NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

November 19, 1970

REPLY TO
ATTN OF: GP

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for
Patent Matters

SUBJECT: Announcement of NASA-Owned U. S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code USI, the attached NASA-owned U. S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U. S. Patent No.	3,526,845
Government or Corporate Employee	Honeywell Inc. Minneapolis, Minnesota
Supplementary Corporate Source (if applicable)	North American Aviation, Inc.
NASA Patent Case No.	MSC-12033-1

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

Yes [XX] No [ ]

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

Elizabeth A. Carter

Enclosure
Copy of Patent cited above

COSATI 09E

NYI-13531

Sept. 1, 1970 D. J. SIKORRA 3,526,845

APPARATUS FOR OVERCURRENT PROTECTION OF A PUSH-PULL AMPLIFIER

Filed Dec. 19, 1966

NYI-13531

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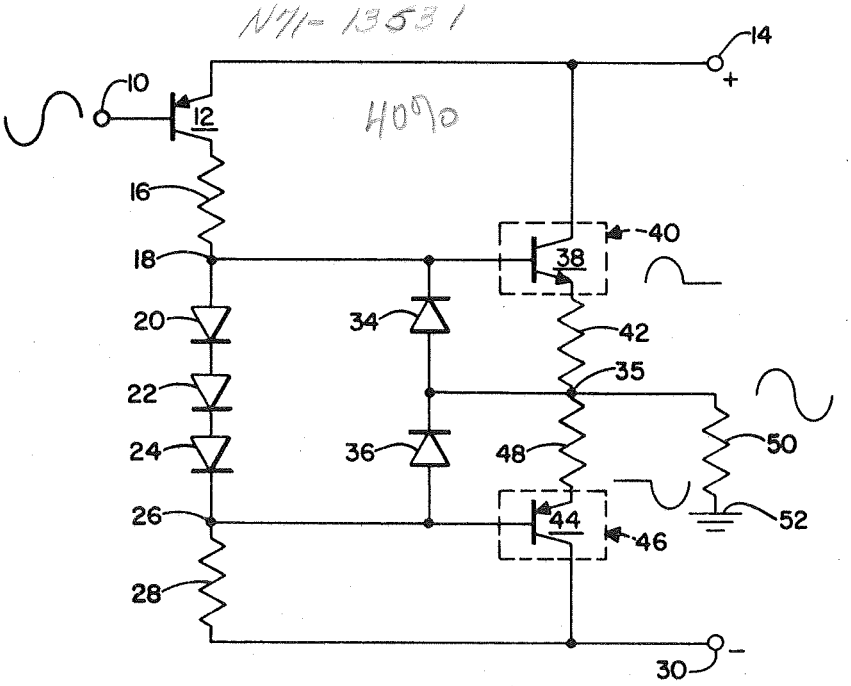

FIG. 1

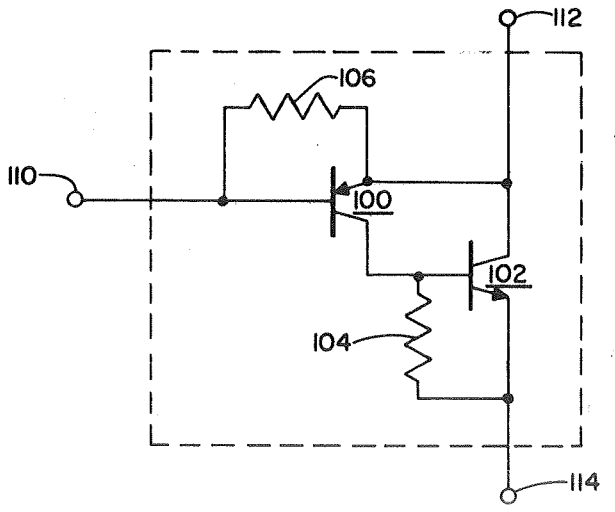

FIG. 2

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United States Patent Office 3,526,845 Patented Sept. 1, 1970

3,526,845

APPARATUS FOR OVERCURRENT PROTECTION OF A PUSH-PULL AMPLIFIER

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Filed Dec. 19, 1966, Ser. No. 602,828
Int. Cl. H03f 3/18, 3/30, 3/50
U.S. Cl. 330—11 3 Claims

ABSTRACT OF THE DISCLOSURE

This disclosure relates to electronic circuitry which may be used to provide overcurrent protection to a push-pull amplifier. A pair of complementary amplifying transistors arranged in push-pull amplifier configuration are provided with voltage biasing circuits coupled to the input of each transistor and degeneration resistance means connected between each transistor and a common node output terminal. Voltage breakdown means are coupled between the common node and each input terminal of the amplifying transistors in a direction such that excess current in the degeneration resistance means associated with either amplifying transistor causes the voltage breakdown means associated with the other amplifying transistor to conduct and apply a voltage to turn off said other transistor whereby short circuit protection is provided the amplifier by the voltage breakdown means in conjunction with the biasing means.

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85–568 (72 Stat. 435; 42 U.S.C. 2457).

BACKGROUND AND SUMMARY

In many push-pull amplifiers if the load is shorted inadvertently, the amplifier will be destroyed. The present invention was developed in response to this problem. The circuitry of the present invention prevents a current greater than a predetermined amount from flowing in the amplifier.

Another problem in push-pull amplifiers is that they may oscillate or be driven at a high frequency. If complementary symmetry transistors are used, the oscillation and inherent storage effects in amplifiers may cause both sides of the push-pull amplifier to conduct at the same time for a brief period. This causes a short circuit between the two bias supplies providing bias to the push-pull amplifier and destroys the amplifier. The present invention eliminates this problem also by providing that overcurrent in one part or side of a push-pull amplifier turns off the other part or side.

DESCRIPTION

It is an object of this invention to advance the amplifier art by providing short circuit protection to a push-pull amplifier.

Further objects and advantages will become apparent from the reading of this specification and claims in conjunction with the drawings wherein:

FIG. 1 shows a preferred embodiment of a push-pull amplifier using the teachings of the present invention; and

FIG. 2 shows a substitute circuit to be combined with a portion of FIG. 1 to provide another embodiment of the invention.

In FIG. 1, an apparatus input means **10** is connected to a base of a PNP transistor **12** having an emitter, a base and a collector. The emitter of transistor **12** is connected to a terminal **14** which is adapted to be connected to a source of direct voltage of a first polarity. A resistor **16** is connected between a junction point **18** and the collector of transistor **12**. Junction point **18** also functions as an input means to one-half, a side, or a part of the push-pull amplifier. A series of diodes **20**, **22**, and **24** are connected between junction point **18** and a junction point **26**, so that the easy direction of a current flows from junction point **18** to junction point **26**. Junction point **26** functions as an input means to the other half, side, or part or the push-pull amplifier. A resistor **28** is connected between junction point **26** and a terminal **30**. Terminal **30** is adapted to be connected to a second source of direct voltage of a second polarity. Another diode, non-linear impedance means, or non-linear voltage breakdown means **34** has its cathode connected to junction point **18** and its anode connected to a junction point **35**. Still another diode, non-linear impedance means, or non-linear voltage breakdown means **36** has its anode connected to junction point **26** and its cathode connected to junction point **35**. An NPN transistor or three terminal amplifying transistor **38** having a base, emitter, and collector forms a portion **40** of the push-pull amplifier in the embodiment shown. Transistor **38** has its collector connected to terminal **14**, its base connected to junction point **18** and its emitter connected to junction point **35** through an impedance means or degeneration resistor **42**. A PNP transistor or three terminal amplifying transistor **44** having a base, emitter, and collector forms another portion **46** of the push-pull amplifier. Transistor **44** has its collector connected to terminal **30**, its base connected to junction point **26**, and its emitter connected to junction poin **35** through an impedance means, or degeneration resistor **48**. A load means or resistor **50** is connected between junction point **35** and a common potential or ground **52**.

In FIG. 2, a PNP transistor **100** having a base, emitter, and a collector and an NPN transistor **102** having a base, emitter, and collector are interconnected such that collector of transistor **102** is connected to the emitter of transistor **100** and the base of transistor **102** is connected to the collector of transistor **100**. A resistor **104** is connected between the emitter of transistor **102** and the collector of transistor **100**. A resistor **106** is connected between the emitter of transistor **100** and the base of transistor **100**. The base of transistor **100** is also connected to a terminal **110**. The collector of transistor **102** is connected to a terminal **112**. The emitter of transistor **102** is connected to a terminal **114**.

OPERATION

Assume for the moment that diodes **34** and **36** are not present. A signal at input means **10** is amplified by transistor **12** and appears at junction points **18** and **26**. If transistors **38** and **44** are biased class B or class AB, then the positive portion of the signal at junction point **18** will be amplified by transistor **38** because it is an NPN transistor and the negative portion of the signal at junction point **26** will be amplified by transistor **44** because it is a PNP transistor. The negative portion of the signal at junction point **18** will turn transistor **38** off, and the positive portion of the signal at junction point **26** will turn transistor **44** OFF. All of this is well known to those skilled in the art. This means that load means **50** is driven by transistor **38** during one-half of the cycle and by transistor **44** during the other half of the cycle.

This is what is meant by a push-pull amplifier, as again is well known to those skilled in the art.

The diodes **20**, **22**, and **24** are inserted to provide bias separation to transistors **38** and **44**. That is, two of the diodes compensate for the emitter base diode effect of transistors **38** and **44** and the remaining diode biases the

transistors slightly ON so as to become, in this case, biased in class AB. It will be realized by those skilled in the art that fewer or more diodes can be used depending on the type or class of bias desired.

Thus far the conventional class AB emitter follower type amplifier has been explained. Now the circuit with diodes **34** and **36** inserted will be considered.

Assume that an excessive current is drawn by transistor **38**. Considering the series circuit formed by resistor **42**, diode **36**, diode **24**, diode **22**, diode **20**, and emitter base junction of transistor **38**, it is seen that all of the voltage drops in this series circuit are fixed by non-linear characteristics except the voltage drop in resistor **42**. It is also seen that the voltage across the emitter base junction of transistor **38** and the voltage across diode **36** approximately balance each other in the series circuit and therefore these two terms may be stricken from consideration. What remains is equal and opposite voltage drops across the diodes **20**, **22**, and **24** and the resistor **42**. Thus it is easily seen that the instantaneous voltage across resistor **42** can be no greater than the voltage across diodes **20**, **22**, and **24** or there will be less instantaneous bias on transistor **38** than required, and it will begin to turn off. This means that if an excess current through resistor **42** causes the voltage across resistor **42** to equal the sum of the diode voltages, the circuit will begin current limiting. The level of current limiting is determined by resistor **42** since the size of the resistor determines what voltage is developed from the current flowing through it.

Another feature of this invention is that if transistor **38** tends to draw an excessive current, diode **36** turns ON. It is seen that diode **36** impresses a voltage across the emitter base junction of transistor **44** which is opposite from that which transistor **44** needs to remain in a conducting state. This means that whenever one transistor attempts to draw an excessive current, the other transistor is turned off. This feature prevents any high frequency oscillation or driving voltage from causing both transistors to remain conducting at the same time which would cause a short circuit from the voltage impressed at terminal **14** through transistors **38** and **44** to the voltage impressed at terminal **30**.

It is obvious to those skilled in the art that the symmetry of the circuit requires that the converse explanation hold for the remainder of the circuit, if an excess of current is drawn by transistor **44**.

The circuitry of FIG. 2 may be substituted directly for the three terminal element **46** contained within the dashed lines. This is because the circuitry within FIG. 2 performs as a high gain PNP transistor. This circuit is familiar to those skilled in the art. The advantage of this circuit is that an NPN transistor may be used for the power stage and a relatively low power PNP transistor used as a driver. In the current state of the art it is easier and cheaper to obtain the high power NPN transistor than to obtain a high power PNP transistor of equal specifications.

Other configurations will be obvious to one skilled in the art. In fact, it is realized that many three terminal amplifier configurations may replace amplifiers **40** and **46**. Amplifiers **40** and **46** have been represented as a single transistor for the sake of simplicity only.

It is also obvious to those skilled in the art that diodes **20**, **22**, and **24** are not necessarily the only biasing arrangement possible. Resistors, batteries, or Zener diodes could be used. However, diodes are preferred at this time.

I claim:

1. Apparatus providing short circuit protection for a push-pull amplifier comprising:

(a) a plurality of complementary symmetry amplifying transistor means arranded in push-pull amplifier configuration, each amplifying transistor means having three terminals, including a base terminal;

(b) a plurality of degeneration resistance means, one of said degeneration resistance means being connected to a first terminal of a first of said amplifying transistor means and another of said degeneration resistance means being connected to a first terminal of the second of said amplifying transistor means, said degeneration resistance means being connected together at a common node output terminal of said push-pull amplifier;

(c) circuit biasing means coupled to the input of each amplifying transistor means by connection between the base terminal of said first amplifying transistor means and the base terminal of said second amplifying transistor means wherein the base terminal of each transistor means is an input terminal, in each amplifying transistor means said third terminal being operatively connected whereby said amplifying transistor means provide push-pull amplification; and

(d) a pair of non-linear impedance voltage-breakdown means, one of said non-linear impedance means connected between the base terminal of said first amplifying transistor and the common node output terminal and the other of said non-linear impedance means connected between the base terminal of the second amplifying transistor and said common node output terminal, said non-linear impedance means being connected in a direction such that an excess of current in one amplifying transistor and its associated degeneration resistance means coupled thereto causes the other non-linear impedance means associated with the other of said amplifying transistors to conduct current and apply a voltage to turn off said other amplifying transistor whereby short circuit protection is provided the push-pull amplifier by the non-linear impedance means in conjunction with the biasing means.

2. The apparatus of claim **1** wherein the non-linear impedance meanns comprises diode means.

3. The apparatus of claim **1** wherein the biasing means includes diode means.

References Cited

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NATHAN KAUFMAN, Primary Examiner

U.S. Cl. X.R.

330—24, 13, 14, 15, 26