationary arcing contact and are in lateral face engagement therewith to an open position, a driving link connected to said main contact arm for moving said main contact arm and said arcing contact arms between said opened position and said closed position, the portion of said stationary arcing contact received in lateral face engagement between said arcing contact arms being of a width greater than the separation between said arcing contact arms whereby contact pressure is built up between said arcing contact arms and said stationary contact, means electrically connecting

said main contact arm to said second terminal member, said arcing contact arms being driven toward one another against the lateral faces of said stationary arcing contact by electrodynamic forces due to high currents flowing through said arcing contact arms when said main contacts part.

7. A circuit breaker including first and second terminal members, a movable main contact arm having a movable main contact, a pair of elongated resilient substantially parallel arcing contact arms pivotally mounted on said main contact arm and carrying respective movable arcing contacts, companion main and arcing contacts electrically connected to said first terminal member, said arcing contact arms and said main contact arm being electrically connected to said second terminal, means pivotally mounting said main contact arm and said arcing contact arms thereon for movement between an open position and a closed position wherein said main contacts are in engagement and wherein said arcing contacts are in engagement, said arcing contact arms being arranged to effect closing of the arcing contacts slightly in advance of

closing of the main contacts and opening of the arcing contacts slightly later than opening of the main contacts, and said arcing contact arms being arranged to dispose and bias said arcing contacts in the closed position thereof in lateral face engagement with said companion arcing contact at opposite sides thereof, the contact pressure of said arcing contact arms against the lateral faces of said companion arcing contact being enhanced upon parting of said main contacts and transfer of high currents to said arcing contact arms, the enhanced contact pressure being due to electrodynamic reaction between said elongated arcing contact arms.

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