FINAL REPORT

"NO STICK NOZZLES"

NATIONAL SHIPBUILDING RESEARCH PROGRAM
SP-7 WELDING PANEL PROJECT 2003-304

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EDISON WELDING INSTITUTE

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Approved for public release; distribution is unlimited.

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Final Report

No-Stick Nozzles, NSRP Welding Panel Project Subcontract 2003-304

Executive Summary

This project was proposed with an original vision of developing and deploying welding nozzles made from a metal which would significantly reduce, or even eliminate, the amount of spatter and slag that adheres to the nozzles during welding operations, resulting in a significant decrease in downtime due to nozzle cleaning and replacement. Unfortunately, the project was plagued with personnel changes, contractual difficulties and delays which significantly effected the project from its start. The initial literature and patent search revealed that the perceived need was real, and that no one had successfully met the challenge. At the onset of the project a material (Cu-Te) was identified that would perform as desired, but the increased cost factor was more than the return savings factor. About the same time that that the material issue was determined to be a dead-end effort, a company (L&M Welding Supply) which was not part of the original proposed project came forth with a coating solution and a proposed test plan which was outside of the cost and scope of the project. The company provided a limited set of coated nozzles, which, during use at two of the participating shipyards, proved to be a cost effective solution to the problem for one of the two yards. The nozzles, as well as coated contact tips, are commercially available for purchase by any interested shipyards, and have demonstrated a minimum 3:1 increase in life at a 2:1 increase in cost, while reducing welding downtime due to nozzle cleaning by a factor of five.

Introduction and Project Overview

The idea for the project was generated by Bender Shipbuilding and Jeffboat LLC after observing a robotic welding system in operation at the Ship Works Robotics Laboratory (SWRL) at the Gulf Coast Regional Maritime Technology Center (GCRMTC). The robotic welding program included a cleaning evolution in which the robot would finish a weld path, rotate up to a fixed wire brush, spin the nozzle on the brush several times and resume welding. Observing the robotic evolution led to a discussion of time spent cleaning or replacing nozzles during manual and semi-automatic welding operations, and an assessment of the cost.

Nozzles were obtained from the welders at Bender Shipbuilding and inspected for types of damage. Pictures of the nozzles were taken and included in the white paper proposal. The typical causes of damage to the nozzles were interior slag adhesion, resulting in nozzle clogging, wire seizure and contact tip damage; slag adhesion causing an arc across the nozzle, effectively blowing out the end of the nozzle, and damage caused trying to clean the nozzles by banging, brushing or using pliers. A rough estimate of the cost in terms of productivity due to frequency of cleaning and nozzle replacement was assessed in excess of $25K per year in small shipyards, resulting in the proposed project. Pictures of the nozzles were taken and included in the white paper proposal. The pictures are shown below:

Figure 1 - New Nozzle, Slag Damage, Arc damage, Plier Damage

Figure 2 - New Tweco Style Nozzle

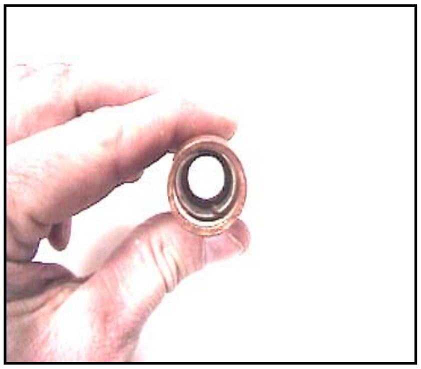

Figure 3 - New Nozzle Inside

Figure 4 - Nozzle Arc Damage

Figure 5 - Arc Damage Inside

As can be seen, there is significant damage to the welding nozzles from spatter adhesion. In many cases the spatter adhesion results in an arc across the nozzle, blowing out the end of the nozzle and rendering it useless. Replacing a nozzle can take as little as a 5 minutes if the welder has a spare in his pocket, or as long as 30 minutes or more if he has to find one.

Cleaning is typically done by banging the end of the gun on the structure being welded, or using pliers to remove bits of adhered slag. This occurs every few minutes, and is not always effective. It also causes damage to the ends of the nozzles, and does not necessarily remove any spatter adhesion from the contact tip. In some shipyards an anti-spatter spray is used, which is kept in a squirt bottle and applied to the nozzle and contact tips as necessary. Some shipyards, such as Bath Iron Works, are prohibited from using the spray for environmental reasons.

The project was proposed by Bender Shipbuilding as the lead shipyard, with Jeffboat, Bath Iron Works and Ingalls as participating shipyards, tasked to provide baseline welding information for nozzle usage, downtime and costs attributed to spatter adhesion and nozzle cleaning & replacement. Edison Welding Institute was contracted to do the initial research and some weld temperature profile studies in order to provide some scientific baseline information for the project.. Alabama Laser Systems, a subsidiary of Alabama Specialty Products, Inc. was contracted to do the metallurgical development work.

The project was set up in a three phase approach (1) data gathering, (2) new nozzle development and (3) testing and evaluation. The project was scoped for a 9 month duration, and kicked off in September, 2002. The project effectively ended in August, 2003. The project was plagued from the beginning with contracting problems, personnel changes and performance delays. Although the results were not what was originally planned, results were obtained that met the intent of the project - identify a method for reducing welding downtime due to spatter adhesion related work stoppages. The entire funded amount was not spent (less than 50% expended), which may allow for further development based on the findings of this project.

Baseline Data

The first tasks in the project were split between EWI and the shipyards. EWI was tasked to identify any previous efforts to address the same problem which are described in literature or accessible through patent searches. The shipyards were tasked to provide an assessment of downtime associated with nozzle and/or contact tip cleaning and replacement.

Ingalls and Bath Iron works were only able to provide some anecdotal information which basically attributed between 15 and 30 minutes per day of down time to each welder due to nozzle cleaning or replacement, plus the replacement cost of approximately one new nozzle every two days per welder. Jeffboat and Bender Shipbuilding provided more detailed hard data from observing welders over a discrete period of time. The detailed analysis revealed essentially the same down time profile as the anecdotal assessments, but provided some additional insight such as to the effects of different welding wires, shield gases, weld positions and weld complexity.

Attachment 1 contains the table of data taken at Jeffboat and at Bender Shipbuilding at the start of the project.

A summary of the baseline data captured at Jeffboat (note that not all data captured is included in the embedded file) follows:

Baseline data (standard copper nozzle)

- Captured 70 days worth of baseline data (original copper nozzles using anti-spatter dips and sprays) through 246 reports filled out by 15 different welders at various times from 8-27-02 to 12-23-02.
- Conclusions in the baseline data analysis:
- 129 nozzles used in 70 days
- 99,029” (~8,252’) of weld with 129 nozzles
- 17.5 hours of downtime during the study caused by (3) issues:
    - nozzle cleaning
    - dipping or spraying of anti-spatter chemicals
    - nozzle changes
- 65 nozzles were changed for 135 flat welding evaluation reports
- 64 nozzles were changed for 111 vertical welding evaluation reports

At Bender Shipbuilding the baseline data was captured by observations over a two week period from 10/7 through 10/18, monitoring 4 welders in the small panel and fixtured subassembly area (Yard 1). The majority of the welding was down hand welding of stiffeners on small panels, and welding of fabricated tee girders. One welder was working on OSV pilothouse sides, which require fixtured welding in vertical and up-angle positions. The summary of captured data is as follows:

Baseline data (Bender Shipbuilding), standard TWECO style nozzle

- Captured 40 shift days over a 10 day period
- All welders working in same area of yard, on similar work content
- 24 nozzle changes in 40 shift days
- 20.25 hours total down time out of 320 shift hours (240 effective working hours)
- 8.5% lost arc time due to cleaning and changing issues
- Anti-spat spray was used but not tracked

The data from both Jeffboat and Bender validates the anecdotal data from Bath and Ingalls, indicating that nozzles are replaced on average every other day, and there is, on average, a 10 percent loss of arc time due to dealing with spatter adhesion related problems.

Literature and Patent Search Results

EWI's literature and patent search was completed and delivered in May, 2003. There were no findings of any new metallurgy developed or proposed. There were several patents identified that incorporated a non-stick sleeve made from ceramic or other materials. There were no patents identified that addressed coating the nozzles or the contact tips. Several of the patents addressed the temperature of the workpiece and the contact tips, identifying maximum operating temperatures between 6000 and 12000 deg F. The general conclusion of the patent search report was that there are no practical applications of any of the patents in use today, and there are no hardware solutions to the problem raised in this project (loss of productivity due to slag adhesion) currently on the market. The report is Attachment 2 of this deliverable.

Further research by Bender Shipbuilding identified several companies that offer long life contact tips through improvements in metallurgy. The most common material identified for extending the tip life was copper chrome zirconium, with 0.65% chrome and 0.08% zirconium. This material has been used in contact tips for a number of robotic welding applications, but it appears that the primary benefit is longer wear life due to hardness, rather than reduction in spatter adhesion. The material is not in widespread use.

Metallurgy Findings

Alabama Laser (a subsidiary of Alabama Specialty Products Inc.) was tasked to evaluate the effectiveness of various metallurgies for replacing the traditional all copper nozzles and contact tips. The evaluation and development work was planned to occur following completion of EWI's literature search and report. Due to the delay in completing the first deliverable, the metallurgy evaluation proceeded without the benefit of the report.

ALSPI had already commenced with a metallurgy development effort seeking a solution to nozzle deterioration in the LASOX project. It should be noted that a laser cutting nozzle is a significantly different configuration and much smaller than a welding gas nozzle. In fact, a laser cutting nozzle more closely resembles a welding contact tip.

The following pictures illustrate the differences between the components. The first two pictures show variations of a LASOX cutting nozzle, in which the laser beam and the oxygen jet are concentric.

Figure 6 - LASOX Shielded Nozzle

Figure 7 - LASOX Unshielded Nozzle

The next pictures are of conventional manual welding contact tips and nozzles. The last picture is a typical robotic welding torch configuration. One of the main differences between robotic welding torches and manual welding torches is that due to the much higher duty cycle of the robotic torch, they typically incorporate either water cooling or a forced air cooling method. In addition, the configuration of the nozzles and tips are designed to accommodate automatic reaming and cleaning systems, which are rarely used in manual welding operations.

Figure 8 - FCAW Contact Tips

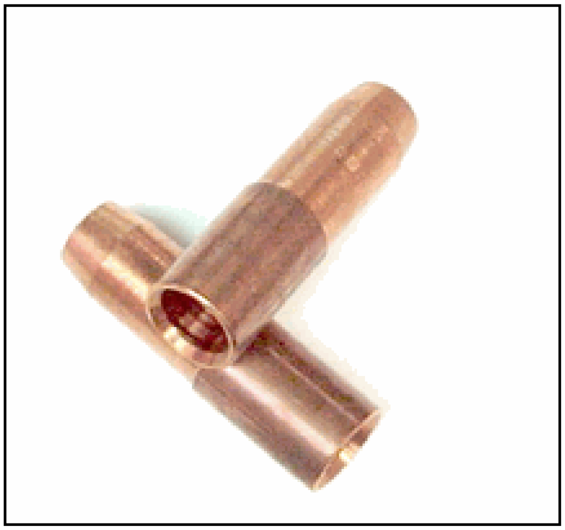

Figure 9 - Conventional FCAW Nozzles

Figure 10 - Robotic Welding Cooled Tip

Figure 11 - Typical Robotic Welding Gun

The development work on LASOX identified a copper-tellurium mix as significantly more durable in high heat conditions than pure copper, as well as being more wear resistant and far less susceptible to slag adhesion. Copper tellurium is available from a number of sources as bar stock in a 0.5% tellurium concentration. ALSPI fabricated several Cu-Te test nozzles for LASOX cutting, with good success.

The material was then adapted to a robotic welding system employed by ALSPI in a fabrication cell. Contact tips were machined from the material, and deployed on the robotic welder. Only the contact tips and not the gas nozzle were fabricated due to manufacturing costs.

Figure 12 - Robotic Contact Tips

Although the contact tips showed an effective increase in tip life and reduction in cleaning cycles, the material costs could not be reduced. After evaluating the material and machining costs for fabricating nozzles, it was determined that it would be impossible to obtain enough of a cost benefit in operational savings to offset the material and fabrication costs.

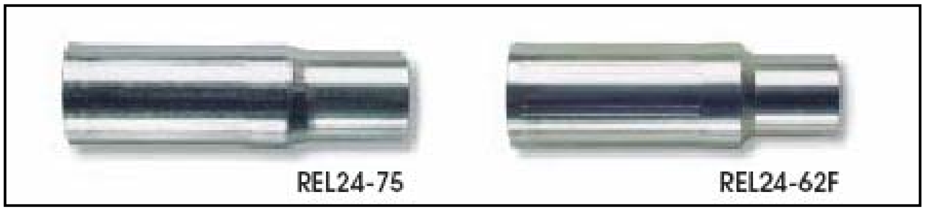

Figure 13 - Robotic Welding Gas Nozzles

The overriding factor is the availability of the material, which is only currently available as bar stock, and not as tube stock. Fabricating a nozzle from bar stock results in excessive waste (as can be ascertained when comparing the contact tips versus the nozzles in the figures above), as well as increased manufacturing time, driving the cost of a nozzle into the +$30.00 per nozzle range. Compared to the current $2.00 nozzles, the 15X cost factor could not be overcome.

However, the study by ALSPI does indicate that Cu-Te contact tips can be cost effectively fabricated from bar stock, and demonstrate a 5X factor of life increase over a 3X cost increase in robotic welding applications. ALSPI continues to use the contact tips in their robotic welding applications.

Anti-Spatter Coating

Following the early conclusions that the cost of the identified metals exceeded the cost benefit of incorporating them in welding nozzles, the project was effectively terminated prior to expending the majority of the funds. However, during the course of the project a local Mobile welding supply company, L&M Welding, came forth with an unsolicited proposal to evaluate a coated nozzle using a proprietary coating called "Blackjack". The test & evaluation proposal far exceeded the scope and budget of the project, so a revised tasking was proposed and approved by the project PTR.

The revised proposal provided for supply of 12 coated nozzles each to Jeffboat and Bender for side by side comparison with uncoated nozzles, with on-site monitoring at Bender for one week, while Jeffboat would monitor their own welding. The nozzles were provided in August, 2003 and evaluated at both Bender and Jeffboat during the latter part of August.

The coated nozzles were used without coated contact tips which effected the outcome to a certain degree. However, the Blackjack nozzles, which cost twice as much as a standard slip on type copper nozzle, typically lasted 3 times longer than the uncoated nozzles at a cost of two times more.

Figure 15 Blackjack & Standard Nozzles After Use - Arc Damage on Right

Figure 14 Blackjack & standard nozzles

Figure 17 Inside Blackjack Nozzle

Figure 16 Inside Damaged Standard Nozzle

Specifically, the nozzles used at Jeffboat lasted on average 1 week (5 shifts) without replacement. Bender had the same experience, and did side by side comparison in the same work area with one welder using coated nozzles and the other using uncoated. The welders involved in the tests both complained of slag adhesion on the uncoated contact tips, which caused work stoppage, but at less frequency than the original baseline observations.

Welders at both shipyards complained that the coating on the coated nozzles tended to chip off during the normal cleaning routine of tapping the nozzle on the workpiece in between weld sequences. The chipped areas then tended to collect slag, but at a significantly lower rate than an uncoated nozzle. The issue appears to be more of a procedure development and training issue than a fault in the coating itself.

Conclusions & Recommendations

Although modifying the metallurgy to a copper tellurium mix proved to be a cost effective means of extending the life of contact tips in robotic welding applications, it was not cost effective for gas shield nozzles. The primary reason is the lack of availability of the material in a tube or extruded form, resulting in high machining costs and excessive material waste. If the manufacturers of conventional slip-on or threaded copper nozzles can identify a supplier of Cu-Te or even Cu-Cr-Zr (as identified through literature search) tube stock, then it is possible that the nozzles can be fabricated and sold at a cost effective market price.

Meanwhile, the “Blackjack” coating has demonstrated in a limited evaluation that it is effective in reducing spatter related downtime in manual welding operations. The Blackjack coating should be evaluated further in a complete and controlled test in order to fully prove its effectiveness in shipbuilding. The proposal put forth by L&M to do such a test was on the order of $65K, and would require either close monitoring in a controlled production area, or lab testing using shipyard materials and procedures.

The Blackjack nozzles are available commercially from L&M Welding Supply in Mobile, Alabama. More information is available from Paul Hancieri, 568 Western Drive, Mobile, Alabama 36607, 251-470-9997.

Additional information about the study may be obtained from:

Project Manager - Patrick Cahill, Bender Shipbuilding & Repair Co., Inc., 265 S. Water Street, Mobile, Alabama 36601 e-mail: cahi@bendership.com.

Other project participants included:

Joe Browning, Jeffboat (has since moved to a different company)
Wayne Penn, ALSPI
Dick Holdren, EWI
Michael Ludwig, Bath Iron Works (GD)
Lee Kvidahl, Ingalls (NGSS)

Area	**Name**	**Date**	**Application**	**Process**	**Gas**	**Position**	**# Down time issues**
YD1	Welder1	10/7/2002	small panel stiffeners	FCAW w/gas	CO2	flat	3
YD1	Welder2	10/7/2002	small panel stiffeners	FCAW w/gas	CO2	flat	1
YD1	Welder3	10/7/2002	small panel stiffeners	FCAW w/gas	CO2	flat	0
YD1	Welder4	10/7/2002	pilothouse	FCAW w/gas	CO2	Angle up/flat	2
YD1	Welder1	10/8/2002	small panel stiffeners	FCAW w/gas	CO2	flat	0
YD1	Welder2	10/8/2002	small panel stiffeners	FCAW w/gas	CO2	flat	2
YD1	Welder3	10/8/2002	small panel stiffeners	FCAW w/gas	CO2	flat	1
YD1	Welder4	10/8/2002	pilothouse	FCAW w/gas	CO2	Angle up/flat	3
YD1	Welder1	10/9/2002	small panel stiffeners	FCAW w/gas	CO2	flat	2
YD1	Welder2	10/9/2002	small panel stiffeners	FCAW w/gas	CO2	flat	1
YD1	Welder3	10/9/2002	small panel stiffeners	FCAW w/gas	CO2	flat	0
YD1	Welder4	10/9/2002	pilothouse	FCAW w/gas	CO2	Angle up/flat	1
YD1	Welder1	10/10/2002	small panel stiffeners	FCAW w/gas	CO2	flat	0
YD1	Welder2	10/10/2002	small panel stiffeners	FCAW w/gas	CO2	flat	0
YD1	Welder3	10/10/2002	small panel stiffeners	FCAW w/gas	CO2	flat	2
YD1	Welder4	10/10/2002	pilothouse	FCAW w/gas	CO2	Angle up/flat	1
YD1	Welder1	10/11/2002	small panel stiffeners	FCAW w/gas	CO2	flat	2
YD1	Welder2	10/11/2002	small panel stiffeners	FCAW w/gas	CO2	flat	3
YD1	Welder3	10/11/2002	small panel stiffeners	FCAW w/gas	CO2	flat	1
YD1	Welder4	10/11/2002	pilothouse	FCAW w/gas	CO2	Angle up/flat	4
YD1	Welder1	10/14/2002	small panel stiffeners	FCAW w/gas	CO2	flat	1
YD1	Welder2	10/14/2002	small panel stiffeners	FCAW w/gas	CO2	flat	1
YD1	Welder3	10/14/2002	small panel stiffeners	FCAW w/gas	CO2	flat	2
YD1	Welder4	10/14/2002	small panel stiffeners	FCAW w/gas	CO2	flat	1
YD1	Welder1	10/15/2002	small panel stiffeners	FCAW w/gas	CO2	flat	1
YD1	Welder2	10/15/2002	small panel stiffeners	FCAW w/gas	CO2	flat	2
YD1	Welder3	10/15/2002	small panel stiffeners	FCAW w/gas	CO2	flat	2
YD1	Welder4	10/15/2002	small panel stiffeners	FCAW w/gas	CO2	flat	3
YD1	Welder1	10/16/2002	small panel stiffeners	FCAW w/gas	CO2	flat	5
YD1	Welder2	10/16/2002	small panel stiffeners	FCAW w/gas	CO2	flat	3
YD1	Welder3	10/16/2002	small panel stiffeners	FCAW w/gas	CO2	flat	2
YD1	Welder4	10/16/2002	small panel stiffeners	FCAW w/gas	CO2	flat	3
YD1	Welder1	10/17/2002	small panel stiffeners	FCAW w/gas	CO2	flat	2
YD1	Welder2	10/17/2002	small panel stiffeners	FCAW w/gas	CO2	flat	4
	Welder3	10/17/2002	small panel stiffeners	FCAW w/gas	CO2	flat	3
	Welder4	10/17/2002	small panel stiffeners	FCAW w/gas	CO2	flat	3
	Welder1	10/18/2002	small panel stiffeners	FCAW w/gas	CO2	flat	1
	Welder2	10/18/2002	small panel stiffeners	FCAW w/gas	CO2	flat	0
	Welder3	10/18/2002	small panel stiffeners	FCAW w/gas	CO2	flat	0
	Welder4	10/18/2002	small panel stiffeners	FCAW w/gas	CO2	flat	2
							70

NSRP Panel Project
No Stick Welding Nozzle

Final Status Report - Attachment #1 - Phase 1 Study Data

Nozzle Cleanings	Changes	time (min.)	notes	
2	1	45	nozzle arced & damaged	
1	0	15		
0	0			
1	1	30	slag stuck on contact tip	
0	0			
1	2	60	nozzle arced, 2nd one bent with plier	
1	0			
2	1	45	slag in nozzle & tip	
2	0	15	chipped off slag	
0	1	0	arced nozzle	
0	0	0		
0	1	15	slag in nozzle & tip	
0	0	0		
0	0	0		
0	2	30	old nozzle, second one slagged	
0	1	60	wire feed jammed	
2	0	30		
3	0	45		
0	1	30	arced nozzle	
2	2	120	problems w/ feeder, tips & nozzles	
1	0	15		
1	0	15		
2	0	30		
1	0	15		
0	1	30	slag adhesion	
2	0	30		
2	0	30		
2	1	45	clogged	
2	3	90	problems w/ feeder, tips & nozzles	
1	2	60	clogged twice	
2	0	15		
2	1	45	clogged	
2	0	15		
2	2	90	arcing, tip worn	
3	0	45		
3	0	45		
1	0	15		
0	0	0		
0	0	0		
1	1	45	clogged	
47	24	1215		20.25

Attachment 2

Final Report - EWI Project No. 46696CSP – Interm

EWI

MATERIALS JOINING TECHNOLOGY

May 2, 2003

Mr. Pat Cahill
Bender Shipbuilding and Repair Company, Inc.
P.O. Box 42
265 South Water Street
Mobile, AL 36601

EWI Project No. 46696CSP, "Current Art - Novel Arc Welding Gas Nozzle and Contact Tip Designs"

Dear Pat:

Enclosed is EWI's interim report for the above referenced project. Please feel free to contact me at 614-688-5139 if you have any questions or comments regarding this project.

Sincerely,

Dick Holdren

Dick Holdren
Principal Welding Engineer
Arc Welding, Materials, and Automation

Enclosure

cc: Clark Kelly (L&M Welding Supply Inc.)

1250 Arthur E. Adams Drive • Columbus, Ohio 43221 • (614) 688-5000 • FAX: (614) 688-5001 • http://www.ewi.org/

Report

May 2, 2003
EWI Project No. 46696CSP

Current Art - Novel Arc Welding Gas Nozzle and Contact Tip Designs

Submitted to:

Bender Shipbuilding and Repair Company, Inc.
Mobile, AL

Materials Joining Technology
EWI

Report

Project No. 46696CSP

on

Current Art - Novel Arc Welding Gas Nozzle and Contact Tip Designs

to

Bender Shipbuilding and Repair Company, Inc.
Mobile, AL

May 2, 2003

Dick Holdren
EWI
1250 Arthur E. Adams Drive
Columbus, OH 43221

Contents

1.0 Introduction

Arc welding processes are the workhorses for shipbuilding applications around the world. Among the numerous processes in this general category, one would venture to say that, today, more than 90% of the arc welding performed is either flux-cored arc or gas metal arc welding. In their most commonly applied configurations, they share several characteristics. First, the working end of the process includes a welding gun, which can be handheld for semiautomatic applications or held by some mechanism that translates the gun (and therefore the welding arc) along some path in the case of mechanized, automatic, automated, robotic, or adaptive control applications.

This welding gun, whether handheld or mechanically held, then incorporates some key components that are critical to the operation and control of the welding process. These are referred to as the contact tip and gas nozzle. The contact tip is critical in terms of the electrical characteristics of the welding arc, since this component is responsible for conducting the welding current from the power source to the mechanically fed electrode. The gas nozzle is a component that concentrically surrounds the contact tip and directs shielding gas to the weld zone. Should either component become damaged, worn or otherwise deteriorated, resulting weld quality can be directly affected in a negative manner.

In the case of the contact tip, continued use will result in erosion of the soft copper as the steel electrode is fed through the contact tip's internal bore. If not replaced periodically, this erosion can lead to changes in the electrical characteristics which could eventually cause weld quality issues. While the contact tip is responsible for conducting electricity to the welding electrode, the gas nozzle directs the shielding gas to the weld zone to assure that the molten metal does not become contaminated and result in defective welds due to porosity or other quality issues. Like the contact tip, high temperature erosion can cause deterioration of the gas nozzle; however, probably the greatest practical concern relates to the propensity for weld spatter to adhere to the end of the gas nozzle. Should this spatter continue to build up on the gas nozzle, the normal result is a disturbance of the shielding gas flow to a degree that the molten metal is no longer being properly protected, and porous welds are created.

2.0 Objective

This project will explore various means for improving the life of these components by attempting to prevent the adhesion of weld spatter. If this can be accomplished, improved life means that these components do not require replacement or maintenance as regularly as is currently the case. That then equates to improved welding productivity due to both increased “arc-on” time and reduced costs associated with improved weld quality and reduced repair and rework. This is certainly not a new problem; however, past attempts at improvements have failed to completely remedy the situation in a cost-effective manner. The goal, therefore, is to develop some means of reducing weld spatter buildup and related degradation of gas nozzles and contact tips at a cost that is offset by the improvement in nozzle and tip life. This report will summarize some past approaches used by manufacturers and users to prolong the lives of these production components that are considered to be consumables.

3.0 Description and Discussion of Patent-Protected Gas Nozzle and Contact Tip Designs

3.1 Reference 1: *Electric Arc Welding Gun Having a Nozzle with a Removable Liner to Protect the Nozzle from Weld Splatter (*U.S. Patent Specification No. 3,690,567)

Reference 1 is one of the earlier patents on the subject of gas nozzle protection devices. The approach taken by Mr. Borneman, as described in this patent, is to provide protection to the end of the gas nozzle by the installation of a disposable metal liner that covers the inner surface of the gas nozzle near the exit end as well as the exposed end of the gas nozzle. The patent states that this approach is aimed specifically at the elimination of spatter buildup on the end of the gas nozzle. The concept here is to eliminate the time required to clean gas nozzles of accumulated weld spatter by simply requiring the welder to remove a spatter-laden liner (that is then discarded) and replacing it with a new liner. This operation takes only a few seconds and allows the welder to quickly return to productive work.

The patent does not disclose that the replaceable liner is a material other than steel; however, it appears that it could be made of various materials and still be covered by this patent. The patent does describe a number of different liner designs and various means for mechanically lodging the liner in its working position. These various designs are intended to allow for easy installation and removal, while still assuring that the liner remains in its proper position during welding.

3.2 References 2 and 3: *Tubular Shielding Gas Nozzle (*U.S. Patent Specification No. 1,332,226) and *Composite Insert for Gas-Shielded Welding Torch Nozzle (*U.S. Patent Specification No. 1,373,501)

References 2 and 3 above will be discussed together since they describe separate components of a composite shielding gas nozzle design, with Reference 1 describing the nozzle (referred to here as the nozzle concept) and Reference 2 describing the composite insert for that nozzle design (referred to here as the insert concept).

The key feature of the nozzle design is that it has an inner surface comprised of pyrolytic graphite. This is accomplished be either manufacturing the entire nozzle from the graphite material, or incorporation of a graphite liner that is described in the accompanying patent (Reference 2). The purpose of this nozzle design is to prolong the life of this component by reducing the tendency for spatter buildup and degradation related to that buildup and the high temperatures generated by the the welding arc. As such, the purpose of these inventions were identical to what is being attempted in this current study. It is interesting to note that this patent establishes the potential temperatures generated by the welding arc to range from 6,000 to 12,000°F. It does not quantify the exposure temperatures expected on the surface of the gas nozzle; however, it certainly implies that those surface temperatures are high enough to result in significant degradation of the nozzle.

A key element of these patents is the incorporation of pyrolytic graphite for either the entire body of the nozzle or as an insert that covers the inside surface of the nozzle. The pyrolytic graphite material was chosen primarily for its ability to withstand the extremely high temperatures emanating from the welding arc. Additionally, the graphite will tend to resist the accumulation of spatter on the inner surface of the nozzle because of the reduced tendency for the weld spatter to adhere to the surface of the graphite. These patents also take advantage of the fact that the pyrolytic graphite exhibits anisotropic properties in terms of its thermal conductivity. The patent prescribes the orientation of the graphite material such that the heat from the welding arc is most efficiently conducted away from the source of that heat, thereby reducing the degree of degradation of the nozzle.

As noted above, the nozzle patent covers the case where the entire nozzle is graphite or those cases where a graphite insert is inserted into the inside diameter of the copper nozzle and somehow secured to that nozzle to assure good thermal conductivity through the graphite and to the outer surface of the copper nozzle. The preferred design, because of its increased robustness, is the nozzle design that incorporates a graphite sleeve inserted into and secured to the outer copper nozzle. This attachment is usually accomplished using a shrink-fit technique in which the copper nozzle is heated to a temperature that causes it to expand to a size large enough to allow the insertion of the graphite sleeve. Then, upon cooling, the shrinkage of the copper nozzle holds the graphite sleeve in place.

The nozzle patent also mentions that the exposed end of the contact tip may also be protected by the use of a graphite sheath to result in increased life.

3.3 Reference 4: *Consumable Electrode Type Arc Welding Contact Tip (*European Patent No. EP0324088)

This particular patent differs from the previous references in that it applies only to the contact tip and not to the shielding gas nozzle. Similar to these previous references, this invention incorporates some type of integral wear-resistant liner to the bore of the contact tip. This liner may be present only at the exit end of the contact tip or extend the entire length of the bore.

This liner, as described in the patent, can take on a number of different configurations, including: partial bore length, complete bore length, machined insert, or coiled wire inserted into recess in contact tip. In each of these cases, the insert material is a more wear resistant material than that typically used for these components. Since the key performance factor for the contact tip is to provide effective electrical contact with the electrode being fed, the material used for the insert must exhibit relatively low electrical resistance so the end of the contact tip does not overheat due to resistance heating effects.

Consequently, the ideal material for this insert is one with high electrical conductivity (low resistance) and with excellent resistance to the abrasion of the sliding electrode acting to enlarge the bore. Should a material be used that does not provide both of these key elements, premature failure or process degradation will occur. If the resistance of the material is too high, it will overheat and deteriorate prematurely, and if the material has insufficient wear resistance, the bore will enlarge to the extent that the process variables exceed limits of acceptability.

The patent describes the bore liner material as a chromium-copper alloy having a chromium content between 0.1 and 5%. One would surmise that the higher the chromium content, the greater the wear resistance; however, there would be a penalty in terms of how much degradation would result from the higher heating effects from the increase in resistance.

The patent also provides numerous configurations for this contact tip insert. In some configurations, the insert only extends a short distance from the end of the contact tip while other liners extend the entire length of the bore. One configuration involves the production of a tight coil of the chromium-copper wire that is inserted in the end of the contact tip. The contact surface for the electrode then becomes the inside surface of the coil. The patent also describes various configurations with different means of mechanically trapping the insert in the contact tip so it remains in place during the welding operation.

3.4 Reference 5: *Protective Gas Nozzle for a Gas-Shielded Welding Torch with an Insulating Sheath at the Current-Contacting Tube* (European Patent No. EP0372429)

This patent, from Germany and only available in German other than a brief abstract, describes both contact tip and gas nozzle protection devices. The description is limited here because of translation problems, but from illustrations and the abstract some sense can be made of the invention.

The contact tip protection is provided by a two-piece device that includes both a wear-resistant sleeve covered by an insulating casing. This design is aimed at improving contact tip life by reducing the wear effects of the sliding electrode and protecting the contact tip from degradation due to overheating due to the arc. The primary difference between this approach and that described in the previous patent is that this design provides more protection of the contact tip end from the degrading effects of the welding arc.

The other aspect of this patent involves a sleeve-type insert for the gas nozzle, similar to that described in Reference 1. From the limited information, it appears that this insert is designed to be a consumable, which gets replaced when spatter buildup becomes excessive or the arc heating causes the insert to become deteriorated to a degree that it no longer serves its intended purpose effectively.

3.5 Reference 6: *Gas-Metal-Arc Welding Contact Tip* (International Patent No. WO9965635)

The last patent reviewed from this search involves another contact tip design. A number of claims are made in this patent, but the key feature is that the material from which the contact tip may be manufactured is a powder metallurgy alloy of copper and ceramic materials. When manufactured and then machined into its final configuration, it provides a contact tip with excellent electrical properties (low resistance) and good resistance to abrasion from the action of the electrode.

While the invention also covers contact tips produced with specific physical features from conventional copper alloys, one key feature is the embodiment where the component is produced from a composite material. The specific composition of that composite material material is a copper-graphite mixture that includes up to 20% graphite. The mixture is compressed and sintered using conventional powder metallurgical techniques to produce a bulk density higher than 80% of the ideal densities of the solid counterparts and then machined to shape. Specific crystalline forms of graphite have excellent electrical conductivity. When properly manufactured, the graphite alloying will provide reduced spatter adherence and increased lubricity for improved electrode feedability.

Another embodiment of the invention has the contact tip lined with a cylindrical insert comprised of a ceramic material, including, but not limited to: aluminum oxide, boron carbide, silicon carbide, silicon oxide, aluminum nitride, zirconium oxide, boron nitride, or any mixture of these substances. In this configuration, the ceramic insert limits current transfer to the front end of the contact tip, minimizing the occurrence of burnback. When used, this insert only extends part of the way from the back end of the contact tip and is intended primarily for guiding the electrode through the bore.

To further improve the robustness of the contact tip in the high-temperature operating conditions adjacent to the welding arc, the outside diameter of the contact tip is increased to create more themal mass. Other unique features of this contact tip design aimed at improving contact tip life include: no chamfer at the outlet part of the wire feed aperture for enhanced current transfer, lower operating temperatures and freedom from microspatter entering the opening of the contact tip adjacent to the electrode; an enlarged radius of curvature and bulbous shape which maximizes metal mass at the front end to reduce the operating temperature of the contact tip; and the possible inclusion of an extra-hard protective layer of diamond-like carbon which enhances the ability to reject spatter buildup.

4.0 Summary and Conclusions

The idea of designing a better gas nozzle and contact tip for arc welding processes where the electrode is continously fed has been on the minds of numerous individuals, almost since the introduction of those welding processes. The patents discussed herein only describe the more recent concepts that have gained approval by the various patenting agencies.

In most cases, the approach has been to apply either additional components or coatings to existing components to improve their life. The environment in which these components are intended to operate are quite severe, with maximum operating temperatures somewhere in the range of 6,000 to 12,000°F. In addition to withstanding these elevated temperatures, the components are also required to provide good feedability (contact tips), good electrical conductivity (contact tips), good abrasion resistance (contact tips), and resistance to spatter adherance (both contact tips and gas nozzles).

A number of the inventions described “consumable” components that are inserted in gas nozzles and then simply discarded and replaced when no longer performing effectively. In other cases, some type of coating has been applied for insulation, spatter resistance, temperature resistance, etc.

While some excellent ideas have been put forth, the fact that they are virtually nonexistent in real manufacturing operations indicates that they really have not been perceived as being economically feasible.

With that in mind, the efforts of this project should concentrate on the creation of components that are both low cost and performance enhancing.

The degree to which the results of this project will be patentable will be up to some interpretation; however, there is a good chance that patentable concepts could result.

5.0 References

1. Borneman, L. A., "*Electric Arc Welding Gun Having a Nozzle with a Removable Liner to Protect the Nozzle from Weld Splatter*", U.S. Patent Specification No. 3,690,567 (Sept. 12, 1972).

2. Pfizer, Inc., "*Tubular Shielding Gas Nozzle*", U.S. Patent Specification No.1,332,226 (Oct. 13, 1973).

3. Pfizer, Inc., "*Composite Insert for Gas-Shielded Welding Torch Nozzle*", U.S. Patent Specification No. 1,373,501 (Nov. 13, 1974).

4. Yoshinoaka, M., Kiuchi, C., Tokushige, H., Sakano, Y., Yamada, Y., and Handa, K., "*Consumable Electrode Type Arc Welding Contact Tip*", European Patent No. EP0324088 (July 19, 1989).

5. Schulz, U., "*Protective Gas Nozzle for a Gas-Shielded Welding Torch with an Insulating Sheath at the Current-Contacting Tube*", European Patent No. EP0372429 (June 13, 1990).

6. Villafuerte, Julio, "*Gas-Metal-Arc Welding Contact Tip*", International Patent No. WO9965635 (Dec. 23, 1999).

Appendix A

Electric Arc Welding Gun Having a Nozzle with a Removable Liner to Protect the Nozzle from Weld Splatter

United States Patent

Borneman

[15] **3,690,567**

[45] **Sept. 12, 1972**

[54] **ELECTRIC ARC WELDING GUN HAVING A NOZZLE WITH A REMOVABLE METAL LINER TO PROTECT THE NOZZLE FROM WELD SPLATTER**

[72] Inventor: **Lawrence A. Borneman,** 411 W. Ethel Ave., Lombard, Ill. 60148

[22] Filed: **March 9, 1970**

[21] Appl. No.: **17,361**

[52] **U.S. Cl.** ....**239/591,** 219/121 P
[51] **Int. Cl.** **B05b 1/00**
[58] **Field of Search** ....239/591; 175/340, 393; 285/175, 334.4, 345, 238; 219/121 P

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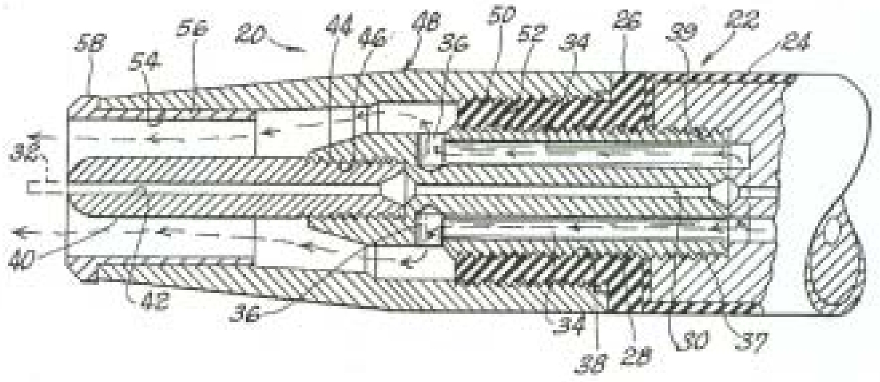
Primary Examiner—M. Henson Wood, Jr.
Assistant Examiner—Thomas C. Culp, Jr.
Attorney—Burmeister, Palmatier & Hamby

[57] **ABSTRACT**

The welding gun construction utilizes a nozzle member having an opening for directing an inert gas against the work to be welded. A tubular welding tip is disposed centrally within such opening to guide a welding wire toward the work. A welding arc is drawn between the work and the wire. A tubular metal liner is received within the opening to protect the nozzle member from weld splatter, which comprises molten metal globules thrown up from the welding area. The solidified weld splatter accumulates within the liner, which can be removed and disposed of as needed, before the weld splatter builds up to a thickness sufficient to cause a short circuit between the welding tip and the nozzle member. A new liner is then inserted into the nozzle. The liner is formed with a retaining element whereby the liner is held within the nozzle against accidental dislodgement. Such retaining element may take the form of an oval portion, one or more spring fingers bent outwardly from the liner, or a dimple portion formed by outward deformation of the liner. A pocket or tapered portion may be formed within the nozzle member to retain the outwardly projecting fingers or dimples. The liner may also be arranged for insertion into the nozzle from the rear, and may be retained in the nozzle by an outwardly projecting flange on the rear portion of the liner.

15 Claims, 16 Drawing Figures



PATENTED SEP 12 1972 3,690,567

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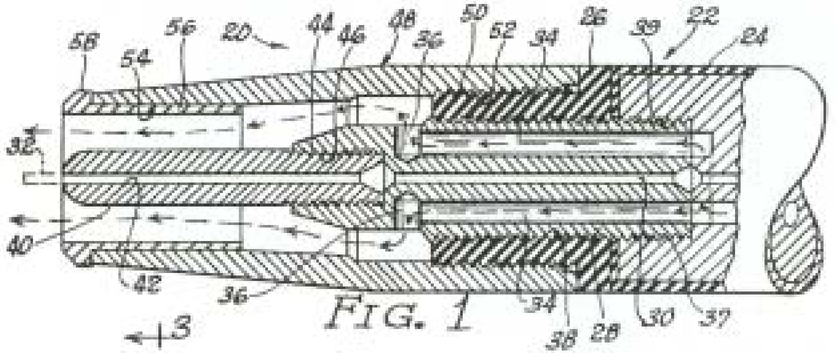
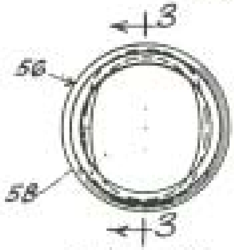


FIG. 1



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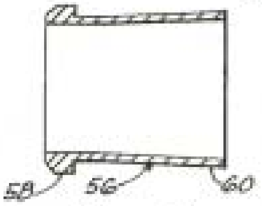

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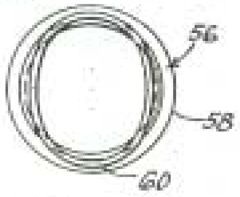
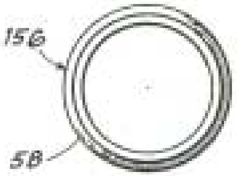


FIG. 4



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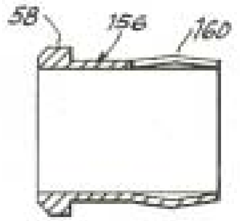

FIG. 6

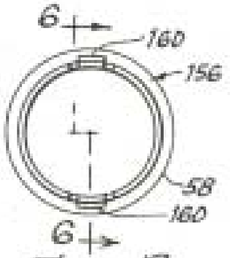

FIG. 7

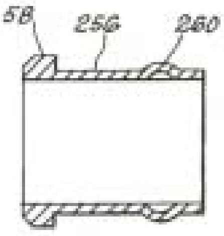

FIG. 8

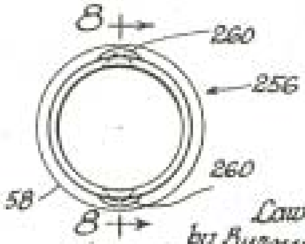

FIG. 9

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by Burmeister Palmatier and Hamby Att'ys

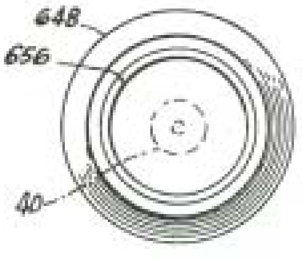


FIG. 16

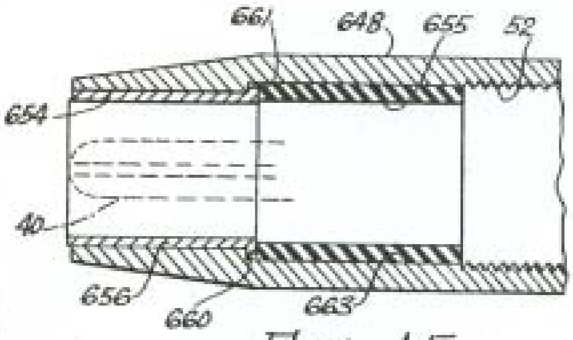


FIG. 15

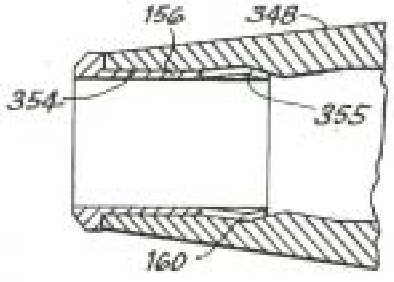


FIG. 10

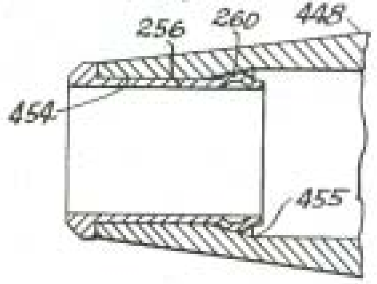


FIG. 11

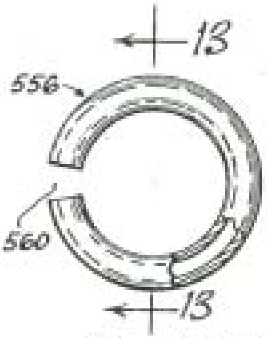


FIG. 12

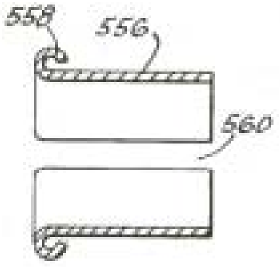
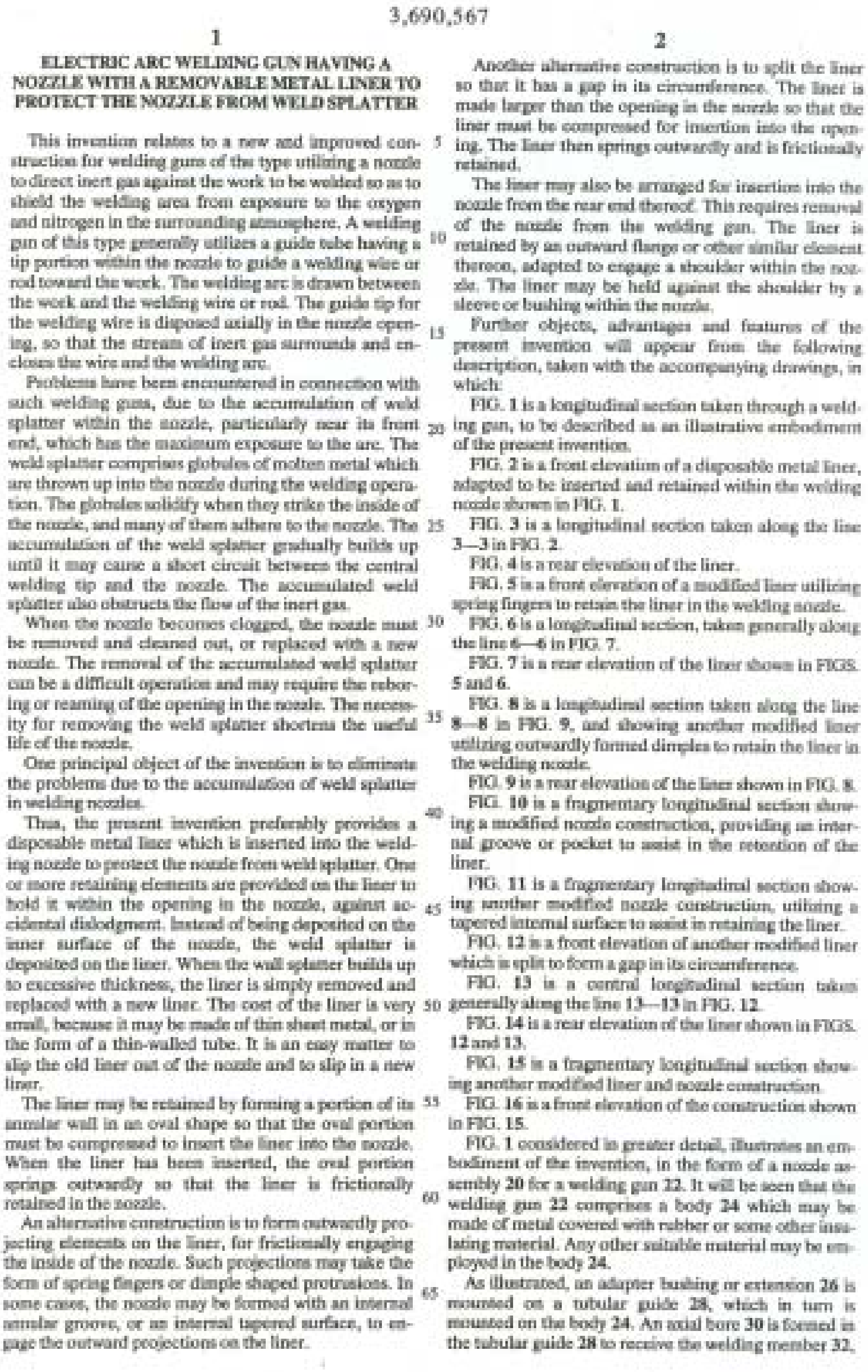


FIG. 13

FIG. 14



ELECTRIC ARC WELDING GUN HAVING A NOZZLE WITH A REMOVABLE METAL LINER TO PROTECT THE NOZZLE FROM WELD SPLATTER

This invention relates to a new and improved construction for welding guns of the type utilizing a nozzle to direct inert gas against the work to be welded so as to shield the welding area from exposure to the oxygen and nitrogen in the surrounding atmosphere. A welding gun of this type generally utilizes a guide tube having a tip portion within the nozzle to guide a welding wire or rod toward the work. The welding arc is drawn between the work and the welding wire or rod. The guide tip for the welding wire is disposed axially in the nozzle opening, so that the stream of inert gas surrounds and encloses the wire and the welding arc.

Problems have been encountered in connection with such welding guns, due to the accumulation of weld splatter within the nozzle, particularly near its front end, which has the maximum exposure to the arc. The weld splatter comprises globules of molten metal which are thrown up into the nozzle during the welding operation. The globules solidify when they strike the inside of the nozzle, and many of them adhere to the nozzle. The accumulation of the weld splatter gradually builds up until it may cause a short circuit between the central welding tip and the nozzle. The accumulated weld splatter also obstructs the flow of the inert gas.

When the nozzle becomes clogged, the nozzle must be removed and cleaned out, or replaced with a new nozzle. The removal of the accumulated weld splatter can be a difficult operation and may require the reboring or reaming of the opening in the nozzle. The necessity for removing the weld splatter shortens the useful life of the nozzle.

One principal object of the invention is to eliminate the problems due to the accumulation of weld splatter in welding nozzles.

Thus, the present invention preferably provides a disposable metal liner which is inserted into the welding nozzle to protect the nozzle from weld splatter. One or more retaining elements are provided on the liner to hold it within the opening in the nozzle, against accidental dislodgment. Instead of being deposited on the inner surface of the nozzle, the weld splatter is deposited on the liner. When the wall splatter builds up to excessive thickness, the liner is simply removed and replaced with a new liner. The cost of the liner is very small, because it may be made of thin sheet metal, or in the form of a thin-walled tube. It is an easy matter to slip the old liner out of the nozzle and to slip in a new liner.

The liner may be retained by forming a portion of its annular wall in an oval shape so that the oval portion must be compressed to insert the liner into the nozzle. When the liner has been inserted, the oval portion springs outwardly so that the liner is frictionally retained in the nozzle.

An alternative construction is to form outwardly projecting elements on the liner, for frictionally engaging the inside of the nozzle. Such projections may take the form of spring fingers or dimple shaped protrusions. In some cases, the nozzle may be formed with an internal annular groove, or an internal tapered surface, to engage the outward projections on the liner.

Another alternative construction is to split the liner so that it has a gap in its circumference. The liner is made larger than the opening in the nozzle so that the liner must be compressed for insertion into the opening. The liner then springs outwardly and is frictionally retained.

The liner may also be arranged for insertion into the nozzle from the rear end thereof. This requires removal of the nozzle from the welding gun. The liner is retained by an outward flange or other similar element thereon, adapted to engage a shoulder within the nozzle. The liner may be held against the shoulder by a sleeve or bushing within the nozzle.

Further objects, advantages and features of the present invention will appear from the following description, taken with the accompanying drawings, in which:

FIG. **1** is a longitudinal section taken through a welding gun, to be described as an illustrative embodiment of the present invention.

FIG. **2** is a front elevation of a disposable metal liner, adapted to be inserted and retained within the welding nozzle shown in FIG. **1**.

FIG. **3** is a longitudinal section taken along the line **3—3** in FIG. **2**.

FIG. **4** is a rear elevation of the liner.

FIG. **5** is a front elevation of a modified liner utilizing spring fingers to retain the liner in the welding nozzle.

FIG. **6** is a longitudinal section, taken generally along the line **6—6** in FIG. **7**.

FIG. **7** is a rear elevation of the liner shown in FIGS. **5** and **6**.

FIG. **8** is a longitudinal section taken along the line **8—8** in FIG. **9**, and showing another modified liner utilizing outwardly formed dimples to retain the liner in the welding nozzle.

FIG. **9** is a rear elevation of the liner shown in FIG. **8**.

FIG. **10** is a fragmentary longitudinal section showing a modified nozzle construction, providing an internal groove or pocket to assist in the retention of the liner.

FIG. **11** is a fragmentary longitudinal section showing another modified nozzle construction, utilizing a tapered internal surface to assist in retaining the liner.

FIG. **12** is a front elevation of another modified liner which is split to form a gap in its circumference.

FIG. **13** is a central longitudinal section taken generally along the line **13—13** in FIG. **12**.

FIG. **14** is a rear elevation of the liner shown in FIGS. **12** and **13**.

FIG. **15** is a fragmentary longitudinal section showing another modified liner and nozzle construction.

FIG. **16** is a front elevation of the construction shown in FIG. **15**.

FIG. **1** considered in greater detail, illustrates an embodiment of the invention, in the form of a nozzle assembly **20** for a welding gun **22**. It will be seen that the welding gun **22** comprises a body **24** which may be made of metal covered with rubber or some other insulating material. Any other suitable material may be employed in the body **24**.

As illustrated, an adapter bushing or extension **26** is mounted on a tubular guide **28**, which in turn is mounted on the body **24**. An axial bore **30** is formed in the tubular guide **28** to receive the welding member **32**.

ELECTRIC ARC WELDING GUN HAVING A NOZZLE WITH A REMOVABLE METAL LINER TO PROTECT THE NOZZLE FROM WELD SPLATTER

This invention relates to a new and improved construction for welding guns of the type utilizing a nozzle to direct inert gas against the work to be welded so as to shield the welding area from exposure to the oxygen and nitrogen in the surrounding atmosphere. A welding gun of this type generally utilizes a guide tube having a tip portion within the nozzle to guide a welding wire or rod toward the work. The welding arc is drawn between the work and the welding wire or rod. The guide tip for the welding wire is disposed axially in the nozzle opening, so that the stream of inert gas surrounds and encloses the wire and the welding arc.

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When the nozzle becomes clogged, the nozzle must be removed and cleaned out, or replaced with a new nozzle. The removal of the accumulated weld splatter can be a difficult operation and may require the reboring or reaming of the opening in the nozzle. The necessity for removing the weld splatter shortens the useful life of the nozzle.

One principal object of the invention is to eliminate the problems due to the accumulation of weld splatter in welding nozzles.

Thus, the present invention preferably provides a disposable metal liner which is inserted into the welding nozzle to protect the nozzle from weld splatter. One or more retaining elements are provided on the liner to hold it within the opening in the nozzle, against accidental dislodgment. Instead of being deposited on the inner surface of the nozzle, the weld splatter is deposited on the liner. When the wall splatter builds up to excessive thickness, the liner is simply removed and replaced with a new liner. The cost of the liner is very small, because it may be made of thin sheet metal, or in the form of a thin-walled tube. It is an easy matter to slip the old liner out of the nozzle and to slip in a new liner.

The liner may be retained by forming a portion of its annular wall in an oval shape so that the oval portion must be compressed to insert the liner into the nozzle. When the liner has been inserted, the oval portion springs outwardly so that the liner is frictionally retained in the nozzle.

An alternative construction is to form outwardly projecting elements on the liner, for frictionally engaging the inside of the nozzle. Such projections may take the form of spring fingers or dimple shaped protrusions. In some cases, the nozzle may be formed with an internal annular groove, or an internal tapered surface, to engage the outward projections on the liner.

Another alternative construction is to split the liner so that it has a gap in its circumference. The liner is made larger than the opening in the nozzle so that the liner must be compressed for insertion into the opening. The liner then springs outwardly and is frictionally retained.

The liner may also be arranged for insertion into the nozzle from the rear end thereof. This requires removal of the nozzle from the welding gun. The liner is retained by an outward flange or other similar element thereon, adapted to engage a shoulder within the nozzle. The liner may be held against the shoulder by a sleeve or bushing within the nozzle.

Further objects, advantages and features of the present invention will appear from the following description, taken with the accompanying drawings, in which:

FIG. **1** is a longitudinal section taken through a welding gun, to be described as an illustrative embodiment of the present invention.

FIG. **2** is a front elevation of a disposable metal liner, adapted to be inserted and retained within the welding nozzle shown in FIG. **1**.

FIG. **3** is a longitudinal section taken along the line **3**—**3** in FIG. **2**.

FIG. **4** is a rear elevation of the liner.

FIG. **5** is a front elevation of a modified liner utilizing spring fingers to retain the liner in the welding nozzle.

FIG. **6** is a longitudinal section, taken generally along the line **6**—**6** in FIG. **7**.

FIG. **7** is a rear elevation of the liner shown in FIGS. **5** and **6**.

FIG. **8** is a longitudinal section taken along the line **8**—**8** in FIG. **9**, and showing another modified liner utilizing outwardly formed dimples to retain the liner in the welding nozzle.

FIG. **9** is a rear elevation of the liner shown in FIG. **8**.

FIG. **10** is a fragmentary longitudinal section showing a modified nozzle construction, providing an internal groove or pocket to assist in the retention of the liner.

FIG. **11** is a fragmentary longitudinal section showing another modified nozzle construction, utilizing a tapered internal surface to assist in retaining the liner.

FIG. **12** is a front elevation of another modified liner which is split to form a gap in its circumference.

FIG. **13** is a central longitudinal section taken generally along the line **13**—**13** in FIG. **12**.

FIG. **14** is a rear elevation of the liner shown in FIGS. **12** and **13**.

FIG. **15** is a fragmentary longitudinal section showing another modified liner and nozzle construction.

FIG. **16** is a front elevation of the construction shown in FIG. **15**.

FIG. **1** considered in greater detail, illustrates an embodiment of the invention, in the form of a nozzle assembly **20** for a welding gun **22**. It will be seen that the welding gun **22** comprises a body **24** which may be made of metal covered with rubber or some other insulating material. Any other suitable material may be employed in the body **24**.

As illustrated, an adapter bushing or extension **26** is mounted on a tubular guide **28**, which in turn is mounted on the body **24**. An axial bore **30** is formed in the tubular guide **28** to receive the welding member **32**.

FIG. **11** illustrates another modified nozzle **448** having a bore or opening **454**. In this case, the nozzle **448** is formed with a tapered annular surface **455** which connects with the rear end of the bore **454**. It will be seen that the liner **256** of FIGS. **8** and **9** is mounted within the bore **454**. The dimples **260** are in engagement with the tapered surface **455**. As the liner **256** is inserted into the nozzle **448**, the dimples **260** spring outwardly when they encounter the tapered surface **455**. It will be understood that the liner **156** of FIGS. **5**–**7** can also be inserted into the bore **454**. In that case, the fingers **160** spring outwardly to engage the tapered surface **455**.

FIGS. **12**–**14** illustrate another modified liner **556** which is generally cylindrical in shape but is formed with an outwardly projecting flange **558** at its front end. In this case, the flange **558** is rolled or curled from the wall of the liner **556**.

To provide for retention of the liner **556**, it is split so that a gap **560** is formed in its circumference. The initial diameter of the liner **556** is made greater than the diameter of the opening **54** in the nozzle **48**. Thus, the liner **556** must be compressed when it is to be inserted into the opening **54**. Such compression closes the gap **560** or at least reduces its width. When the liner **556** has been inserted, it springs outwardly into frictional engagement with the nozzle **48** within the opening **54**. The flange **558** increases the stiffness of the liner **556** so that the spring pressure between the liner and the nozzle is increased. The flange **558** makes it easy to grip the liner **556** when it is to be removed from the nozzle **48**.

FIGS. **15** and **16** illustrate a modified construction in which both the nozzle and the liner are modified. The liner is inserted from the rear of the nozzle rather than from the front. Thus, the nozzle must be unscrewed from the welding gun when the liner is to be inserted.

Specifically, FIGS. **15** and **16** illustrate a modified nozzle **648** having a bore or opening **654** therein. Behind the bore **654**, the nozzle **648** has an enlarged bore **655**. As previously described, the internally threaded portion **52** is to the rear of the enlarged bore **655**.

A liner **656** is adapted to be inserted into the bore **654** through the enlarged bore **655** to the rear of the bore **654**. The liner **656** is generally cylindrical but is retained by an outwardly projecting flange or other element **660** at the rear end thereof. The flange **660** is of such a size that it can be inserted through the enlarged bore **655**. The flange **660** is engageable with a rearwardly facing shoulder **661** which is formed within the nozzle **648** between the bore **654** and enlarged bore **655**. The shoulder **661** retains the liner **656** against forward movement out of the nozzle **648**.

To prevent rearward movement of the liner **656** it is preferred to provide a bushing or sleeve **663** within the enlarged bore **655** behind the flange **660**. The bushing **663** is preferably made of an electrically insulating material, such as a heat resistant plastic. When the nozzle **648** is screwed onto the bushing **26** the bushing **663** engages the bushing **26** and is pushed forwardly so that it pushes the flange **660** against the shoulder **661**.

I claim:

1. An electric arc welding gun construction,

comprising a metal nozzle member having an axial generally cylindrical opening of substantially circular cross section in the outer end portion of said nozzle member for directing an inert gas against the work to be welded,

a tubular metal generally cylindrical tip member disposed centrally in said generally cylindrical opening and having an axial guide bore therein,

a consumable arc welding member slidably movable through said bore and extending out of said tip member and beyond said opening and the outer end portion of said nozzle member for movement toward the work,

and a tubular generally cylindrical metal liner removably slip fitted within said generally cylindrical opening for protecting said nozzle member from weld splatter,

said metal liner having a substantially larger inner size than the outer size of said tip member to provide an annular space therebetween for the passage of the inert gas,

said liner having a retaining element for removably holding said liner in said nozzle member against accidental dislodgment.

2. A welding gun construction according to claim 1,

in which said retaining element of said liner comprises a wall portion thereof formed into an oval shape and having a maximum dimension greater than the diameter of said generally cylindrical opening whereby said wall portion must be compressed to provide for insertion of said liner into said opening,

said wall portion being effective to spring outwardly against said nozzle to retain said liner in said opening.

3. A welding gun construction according to claim 1,

in which said retaining element comprises at least one wall portion projecting outwardly from said liner and frictionally engageable with said nozzle member within said generally cylindrical opening.

4. A welding gun construction according to claim 3,

in which said nozzle member is formed with a pocket within said generally cylindrical opening for receiving and retaining said outwardly projecting wall portion.

5. A welding gun construction according to claim 3,

in which said wall portion comprises a spring finger struck from said liner and bent outwardly therefrom for frictional engagement with said nozzle member within said generally cylindrical opening.

6. A welding gun construction according to claim 3,

in which said wall portion comprises an outwardly projecting dimple-shaped deformation on said liner and frictionally engageable with said nozzle member within said generally cylindrical opening.

7. A welding gun construction according to claim 4,

in which said nozzle member is formed with a tapered surface within said generally cylindrical opening for engaging and retaining said wall portion.

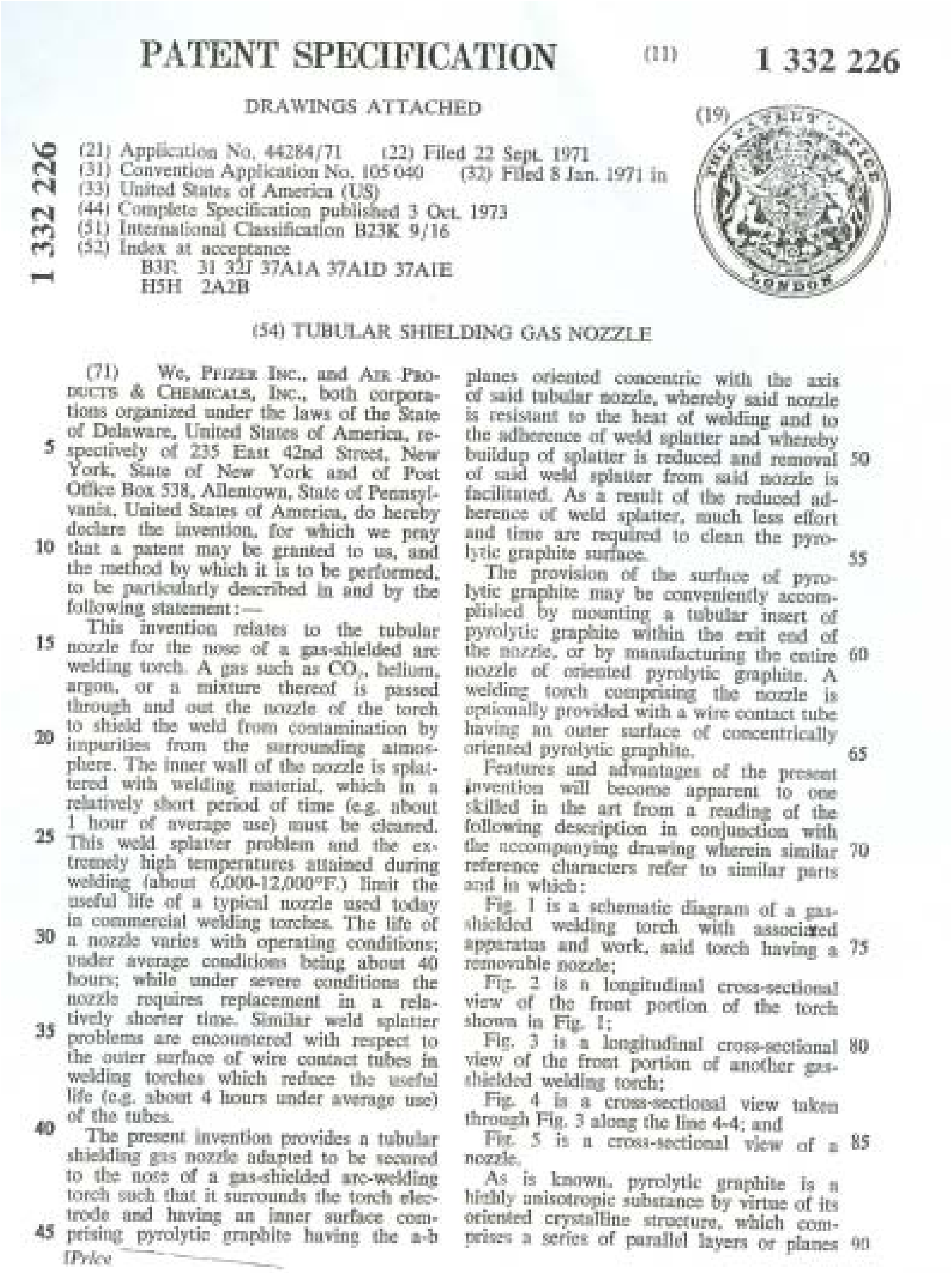
8. A welding gun construction according to claim 1,

in which said liner comprises means forming an open split in the circumference thereof and extending entirely through the wall of said liner,

said liner being of a dimension greater than the size of said opening whereby said liner must be compressed for insertion into said generally cylindrical opening.

Appendix B

Tubular Shielding Gas Nozzle



PATENT SPECIFICATION

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DRAWINGS ATTACHED

(19) THE PATENT OFFICE LONDON

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(52) Index at acceptance
B3R 31 32J 37A1A 37A1D 37A1E
H5H 2A2B

(54) TUBULAR SHIELDING GAS NOZZLE

(71) We, PFIZER INC., and AIR PRODUCTS & CHEMICALS, INC., both corporations organized under the laws of the State of Delaware, United States of America, respectively of 235 East 42nd Street, New York, State of New York and of Post Office Box 538, Allentown, State of Pennsylvania, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the tubular nozzle for the nose of a gas-shielded arc welding torch. A gas such as CO_2, helium, argon, or a mixture thereof is passed through and out the nozzle of the torch to shield the weld from contamination by impurities from the surrounding atmosphere. The inner wall of the nozzle is splattered with welding material, which in a relatively short period of time (e.g. about 1 hour of average use) must be cleaned. This weld splatter problem and the extremely high temperatures attained during welding (about 6,000-12,000°F.) limit the useful life of a typical nozzle used today in commercial welding torches. The life of a nozzle varies with operating conditions; under average conditions being about 40 hours; while under severe conditions the nozzle requires replacement in a relatively shorter time. Similar weld splatter problems are encountered with respect to the outer surface of wire contact tubes in welding torches which reduce the useful life (e.g. about 4 hours under average use) of the tubes.

The present invention provides a tubular shielding gas nozzle adapted to be secured to the nose of a gas-shielded arc-welding torch such that it surrounds the torch electrode and having an inner surface comprising pyrolytic graphite having the a-b planes oriented concentric with the axis of said tubular nozzle, whereby said nozzle is resistant to the heat of welding and to the adherence of weld splatter and whereby buildup of splatter is reduced and removal of said weld splatter from said nozzle is facilitated. As a result of the reduced adherence of weld splatter, much less effort and time are required to clean the pyrolytic graphite surface.

The provision of the surface of pyrolytic graphite may be conveniently accomplished by mounting a tubular insert of pyrolytic graphite within the exit end of the nozzle, or by manufacturing the entire nozzle of oriented pyrolytic graphite. A welding torch comprising the nozzle is optionally provided with a wire contact tube having an outer surface of concentrically oriented pyrolytic graphite.

Features and advantages of the present invention will become apparent to one skilled in the art from a reading of the following description in conjunction with the accompanying drawing wherein similar reference characters refer to similar parts and in which:

Fig. 1 is a schematic diagram of a gas-shielded welding torch with associated apparatus and work, said torch having a removable nozzle;

Fig. 2 is a longitudinal cross-sectional view of the front portion of the torch shown in Fig. 1;

Fig. 3 is a longitudinal cross-sectional view of the front portion of another gas-shielded welding torch;

Fig. 4 is a cross-sectional view taken through Fig. 3 along the line 4-4; and

Fig. 5 is a cross-sectional view of a nozzle.

As is known, pyrolytic graphite is a highly anisotropic substance by virtue of its oriented crystalline structure, which comprises a series of parallel layers or planes

[Price

which are commonly designated the "a-b planes". The direction normal to the a-b planes is commonly designated the "c-axis" or "c-direction". Thermal conductivity of pyrolytic graphite is many times greater along the a-b planes than in the c-direction perpendicular to those planes. The lower adherence to weld splatter achieved by using surfaces composed of oriented pyrolytic graphite gives rise to two important results. First, a substantial proportion of the weld splatter is prevented from sticking to the surface at all. Secondly, that amount of weld splatter which actually does adhere to the surface of a nozzle or contact tube is much easier to remove because it does not become firmly bonded to the pyrolytic graphite as it does in the case of other surfaces (e.g. copper).

As shown in Figs. 1 and 2, a gas-shielded arc welding torch 10 is being used to form a weld 12 between steel plates 14 and 16. Torch 10 is connected to gas supply 18, which is for example, a source of shielding gas such as argon or CO_2 and to a source of weld metal or wire supply 20 which is for example a reel of steel welding wire. A power supply 22 which may be of the AC or DC type is connected between torch 10 and workpieces 14 and 16. Torch 10 has a nose or heat sink 24 within which is longitudinally disposed the metal electrode 26 which is a consumable wire fed from wire supply 20. A shielding gas designated by arrows 28 flows through nose 24 about the consumable metal electrode 26 to shield it from the atmosphere.

Nose 24 incorporates a removable nozzle 30, which is shown in detail in Fig. 2. Nozzle 30 is removably mounted within nose 24 by threaded boss 32 screwed within internally threaded end 34 of nose 24. Nozzle 30 is removable to facilitate replacement, and a number of nozzles are provided to permit them to be replaced. Contact tube 52 having central bore 54, inner end 64 and outer end 62 being disposed within the inner and outer ends of nozzle 30, is concentrically disposed within nozzle 30 and is mounted within nose 24 in the customary manner (e.g. by threaded or collet chuck attachment). Contact tube 52 is provided for the purpose of supporting and supplying current to weld wire 26. Since contact tube 52, like nozzle 30, is subject to weld splatter, it is advantageously formed of pyrolytic graphite with the a-b planes thereof oriented concentric with the axis of said tube. Alternatively, contact tube 52 may for example be formed of metal, e.g. copper, having an outer surface, e.g. sheath or coating, of pyrolytic graphite for the same purpose. Contact tube 52 is removable to facilitate replacement and a number of contact tubes 52 are provided to permit them to be replaced.

The system described in Fig. 1 includes carbon dioxide gas-shielded torches as well as the MIG type of welding system, which stands for 'metal inert gas'. This invention is also applicable to the other types of gas-shielded welding systems such as TIG (tungsten inert gas).

The outer end of nozzle 30, shown in Fig. 2, is internally surfaced with pyrolytic graphite by tubular insert 36. As indicated schematically by parallel horizontal lines, insert 36 has the pyrolytic graphite a-b planes oriented concentric with the axis of said insert, so that heat is conducted along the a-b planes through nozzle 30 and dissipated by reradiation back into the welding arc. Insert 36 is mounted within the end of nozzle 30 by press or interference fit. This interference fit is for example conveniently accomplished by press and shrink fitting. Nozzle 30, which is for example made of copper, is heated to about 600°C. and insert 36 is pressed within it. When nozzle 30 cools, a strong interference fit is achieved. Any other dependable means of attachment such as clamping, swaging, staking, brazing or high temperature cementing may be utilized. Entire nozzle 30 may be made of the same pyrolytic graphite material as insert 36 (as shown in Fig. 5) but more rugged and economical nozzles are made in the inserted form here described.

Tubular insert 36 is for example made in the following manner in order to achieve a structure wherein the pyrolytic graphite a-b planes are oriented concentric to the axis of said insert.

A pyrolytic graphite tube is deposited on a polycrystalline graphite rod (e.g. ½ inch diameter × 12 inches long) in a vacuum furnace. Deposition conditions are 6 liters per minute natural gas, 6 liters per minute hydrogen, temperature of 2100°C. and absolute pressure of 13 mm. Hg. The inner rod is removed and the outer tube is then machined to 0.625 inches OD and cut into 0.700 inch length inserts.

One of these cut off lengths was pressed as an insert into a copper sleeve as previously described and mounted on a gas shielded metal-arc. welding gun. The gun ran at 250 amps using 25 CFM CO_2 and 0.030 inch medium carbon steel welding wire. The nozzle with insert was run for 80 hours with only minimal wear. It was cleaned of splatter once every 8 hours. The standard copper nozzle is usually worn out under average use after 40 hours and must be cleaned every hour. Wire contact tube 52 is made by similar deposition techniques to achieve a structure having pyrolytic graphite a-b planes oriented concentric to the axis of said tube. Again, the tube is rendered less adherent to weld splatter and its life (e.g. about 4 hours) is prolonged similarly. Typically, the contact tube dimensions are about $\frac{1}{16}$ inch I.D. × 3-4 inches length; the tube O.D. being about $\frac{3}{16}$-$\frac{1}{4}$ inch.

In Figs. 3 and 4 is shown an insert 36A made of pyrolytic graphite, press-fitted within counterbore 38A in nozzle 30A. As indicated schematically by parallel horizontal lines in Fig. 3 and by concentric circles in Fig. 4, insert has the pyrolytic graphite a-b planes oriented concentric with the axis of said insert. Nozzle 30A, which optionally carries integrally and externally cast flange 50A at the inner end of nozzle 30A, is mounted to nose 24A by a collet chuck 46A which retains nozzle 30A by compressing external flange 50A.

Further embodiments of the invention will be apparent to those skilled in the art. For example, the nozzle for an arc torch may be comprised of oriented pyrolytic graphite, without the use of an insert, as provided in Fig. 5. Therein is shown pyrolytic graphite having the a-b planes oriented concentric with the axis of said nozzle, as indicated schematically by concentric circles. A welding torch comprising nozzle 30B may optionally be provided with a wire contact tube having an outer surface of oriented pyrolytic graphite as discussed hereinbefore. Pyrolytic graphite is obtained by the chemical vapor deposition of graphite at temperatures above about 2000°C. This provides a highly oriented and anisotropic pyrolytic graphite, which is planar crystalline and has highly anisotropic properties. For example, the thermal conductivity within its oriented planes is about 200 times greater than the thermal conductivity normal to the planes of orientation. Pyrolytic graphite and processes to obtain it are described in United States Patent 3,375,308. See particularly the portions beginning Col. 2, line 59 and Col. 3, line 36. Another patent describing the pyrolytic graphite utilized in this invention is United States Patent 3,410,746. Of course, the term tubular as employed herein and in the appended claims, is meant to include conical configurations, as well as cylindrical.

WHAT WE CLAIM IS:

1. A tubular shielding gas nozzle adapted to be secured to the nose of a gas-shielded arc-welding torch such that it surrounds the torch electrode and having an inner surface comprising pyrolytic graphite having the a-b planes oriented concentric with the axis of said tubular nozzle, whereby said nozzle is resistant to the heat of welding and to the adherence of weld splatter and whereby buildup of splatter is reduced and removal of said weld splatter from said nozzle is facilitated.

2. A tubular nozzle as set forth in claim 1, comprising a supporting tube, and wherein said inner surface is provided by a tubular insert comprising pyrolytic graphite having the a-b planes oriented concentric with the axis of said tubular nozzle, said insert being mounted within said supporting tube.

3. A nozzle as set forth in claim 2, wherein said supporting tube has entrance and exit ends and a counterbore within the exit end, and said insert is mounted within said counterbore.

4. A gas shielded welding torch comprising the nozzle according to claims 1, 2 or 3 in combination with a wire contact tube concentrically mounted within said nozzle, said contact tube having an outer surface of pyrolytic graphite with the a-b planes thereof oriented concentric with the axis of said tube.

5. A tubular nozzle for a gas-shielded welding torch substantially as described with reference to Figures 1 and 2, Figures 3 and 4, or Figure 5 of the accompanying drawings.

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1332226 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

Fig.1.

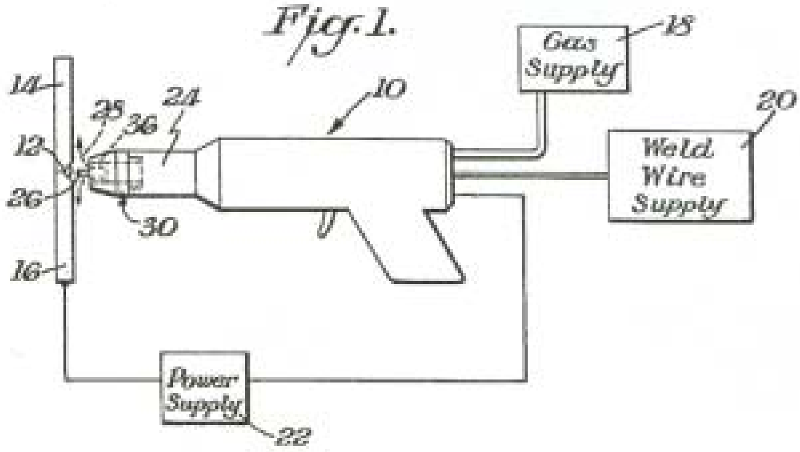


Fig.3.

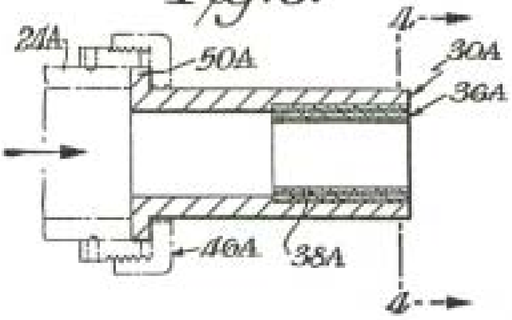


Fig.4.

Fig.2.

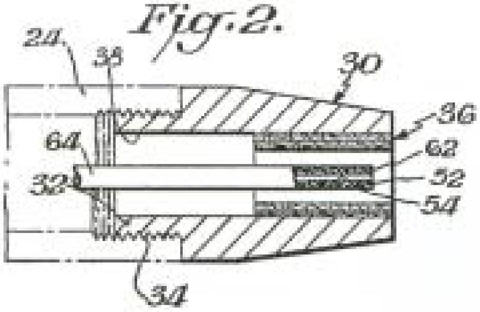
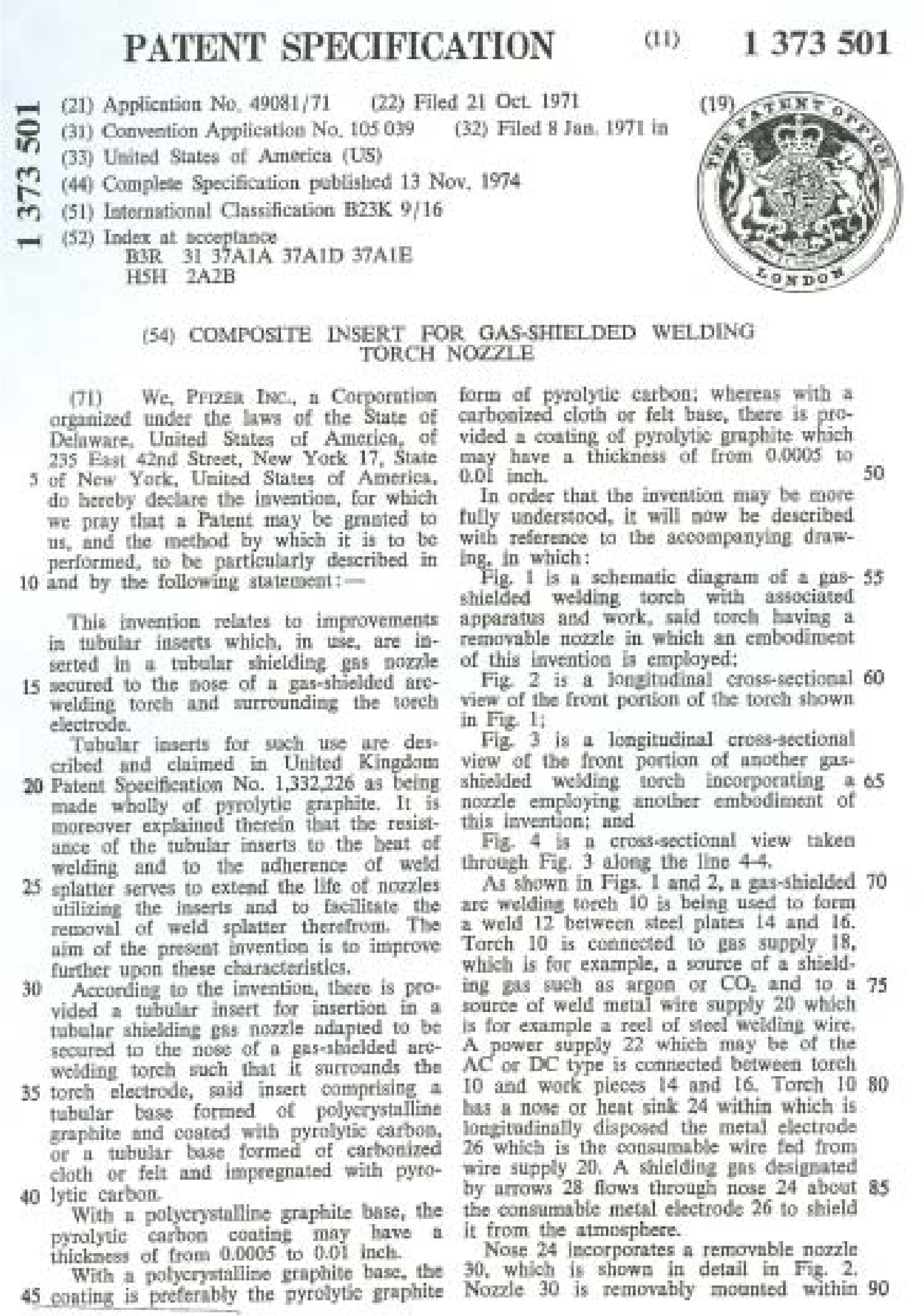


Fig.5.

Appendix C

Composite Insert for Gas-Shielded Welding Torch Nozzle



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(51) International Classification B23K 9/16
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H5H 2A2B

(19) THE PATENT OFFICE LONDON

(54) COMPOSITE INSERT FOR GAS-SHIELDED WELDING TORCH NOZZLE

(71) We, PFIZER INC., a Corporation organized under the laws of the State of Delaware, United States of America, of 235 East 42nd Street, New York 17, State of New York, United States of America, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to improvements in tubular inserts which, in use, are inserted in a tubular shielding gas nozzle secured to the nose of a gas-shielded arc-welding torch and surrounding the torch electrode.

Tubular inserts for such use are described and claimed in United Kingdom Patent Specification No. 1,332,226 as being made wholly of pyrolytic graphite. It is moreover explained therein that the resistance of the tubular inserts to the heat of welding and to the adherence of weld splatter serves to extend the life of nozzles utilizing the inserts and to facilitate the removal of weld splatter therefrom. The aim of the present invention is to improve further upon these characteristics.

According to the invention, there is provided a tubular insert for insertion in a tubular shielding gas nozzle adapted to be secured to the nose of a gas-shielded arc-welding torch such that it surrounds the torch electrode, said insert comprising a tubular base formed of polycrystalline graphite and coated with pyrolytic carbon, or a tubular base formed of carbonized cloth or felt and impregnated with pyrolytic carbon.

With a polycrystalline graphite base, the pyrolytic carbon coating may have a thickness of from 0.0005 to 0.01 inch.

With a polycrystalline graphite base, the coating is preferably the pyrolytic graphite form of pyrolytic carbon; whereas with a carbonized cloth or felt base, there is provided a coating of pyrolytic graphite which may have a thickness of from 0.0005 to 0.01 inch.

In order that the invention may be more fully understood, it will now be described with reference to the accompanying drawing, in which:

Fig. 1 is a schematic diagram of a gas-shielded welding torch with associated apparatus and work, said torch having a removable nozzle in which an embodiment of this invention is employed;

Fig. 2 is a longitudinal cross-sectional view of the front portion of the torch shown in Fig. 1;

Fig. 3 is a longitudinal cross-sectional view of the front portion of another gas-shielded welding torch incorporating a nozzle employing another embodiment of this invention; and

Fig. 4 is a cross-sectional view taken through Fig. 3 along the line 4-4.

As shown in Figs. 1 and 2, a gas-shielded arc welding torch 10 is being used to form a weld 12 between steel plates 14 and 16. Torch 10 is connected to gas supply 18, which is for example, a source of a shielding gas such as argon or CO_2 and to a source of weld metal wire supply 20 which is for example a reel of steel welding wire. A power supply 22 which may be of the AC or DC type is connected between torch 10 and work pieces 14 and 16. Torch 10 has a nose or heat sink 24 within which is longitudinally disposed the metal electrode 26 which is the consumable wire fed from wire supply 20. A shielding gas designated by arrows 28 flows through nose 24 about the consumable metal electrode 26 to shield it from the atmosphere.

Nose 24 incorporates a removable nozzle 30, which is shown in detail in Fig. 2. Nozzle 30 is removably mounted within nose 24 by threaded boss 32 screwed within internally threaded end 34 of nose 24. Nozzle 30 is removable to facilitate replacement. A number of nozzles 30 are provided to permit them to be replaced.

The system described in Fig. 1 includes carbon-dioxide gas-shielded torches as well as the MIG type of welding system, which stands for 'metal inert gas'. This invention is also applicable to other types of gas-shieldeld welding systems such as TIG (tungsten inert gas).

The outer end of nozzle 30, shown in Fig. 2 is internally protected by the provision of a tubular insert 36 having a coating of pyrolytic carbon. Insert 36 is mounted within the end of nozzle 30 by press or interference fit. This interference fit is for example conveniently accomplished by press and shrink fitting. Nozzle 30, which is for example made of copper, is heated to about 600°C. and insert 36 is pressed within it. When nozzle 30 cools, a strong interference fit is achieved. Any other dependable means of attachment such as clamping, swaging, brazing or high temperature cementing may be utilized.

Tubular insert 36 is for example made in accordance with the following examples.

EXAMPLE I

Pyrolytic Graphite Coating on a Graphite Substrate

A polycrystalline graphite is machined from rod stock into a right cylinder. This cylinder is coated in a high temperature vacuum furnace using flowing methane gas at 2100°C. and a pressure of 5 mm Hg abs. to produce a pyrolytic graphite coating about 0.005 inch thick.

EXAMPLE II

Pyrolytic Carbon Impregnated Felt

A carbonized rayon needled felt is impregnated with pyrolytic carbon by placing sheets of the carbonized felt material into a vacuum furnace and processing at 1100°C. with a pressure of 5 mm Hg abs. of flowing methane for a period of about 20 hours. The sheets are then rolled and machined into the right cylinder insert configuration and further processed in the vacuum furnace for an additional 60 hours under the above conditions to obtain a specific gravity of 1.4 gm/cc. These inserts are then swaged into copper nozzles.

Alternatively, the carbonized felt may be initially fabricated in tubular form and then impregnated with pyrolytic carbon. Any type of carbon cloth or felt is satisfactory.

EXAMPLE III

Coated Pyrolytic Carbon Impregnated Felt

The inserts are processed as in Example II, and are then coated with pyrolytic graphite as described in Example I before swaging into the copper nozzles. The coating is only 0.0005 inch thick.

Referring to Fig. 2, insert 36 is formed in accordance with Example I and thus incorporates an outer coating of pyrolytic graphite 40 on a base cylinder 42 of polycrystalline graphite.

In Figs. 3 and 4 is shown an insert 36A made in accordance with Example III having an outer coating 44A of pyrolytic graphite disposed on a tubular base 45A of carbonized felt impregnated with pyrolytic carbon as described in Example III. Nozzle 30A is mounted within nose 24A by a collet chuck 46A which retains nozzle 30A by compressing an elastomer O-ring 50A made of a high temperature resistant elastomeric material.

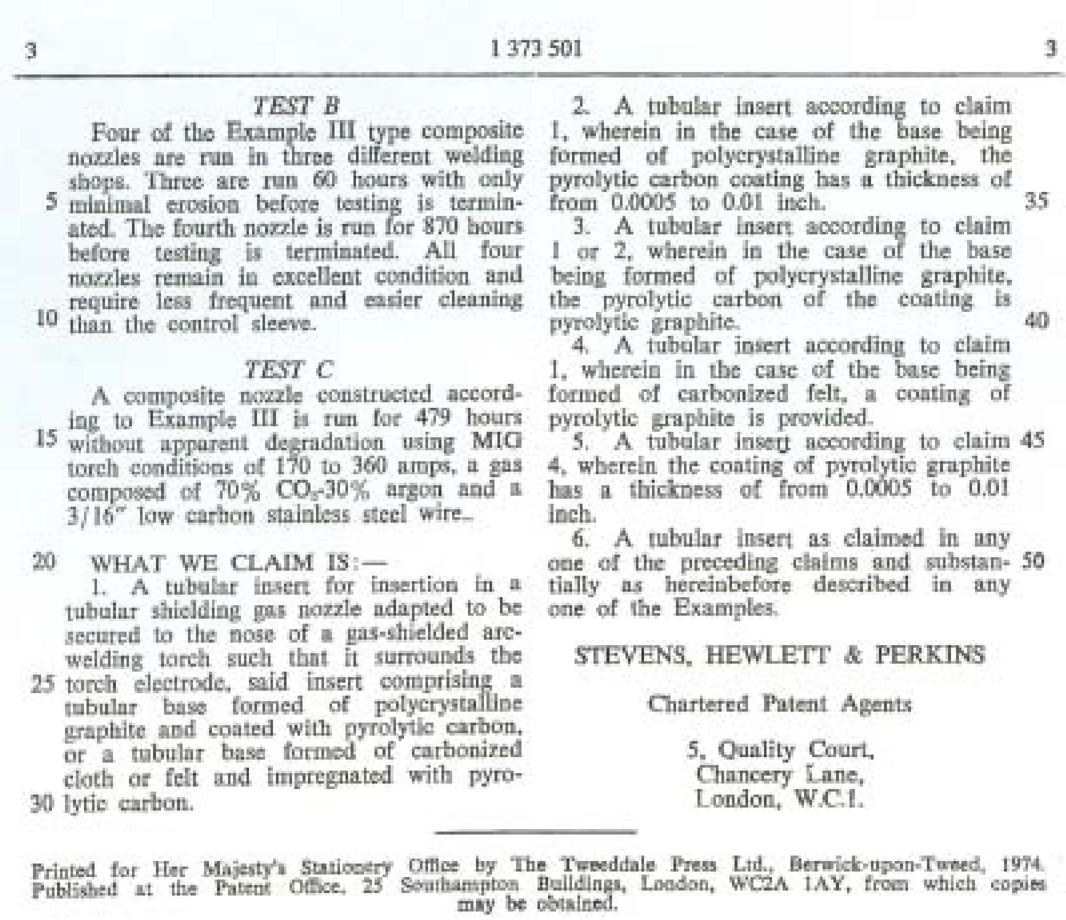
The terms pyrolytic graphite and pyrolytic carbon are widely used and understood. Pyrolytic carbon consists of anisotropic crystalline carbon formed by chemical vapor deposition at temperatures above about 700°C., and pyrolytic graphite is that more highly oriented form of pyrolytic carbon which is formed by chemical vapor deposition at temperatures in excess of about 2000°C. Typical pyrolytic processes for preparing these anisotropic materials are included in Examples I, II and III. Pyrolytic graphite and processes to obtain it are further described in United States Patent 3,375,308. See particularly the portions beginning Col. 2, line 59 and Col. 3, line 36. Another patent describing the pyrolytic graphite utilized in this invention is United States Patent 3,410,746.

A typical insert for this invention has the following dimensions: outside diameter 5/8 inch, inside diameter 1/2 inch and length of 3/4 inch. A useful pyrolytic coating for this invention may range in thickness from about 0.0005 inch to 0.01 inch and is for example 0.005 inch thick.

OPERATION

TEST A

Three types of inserts, made in accordance with Examples I, II and III, are incorporated in torch nozzles and are tested in gas welding torches under identical running conditions using 3/32 inch cored wire and performing the same commercial steel welding operations. A conventional copper nozzle is run in an identical manner for control purposes. The test is made for a 20 hour duration. The control tip requires 206 minutes of cleaning time due to build-up of the weld splatter. The Example I type requires 34 minutes. The Example II type requires 28 minutes and the Example III type requires 22 minutes total cleaning time.



TEST B

Four of the Example III type composite nozzles are run in three different welding shops. Three are run 60 hours with only minimal erosion before testing is terminated. The fourth nozzle is run for 870 hours before testing is terminated. All four nozzles remain in excellent condition and require less frequent and easier cleaning than the control sleeve.

TEST C

A composite nozzle constructed according to Example III is run for 479 hours without apparent degradation using MIG torch conditions of 170 to 360 amps, a gas composed of 70% CO_2-30% argon and a 3/16" low carbon stainless steel wire.

WHAT WE CLAIM IS:—

1. A tubular insert for insertion in a tubular shielding gas nozzle adapted to be secured to the nose of a gas-shielded arc-welding torch such that it surrounds the torch electrode, said insert comprising a tubular base formed of polycrystalline graphite and coated with pyrolytic carbon, or a tubular base formed of carbonized cloth or felt and impregnated with pyrolytic carbon.

2. A tubular insert according to claim 1, wherein in the case of the base being formed of polycrystalline graphite, the pyrolytic carbon coating has a thickness of from 0.0005 to 0.01 inch.

3. A tubular insert according to claim 1 or 2, wherein in the case of the base being formed of polycrystalline graphite, the pyrolytic carbon of the coating is pyrolytic graphite.

4. A tubular insert according to claim 1, wherein in the case of the base being formed of carbonized felt, a coating of pyrolytic graphite is provided.

5. A tubular insert according to claim 4, wherein the coating of pyrolytic graphite has a thickness of from 0.0005 to 0.01 inch.

6. A tubular insert as claimed in any one of the preceding claims and substantially as hereinbefore described in any one of the Examples.

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1373501 COMPLETE SPECIFICATION

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Fig.1.

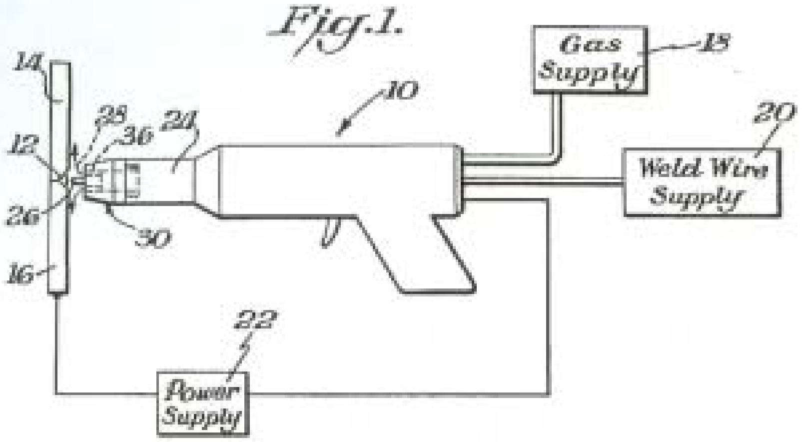


Fig.3.

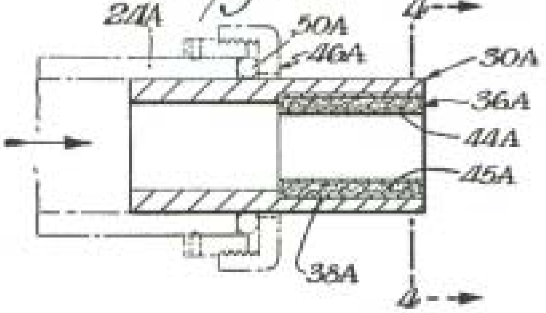


Fig.4.

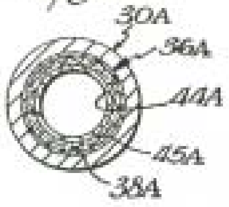
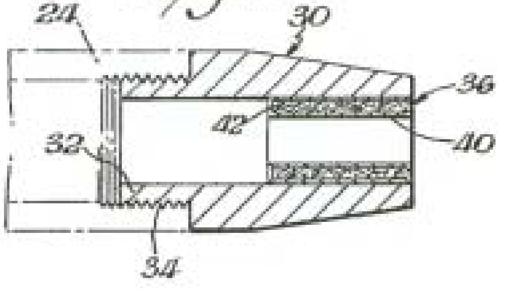


Fig.2.



Appendix D

Consumable Electrode Type Arc Welding Contact Tip

Consumable electrode type arc welding contact tip.

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IPC Classification:	B23K9/26; B23K9/28
EC Classification:	B23K9/12E2
Equivalents:	DE3887676D, DE3887676T, ☐ US4937428
Cited patent(s):	US4560858; FR2565141; EP0080803

Abstract

A welding contact tip for use on a consumable electrode type welder has a core part (1) having a bore (3) for guiding a consumable electrode (4) and capable of supplying welding current to the consumable electrode (4), and a main part (2) which embraces and supports the core part (1). The core part (1) is made of a heat- and wear-resistant conductive metallic material such as a chromium-copper alloy, while the main part (2) is made from a less-expensive material such as copper, a copper alloy, aluminum or an aluminum alloy.

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⑪ Publication number: **0 324 088 A1**

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㉑ Application number: 88119706.5

(51) Int. Cl.4: **B23K 9/28 , B23K 9/26**

㉒ Date of filing: 25.11.88

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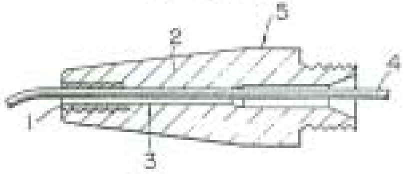
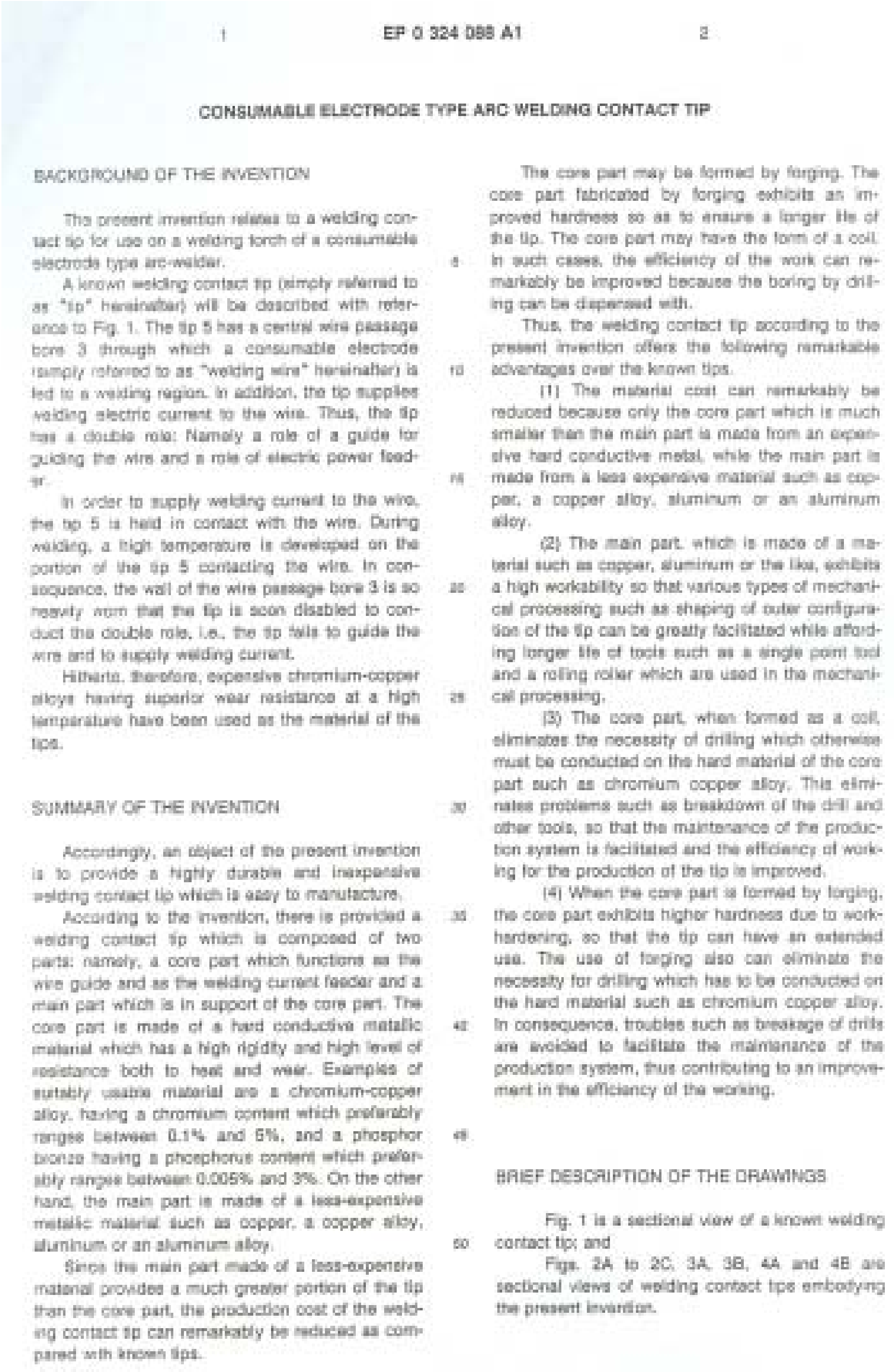
EP 0 324 088 A1

(54) Consumable electrode type arc welding contact tip.

(57) A welding contact tip for use on a consumable electrode type welder has a core part (1) having a bore (3) for guiding a consumable electrode (4) and capable of supplying welding current to the consumable electrode (4), and a main part (2) which embraces and supports the core part (1). The core part (1) is made of a heat- and wear-resistant conductive metallic material such as a chromium-copper alloy, while the main part (2) is made from a less-expensive material such as copper, a copper alloy, aluminum or an aluminum alloy.

FIG. 2B





CONSUMABLE ELECTRODE TYPE ARC WELDING CONTACT TIP

BACKGROUND OF THE INVENTION

This present invention relates to a welding contact tip for use on a welding torch of a consumable electrode type arc-welder.

A known welding contact tip (simply referred to as "tip" hereinafter) will be described with reference to Fig. 1. The tip 5 has a central wire passage bore 3 through which a consumable electrode (simply referred to as "welding wire" hereinafter) is fed to a welding region. In addition, the tip supplies welding electric current to the wire. Thus, the tip has a double role: Namely a role of a guide for guiding the wire and a role of electric power feeder.

In order to supply welding current to the wire, the tip 5 is held in contact with the wire. During welding, a high temperature is developed on the portion of the tip 5 contacting the wire. In consequence, the wall of the wire passage bore 3 is so heavily worn that the tip is soon disabled to conduct the double role, i.e., the tip fails to guide the wire and to supply welding current.

Hitherto, therefore, expensive chromium-copper alloys having superior wear resistance at a high temperature have been used as the material of the tips.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide a highly durable and inexpensive welding contact tip which is easy to manufacture.

According to the invention, there is provided a welding contact tip which is composed of two parts: namely, a core part which functions as the wire guide and as the welding current feeder and a main part which is in support of the core part. The core part is made of a hard conductive metallic material which has a high rigidity and high level of resistance both to heat and wear. Examples of suitably usable material are a chromium-copper alloy, having a chromium content which preferably ranges between 0.1% and 5%, and a phosphor bronze having a phosphorus content which preferably ranges between 0.005% and 3%. On the other hand, the main part is made of a less-expensive metallic material such as copper, a copper alloy, aluminum or an aluminum alloy.

Since the main part made of a less-expensive material provides a much greater portion of the tip than the core part, the production cost of the welding contact tip can remarkably be reduced as compared with known tips.

The core part may be formed by forging. The core part fabricated by forging exhibits an improved hardness so as to ensure a longer life of the tip. The core part may have the form of a coil. In such cases, the efficiency of the work can remarkably be improved because the boring by drilling can be dispensed with.

Thus, the welding contact tip according to the present invention offers the following remarkable advantages over the known tips.

(1) The material cost can remarkably be reduced because only the core part which is much smaller than the main part is made from an expensive hard conductive metal, while the main part is made from a less expensive material such as copper, a copper alloy, aluminum or an aluminum alloy.

(2) The main part, which is made of a material such as copper, aluminum or the like, exhibits a high workability so that various types of mechanical processing such as shaping of outer configuration of the tip can be greatly facilitated while affording longer life of tools such as a single point tool and a rolling roller which are used in the mechanical processing.

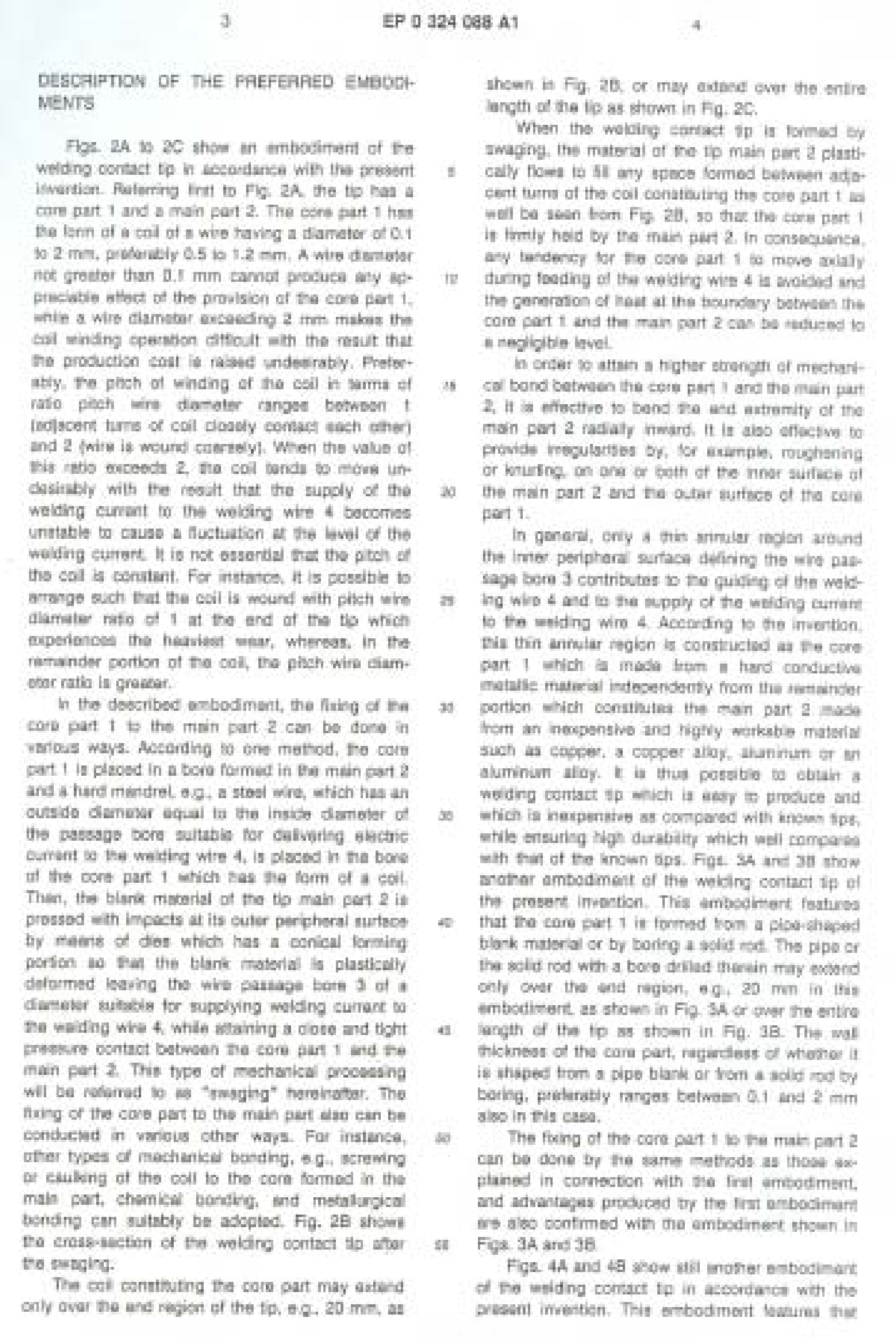
(3) The core part, when formed as a coil, eliminates the necessity of drilling which otherwise must be conducted on the hard material of the core part such as chromium copper alloy. This eliminates problems such as breakdown of the drill and other tools, so that the maintenance of the production system is facilitated and the efficiency of working for the production of the tip is improved.

(4) When the core part is formed by forging, the core part exhibits higher hardness due to work-hardening, so that the tip can have an extended use. The use of forging also can eliminate the necessity for drilling which has to be conducted on the hard material such as chromium copper alloy. In consequence, troubles such as breakage of drills are avoided to facilitate the maintenance of the production system, thus contributing to an improvement in the efficiency of the working.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view of a known welding contact tip; and

Figs. 2A to 2C, 3A, 3B, 4A and 4B are sectional views of welding contact tips embodying the present invention.



DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figs. 2A to 2C show an embodiment of the welding contact tip in accordance with the present invention. Referring first to Fig. 2A, the tip has a core part 1 and a main part 2. The core part 1 has the form of a coil of a wire having a diameter of 0.1 to 2 mm, preferably 0.5 to 1.2 mm. A wire diameter not greater than 0.1 mm cannot produce any appreciable effect of the provision of the core part 1, while a wire diameter exceeding 2 mm makes the coil winding operation difficult with the result that the production cost is raised undesirably. Preferably, the pitch of winding of the coil in terms of ratio pitch wire diameter ranges between 1 (adjacent turns of coil closely contact each other) and 2 (wire is wound coarsely). When the value of this ratio exceeds 2, the coil tends to move undesirably with the result that the supply of the welding current to the welding wire 4 becomes unstable to cause a fluctuation at the level of the welding current. It is not essential that the pitch of the coil is constant. For instance, it is possible to arrange such that the coil is wound with pitch wire diameter ratio of 1 at the end of the tip which experiences the heaviest wear, whereas, in the remainder portion of the coil, the pitch wire diameter ratio is greater.

In the described embodiment, the fixing of the core part 1 to the main part 2 can be done in various ways. According to one method, the core part 1 is placed in a bore formed in the main part 2 and a hard mandrel, e.g., a steel wire, which has an outside diameter equal to the inside diameter of the passage bore suitable for delivering electric current to the welding wire 4, is placed in the bore of the core part 1 which has the form of a coil. Then, the blank material of the tip main part 2 is pressed with impacts at its outer peripheral surface by means of dies which has a conical forming portion so that the blank material is plastically deformed leaving the wire passage bore 3 of a diameter suitable for supplying welding current to the welding wire 4, while attaining a close and tight pressure contact between the core part 1 and the main part 2. This type of mechanical processing will be referred to as "swaging" hereinafter. The fixing of the core part to the main part also can be conducted in various other ways. For instance, other types of mechanical bonding, e.g., screwing or caulking of the coil to the core formed in the main part, chemical bonding, and metallurgical bonding can suitably be adopted. Fig. 2B shows the cross-section of the welding contact tip after the swaging.

The coil constituting the core part may extend only over the end region of the tip, e.g., 20 mm, as shown in Fig. 2B, or may extend over the entire length of the tip as shown in Fig. 2C.

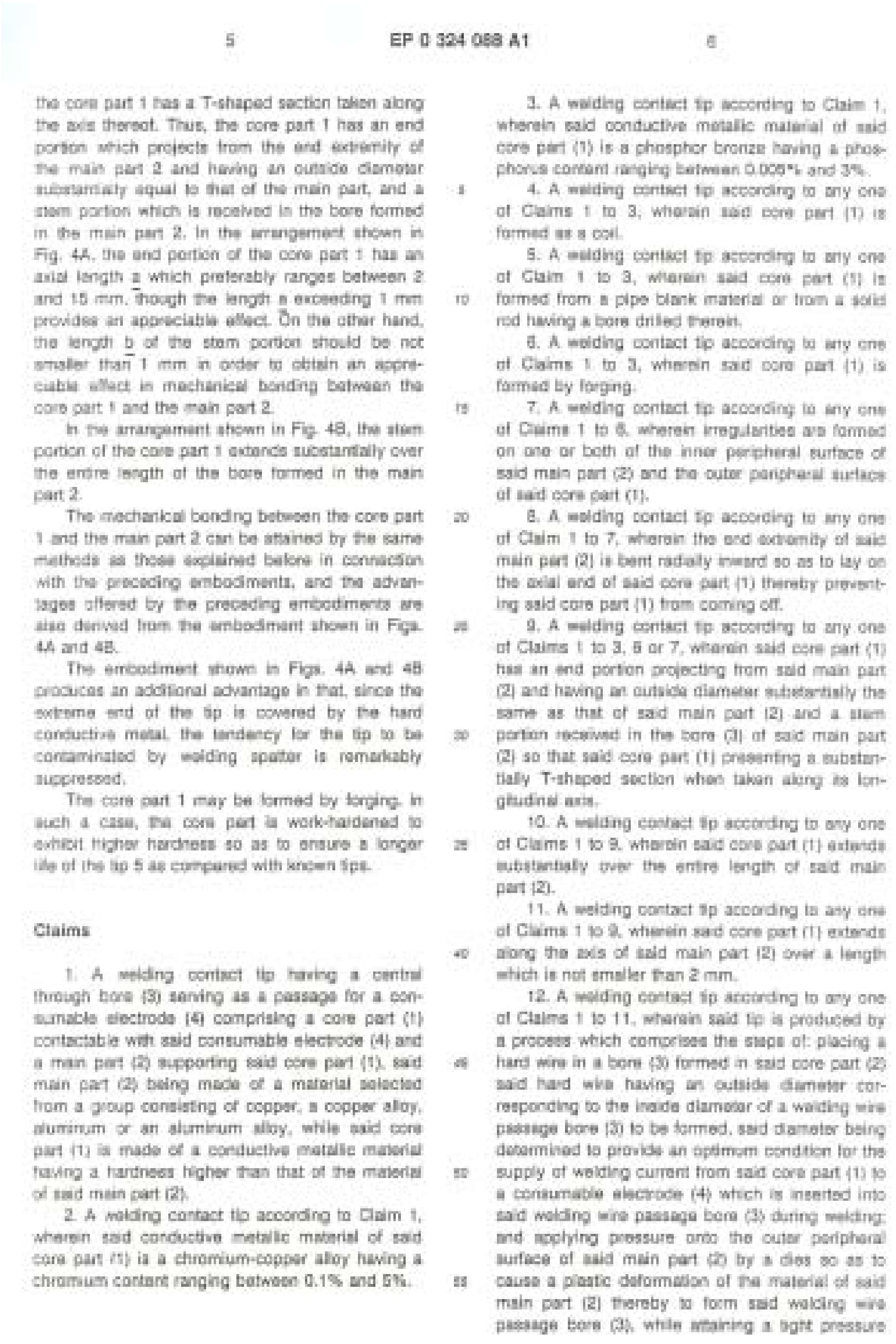
When the welding contact tip is formed by swaging, the material of the tip main part 2 plastically flows to fill any space formed between adjacent turns of the coil constituting the core part 1 as well be seen from Fig. 2B, so that the core part 1 is firmly held by the main part 2. In consequence, any tendency for the core part 1 to move axially during feeding of the welding wire 4 is avoided and the generation of heat at the boundary between the core part 1 and the main part 2 can be reduced to a negligible level.

In order to attain a higher strength of mechanical bond between the core part 1 and the main part 2, it is effective to bend the end extremity of the main part 2 radially inward. It is also effective to provide irregularities by, for example, roughening or knurling, on one or both of the inner surface of the main part 2 and the outer surface of the core part 1.

In general, only a thin annular region around the inner peripheral surface defining the wire passage bore 3 contributes to the guiding of the welding wire 4 and to the supply of the welding current to the welding wire 4. According to the invention, this thin annular region is constructed as the core part 1 which is made from a hard conductive metallic material independently from the remainder portion which constitutes the main part 2 made from an inexpensive and highly workable material such as copper, a copper alloy, aluminum or an aluminum alloy. It is thus possible to obtain a welding contact tip which is easy to produce and which is inexpensive as compared with known tips, while ensuring high durability which well compares with that of the known tips. Figs. 3A and 3B show another embodiment of the welding contact tip of the present invention. This embodiment features that the core part 1 is formed from a pipe-shaped blank material or by boring a solid rod. The pipe or the solid rod with a bore drilled therein may extend only over the end region, e.g., 20 mm in this embodiment, as shown in Fig. 3A or over the entire length of the tip as shown in Fig. 3B. The wall thickness of the core part, regardless of whether it is shaped from a pipe blank or from a solid rod by boring, preferably ranges between 0.1 and 2 mm also in this case.

The fixing of the core part 1 to the main part 2 can be done by the same methods as those explained in connection with the first embodiment, and advantages produced by the first embodiment are also confirmed with the embodiment shown in Figs. 3A and 3B.

Figs. 4A and 4B show still another embodiment of the welding contact tip in accordance with the present invention. This embodiment features that



the core part 1 has a T-shaped section taken along the axis thereof. Thus, the core part 1 has an end portion which projects from the end extremity of the main part 2 and having an outside diameter substantially equal to that of the main part, and a stem portion which is received in the bore formed in the main part 2. In the arrangement shown in Fig. 4A, the end portion of the core part 1 has an axial length a which preferably ranges between 2 and 15 mm, though the length a exceeding 1 mm provides an appreciable effect. On the other hand, the length b of the stem portion should be not smaller than 1 mm in order to obtain an appreciable effect in mechanical bonding between the core part 1 and the main part 2.

In the arrangement shown in Fig. 4B, the stem portion of the core part 1 extends substantially over the entire length of the bore formed in the main part 2.

The mechanical bonding between the core part 1 and the main part 2 can be attained by the same methods as those explained before in connection with the preceding embodiments, and the advantages offered by the preceding embodiments are also derived from the embodiment shown in Figs. 4A and 4B.

The embodiment shown in Figs. 4A and 4B produces an additional advantage in that, since the extreme end of the tip is covered by the hard conductive metal, the tendency for the tip to be contaminated by welding spatter is remarkably suppressed.

The core part 1 may be formed by forging. In such a case, the core part is work-hardened to exhibit higher hardness so as to ensure a longer life of the tip 5 as compared with known tips.

Claims

1. A welding contact tip having a central through bore (3) serving as a passage for a consumable electrode (4) comprising a core part (1) contactable with said consumable electrode (4) and a main part (2) supporting said core part (1), said main part (2) being made of a material selected from a group consisting of copper, a copper alloy, aluminum or an aluminum alloy, while said core part (1) is made of a conductive metallic material having a hardness higher than that of the material of said main part (2).

2. A welding contact tip according to Claim 1, wherein said conductive metallic material of said core part (1) is a chromium-copper alloy having a chromium content ranging between 0.1% and 5%.

3. A welding contact tip according to Claim 1, wherein said conductive metallic material of said core part (1) is a phosphor bronze having a phosphorus content ranging between 0.005% and 3%.

4. A welding contact tip according to any one of Claims 1 to 3, wherein said core part (1) is formed as a coil.

5. A welding contact tip according to any one of Claim 1 to 3, wherein said core part (1) is formed from a pipe blank material or from a solid rod having a bore drilled therein.

6. A welding contact tip according to any one of Claims 1 to 3, wherein said core part (1) is formed by forging.

7. A welding contact tip according to any one of Claims 1 to 6, wherein irregularities are formed on one or both of the inner peripheral surface of said main part (2) and the outer peripheral surface of said core part (1).

8. A welding contact tip according to any one of Claim 1 to 7, wherein the end extremity of said main part (2) is bent radially inward so as to lay on the axial end of said core part (1) thereby preventing said core part (1) from coming off.

9. A welding contact tip according to any one of Claims 1 to 3, 6 or 7, wherein said core part (1) has an end portion projecting from said main part (2) and having an outside diameter substantially the same as that of said main part (2) and a stem portion received in the bore (3) of said main part (2) so that said core part (1) presenting a substantially T-shaped section when taken along its longitudinal axis.

10. A welding contact tip according to any one of Claims 1 to 9, wherein said core part (1) extends substantially over the entire length of said main part (2).

11. A welding contact tip according to any one of Claims 1 to 9, wherein said core part (1) extends along the axis of said main part (2) over a length which is not smaller than 2 mm.

12. A welding contact tip according to any one of Claims 1 to 11, wherein said tip is produced by a process which comprises the steps of: placing a hard wire in a bore (3) formed in said core part (2) said hard wire having an outside diameter corresponding to the inside diameter of a welding wire passage bore (3) to be formed, said diameter being determined to provide an optimum condition for the supply of welding current from said core part (1) to a consumable electrode (4) which is inserted into said welding wire passage bore (3) during welding; and applying pressure onto the outer peripheral surface of said main part (2) by a dies so as to cause a plastic deformation of the material of said main part (2) thereby to form said welding wire passage bore (3), while attaining a tight pressure

contact between said core part (1) and said main part (2).

FIG. 1

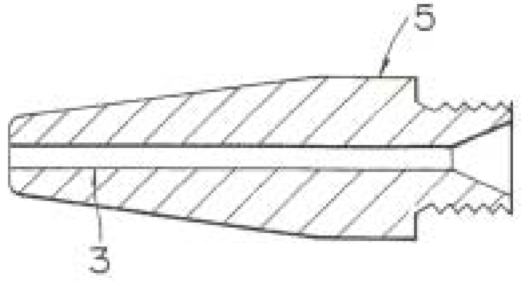


FIG. 2A

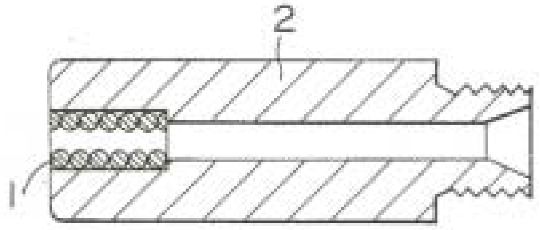


FIG. 2B

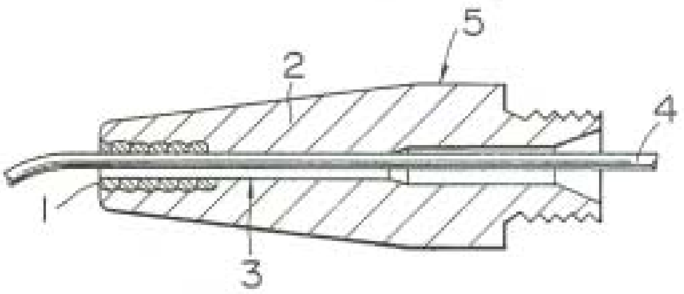


FIG. 2C

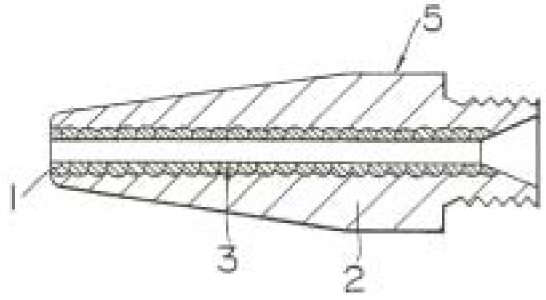


FIG. 3A

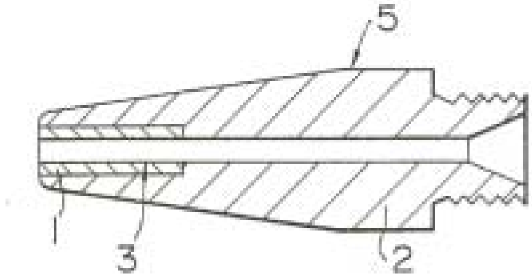


FIG. 3B

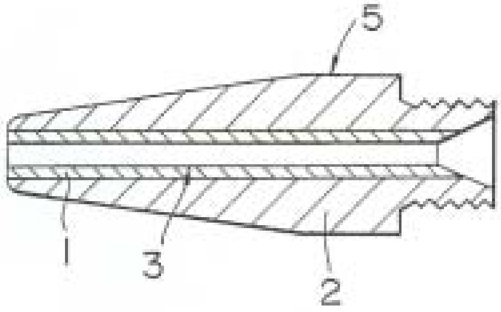


FIG. 4A

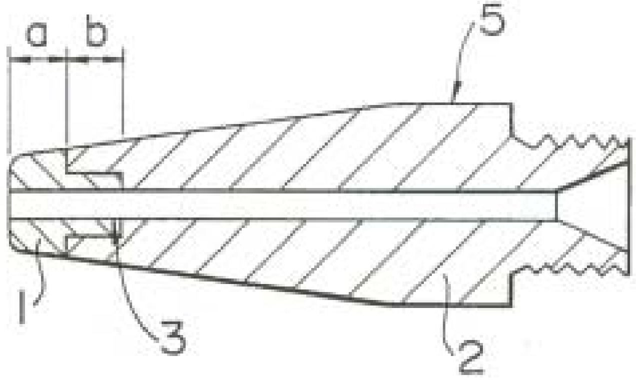
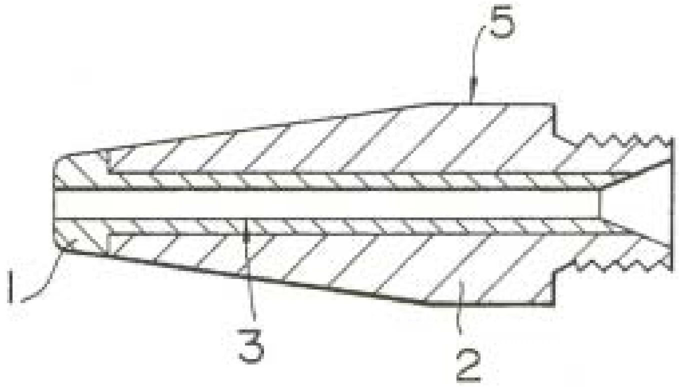
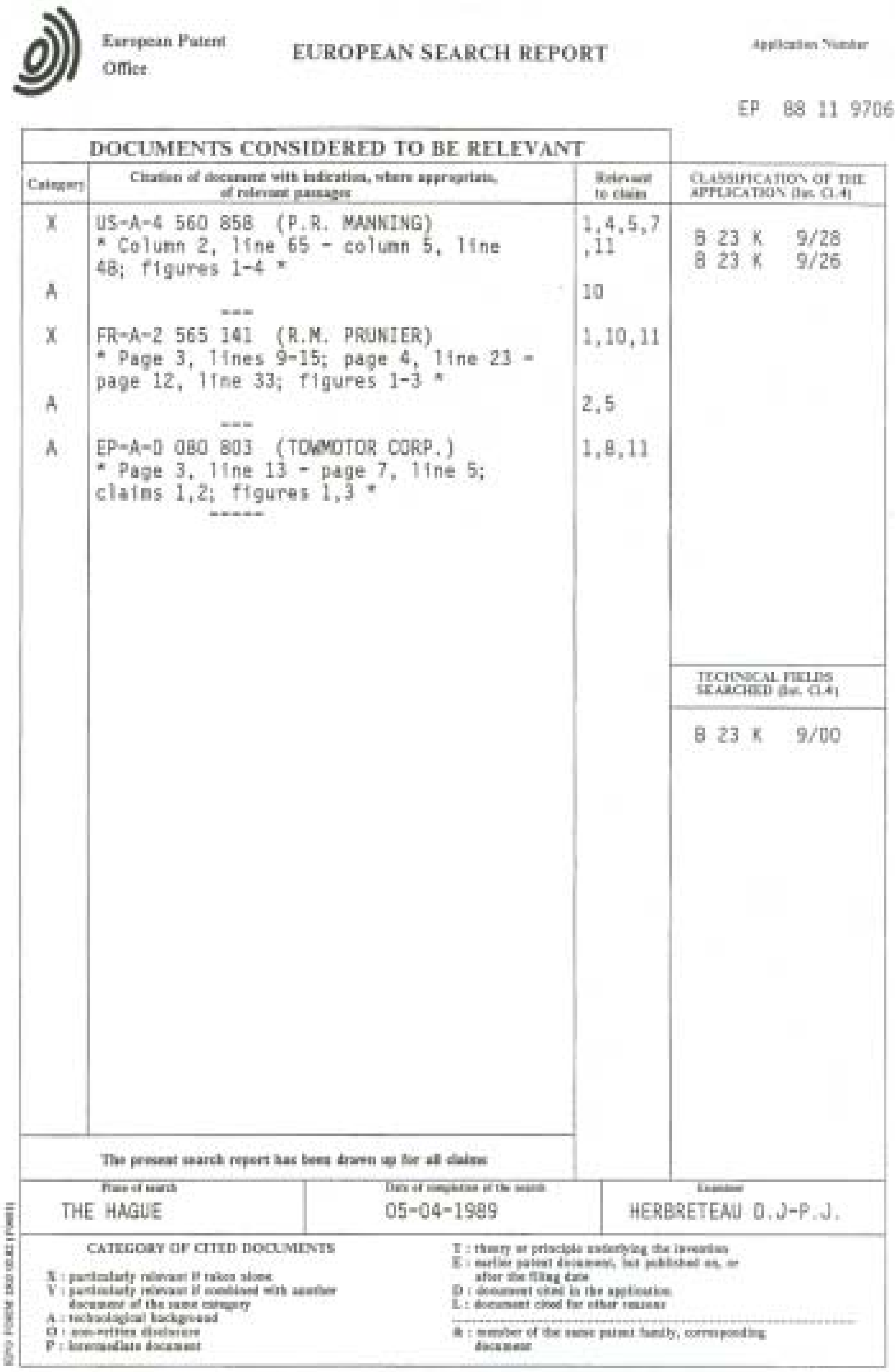


FIG. 4B





European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 11 9706

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	US-A-4 560 858 (P.R. MANNING) * Column 2, line 65 - column 5, line 48; figures 1-4 *	1,4,5,7,11	B 23 K 9/28 B 23 K 9/26
A		10	

X	FR-A-2 565 141 (R.M. PRUNIER) * Page 3, lines 9-15; page 4, line 23 - page 12, line 33; figures 1-3 *	1,10,11	
A		2,5	

A	EP-A-0 080 803 (TOWMOTOR CORP.) * Page 3, line 13 - page 7, line 5; claims 1,2; figures 1,3 * -----	1,8,11	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

B 23 K 9/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	05-04-1989	HERBRETEAU D.J-P.J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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& : member of the same patent family, corresponding document

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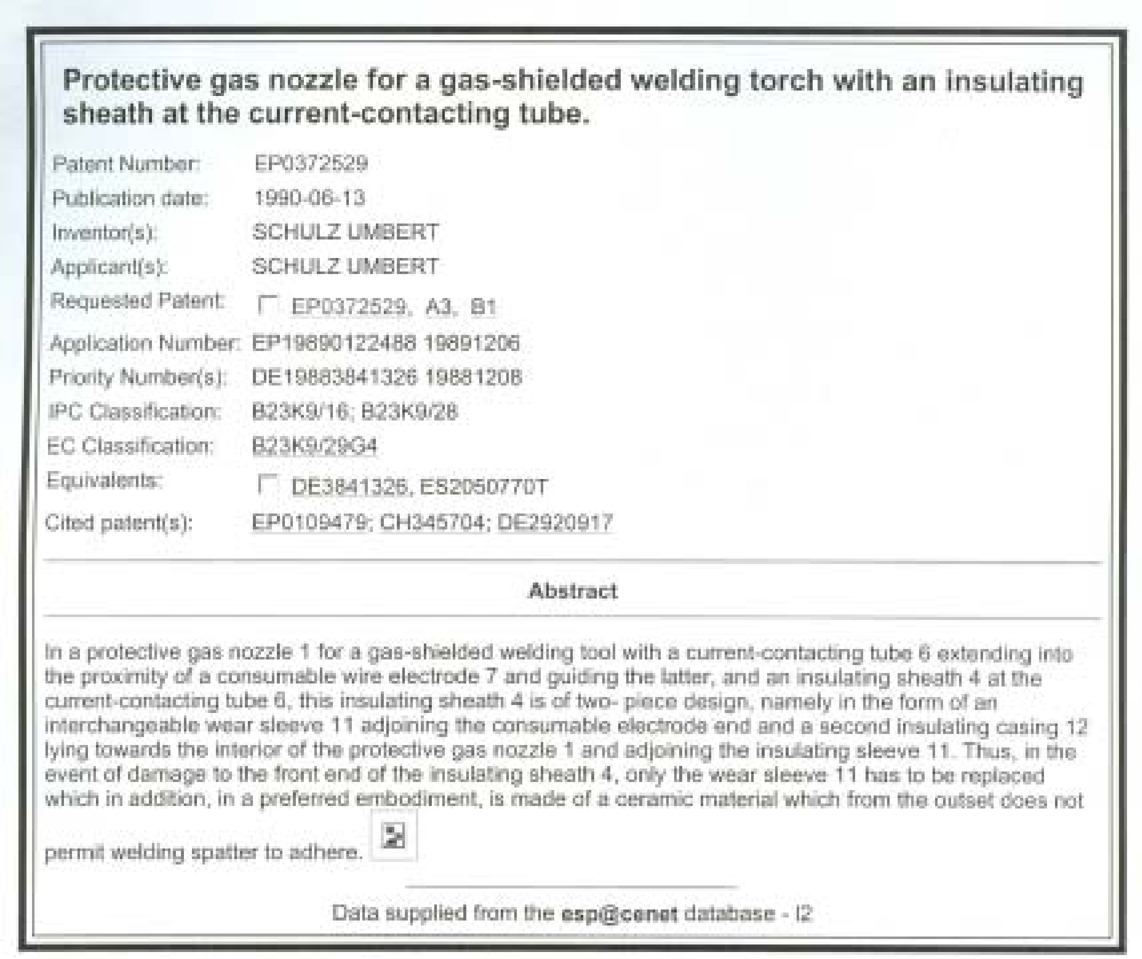
Appendix E

Protective Gas Nozzle for a Gas-shielded Welding Torch with an Insulating Sheath at the Current-Contacting Tube



Protective gas nozzle for a gas-shielded welding torch with an insulating sheath at the current-contacting tube.

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Publication date: 1990-06-13
Inventor(s): SCHULZ UMBERT
Applicant(s): SCHULZ UMBERT
Requested Patent: ☐ EP0372529, A3, B1
Application Number: EP19890122488 19891206
Priority Number(s): DE19883841326 19881208
IPC Classification: B23K9/16; B23K9/28
EC Classification: B23K9/29G4
Equivalents: ☐ DE3841326, ES2050770T
Cited patent(s): EP0109479; CH345704; DE2920917

Abstract

In a protective gas nozzle 1 for a gas-shielded welding tool with a current-contacting tube 6 extending into the proximity of a consumable wire electrode 7 and guiding the latter, and an insulating sheath 4 at the current-contacting tube 6, this insulating sheath 4 is of two- piece design, namely in the form of an interchangeable wear sleeve 11 adjoining the consumable electrode end and a second insulating casing 12 lying towards the interior of the protective gas nozzle 1 and adjoining the insulating sleeve 11. Thus, in the event of damage to the front end of the insulating sheath 4, only the wear sleeve 11 has to be replaced which in addition, in a preferred embodiment, is made of a ceramic material which from the outset does not permit welding spatter to adhere.

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⑪ Veröffentlichungsnummer: **0 372 529**
A2

⑫ EUROPÄISCHE PATENTANMELDUNG

㉑ Anmeldenummer: **89122488.3**

(51) Int. Cl.⁵: **B23K 9/28, B23K 9/16**

㉒ Anmeldetag: **06.12.89**

㉚ Priorität: **08.12.88 DE 3841326**

㊸ Veröffentlichungstag der Anmeldung:
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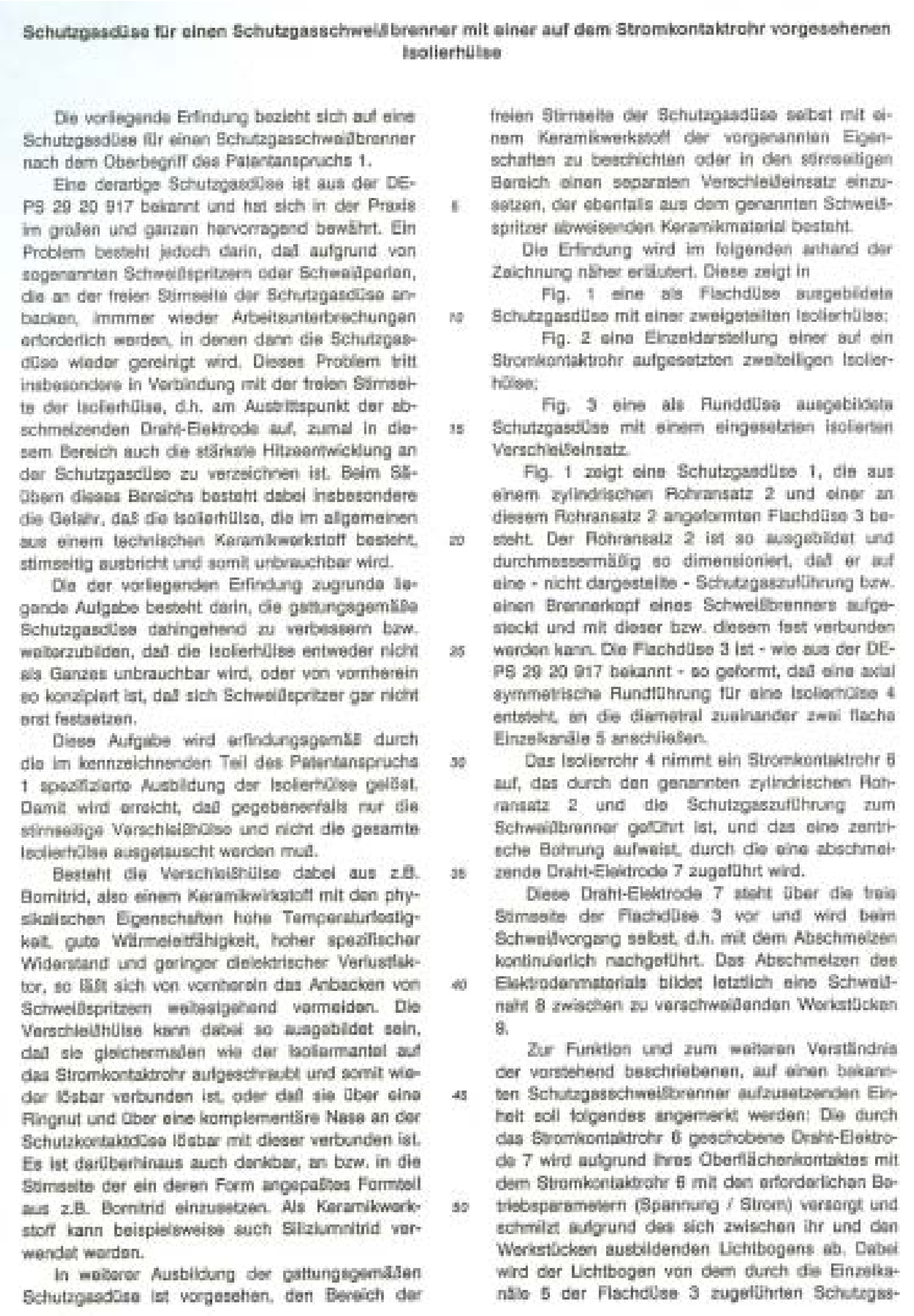
(54) **Schutzgasdüse für einen Schutzgasschweissbrenner mit einer auf dem Stromkontaktrohr vorgesehenen Isolierhülse.**

(57) Bei einer Schutzgasdüse 1 für einen Schutzgasschweißbrenner, mit einem sich bis in die Nähe einer abschmelzenden Draht-Elektrode 7 erstreckenden und diese führenden Stromkontaktrohr 6, und einer auf dem Stromkontaktrohr 6 vorgesehenen Isolierhülse 4 ist diese zweigeteilt ausgebildet und zwar in Form einer an das abschmelzende Elektrodenende anschließenden auswechselbaren Verschleißhülse 11 und einem zum Inneren der Schutzgasdüse 1 hin liegenden, an die Verschleißhülse 11 anschließenden zweiten Isoliermantel 12.

Damit muß bei einer etwaigen Beschädigung der Isolierhülse 4 nur noch die Verschleißhülse 11 ausgewechselt werden, die zudem in bevorzugter Ausführungsform aus einem Keramikwerkstoff besteht, der von vornherein ein Anbacken von Schweißspritzern nicht zuläßt.

Fig. 2

EP 0 372 529 A2



Schutzgasdüse für einen Schutzgasschweißbrenner mit einer auf dem Stromkontaktrohr vorgesehenen Isolierhülse

Die vorliegende Erfindung bezieht sich auf eine Schutzgasdüse für einen Schutzgasschweißbrenner nach dem Oberbegriff des Patentanspruchs 1.

Eine derartige Schutzgasdüse ist aus der DE-PS 29 20 917 bekannt und hat sich in der Praxis im großen und ganzen hervorragend bewährt. Ein Problem besteht jedoch darin, daß aufgrund von sogenannten Schweißspritzern oder Schweißperlen, die an der freien Stirnseite der Schutzgasdüse anbacken, immmer wieder Arbeitsunterbrechungen erforderlich werden, in denen dann die Schutzgasdüse wieder gereinigt wird. Dieses Problem tritt insbesondere in Verbindung mit der freien Stirnseite der Isolierhülse, d.h. am Austrittspunkt der abschmelzenden Draht-Elektrode auf, zumal in diesem Bereich auch die stärkste Hitzeentwicklung an der Schutzgasdüse zu verzeichnen ist. Beim Säubern dieses Bereichs besteht dabei insbesondere die Gefahr, daß die Isolierhülse, die im allgemeinen aus einem technischen Keramikwerkstoff besteht, stirnseitig ausbricht und somit unbrauchbar wird.

Die der vorliegenden Erfindung zugrunde liegende Aufgabe besteht darin, die gattungsgemäße Schutzgasdüse dahingehend zu verbessern bzw. weiterzubilden, daß die Isolierhülse entweder nicht als Ganzes unbrauchbar wird, oder von vornherein so konzipiert ist, daß sich Schweißspritzer gar nicht erst festsetzen.

Diese Aufgabe wird erfindungsgemäß durch die im kennzeichnenden Teil des Patentanspruchs 1 spezifizierte Ausbildung der Isolierhülse gelöst. Damit wird erreicht, daß gegebenenfalls nur die stirnseitige Verschleißhülse und nicht die gesamte Isolierhülse ausgetauscht werden muß.

Besteht die Verschleißhülse dabei aus z.B. Bornitrid, also einem Keramikwirkstoff mit den physikalischen Eigenschaften hohe Temperaturfestigkeit, gute Wärmeleitfähigkeit, hoher spezifischer Widerstand und geringer dielektrischer Verlustfaktor, so läßt sich von vornherein das Anbacken von Schweißspritzern weitestgehend vermeiden. Die Verschleißhülse kann dabei so ausgebildet sein, daß sie gleichermaßen wie der Isoliermantel auf das Stromkontaktrohr aufgeschraubt und somit wieder lösbar verbunden ist, oder daß sie über eine Ringnut und über eine komplementäre Nase an der Schutzkontaktdüse lösbar mit dieser verbunden ist. Es ist darüberhinaus auch denkbar, an bzw. in die Stirnseite der ein deren Form angepaßtes Formteil aus z.B. Bornitrid einzusetzen. Als Keramikwerkstoff kann beispielsweise auch Siliziumnitrid verwendet werden.

In weiterer Ausbildung der gattungsgemäßen Schutzgasdüse ist vorgesehen, den Bereich der freien Stirnseite der Schutzgasdüse selbst mit einem Keramikwerkstoff der vorgenannten Eigenschaften zu beschichten oder in den stirnseitigen Bereich einen separaten Verschleißeinsatz einzusetzen, der ebenfalls aus dem genannten Schweißspritzer abweisenden Keramikmaterial besteht.

Die Erfindung wird im folgenden anhand der Zeichnung näher erläutert. Diese zeigt in

Fig. 1 eine als Flachdüse ausgebildete Schutzgasdüse mit einer zweigeteilten Isolierhülse;

Fig. 2 eine Einzeldarstellung einer auf ein Stromkontaktrohr aufgesetzten zweiteiligen Isolierhülse;

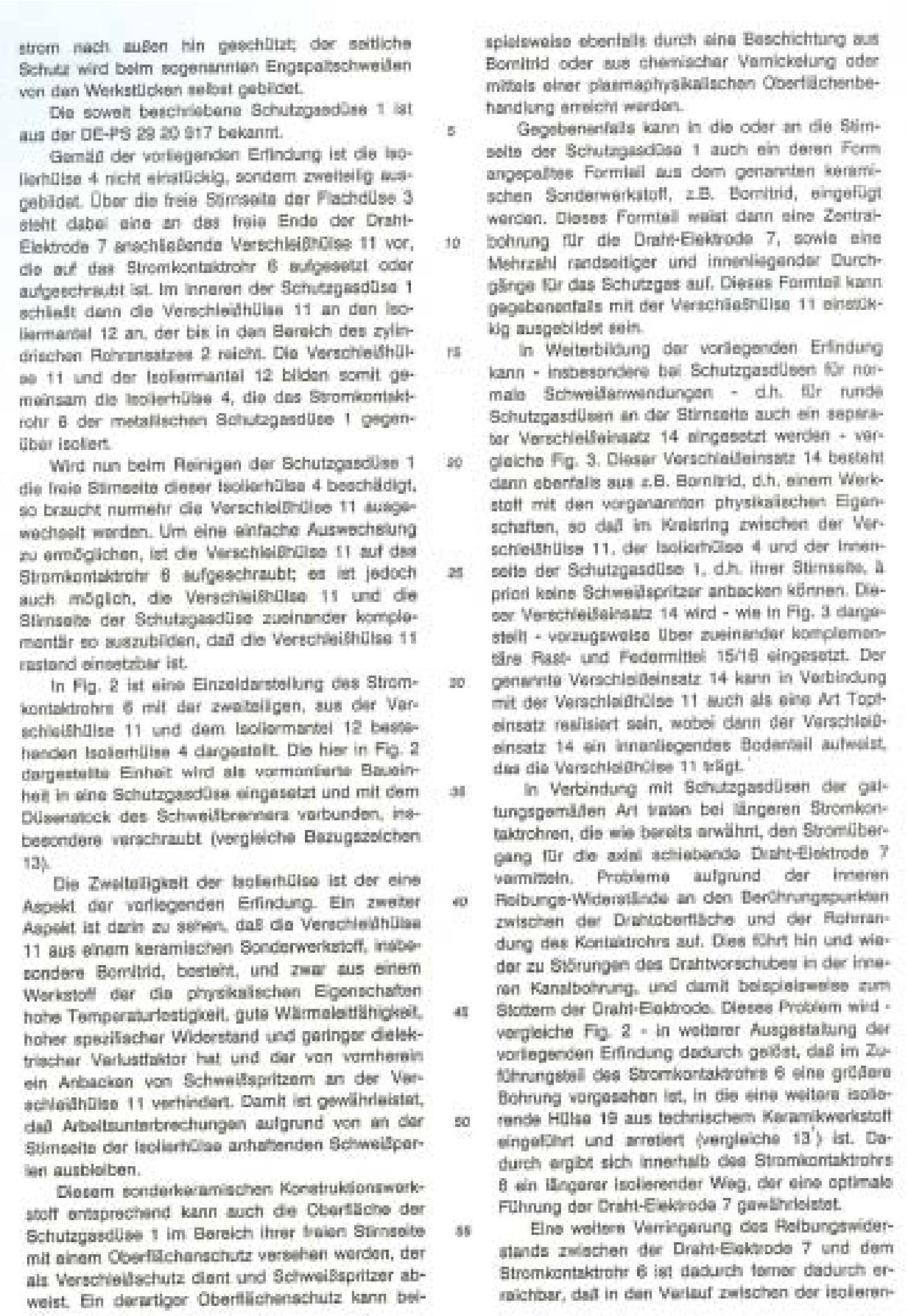
Fig. 3 eine als Runddüse ausgebildete Schutzgasdüse mit einem eingesetzten isolierten Verschleißeinsatz.

Fig. 1 zeigt eine Schutzgasdüse 1, die aus einem zylindrischen Rohransatz 2 und einer an diesem Rohransatz 2 angeformten Flachdüse 3 besteht. Der Rohransatz 2 ist so ausgebildet und durchmessermäßig so dimensioniert, daß er auf eine - nicht dargestellte - Schutzgaszuführung bzw. einen Brennerkopf eines Schweißbrenners aufgesteckt und mit dieser bzw. diesem fest verbunden werden kann. Die Flachdüse 3 ist - wie aus der DE-PS 29 20 917 bekannt - so geformt, daß eine axial symmetrische Rundführung für eine Isolierhülse 4 entsteht, an die diametral zueinander zwei flache Einzelkanäle 5 anschließen.

Das Isolierrohr 4 nimmt ein Stromkontaktrohr 6 auf, das durch den genannten zylindrischen Rohransatz 2 und die Schutzgaszuführung zum Schweißbrenner geführt ist, und das eine zentrische Bohrung aufweist, durch die eine abschmelzende Draht-Elektrode 7 zugeführt wird.

Diese Draht-Elektrode 7 steht über die freie Stirnseite der Flachdüse 3 vor und wird beim Schweißvorgang selbst, d.h. mit dem Abschmelzen kontinuierlich nachgeführt. Das Abschmelzen des Elektrodenmaterials bildet letztlich eine Schweißnaht 8 zwischen zu verschweißenden Werkstücken 9.

Zur Funktion und zum weiteren Verständnis der vorstehend beschriebenen, auf einen bekannten Schutzgasschweißbrenner aufzusetzenden Einheit soll folgendes angemerkt werden: Die durch das Stromkontaktrohr 6 geschobene Draht-Elektrode 7 wird aufgrund ihres Oberflächenkontaktes mit dem Stromkontaktrohr 6 mit den erforderlichen Betriebsparametern (Spannung / Strom) versorgt und schmilzt aufgrund des sich zwischen ihr und den Werkstücken ausbildenden Lichtbogens ab. Dabei wird der Lichtbogen von dem durch die Einzelkanäle 5 der Flachdüse 3 zugeführten Schutzgas-



strom nach außen hin geschützt; der seitliche Schutz wird beim sogenannten Engspaltschweißen von den Werkstücken selbst gebildet.

Die soweit beschriebene Schutzgasdüse 1 ist aus der DE-PS 29 20 917 bekannt.

Gemäß der vorliegenden Erfindung ist die Isolierhülse 4 nicht einstückig, sondern zweiteilig ausgebildet. Über die freie Stirnseite der Flachdüse 3 steht dabei eine an das freie Ende der Draht-Elektrode 7 anschließende Verschleißhülse 11 vor, die auf das Stromkontaktrohr 6 aufgesetzt oder aufgeschraubt ist. Im Inneren der Schutzgasdüse 1 schließt dann die Verschleißhülse 11 an den Isoliermantel 12 an, der bis in den Bereich des zylindrischen Rohransatzes 2 reicht. Die Verschleißhülse 11 und der Isoliermantel 12 bilden somit gemeinsam die Isolierhülse 4, die das Stromkontaktrohr 6 der metallischen Schutzgasdüse 1 gegenüber isoliert.

Wird nun beim Reinigen der Schutzgasdüse 1 die freie Stirnseite dieser Isolierhülse 4 beschädigt, so braucht nunmehr die Verschleißhülse 11 ausgewechselt werden. Um eine einfache Auswechselung zu ermöglichen, ist die Verschleißhülse 11 auf das Stromkontaktrohr 6 aufgeschraubt; es ist jedoch auch möglich, die Verschleißhülse 11 und die Stirnseite der Schutzgasdüse zueinander komplementär so auszubilden, daß die Verschleißhülse 11 rastend einsetzbar ist.

In Fig. 2 ist eine Einzeldarstellung des Stromkontaktrohrs 6 mit der zweiteiligen, aus der Verschleißhülse 11 und dem Isoliermantel 12 bestehenden Isolierhülse 4 dargestellt. Die hier in Fig. 2 dargestellte Einheit wird als vormontierte Baueinheit in eine Schutzgasdüse eingesetzt und mit dem Düsenstock des Schweißbrenners verbunden, insbesondere verschraubt (vergleiche Bezugszeichen 13).

Die Zweiteiligkeit der Isolierhülse ist der eine Aspekt der vorliegenden Erfindung. Ein zweiter Aspekt ist darin zu sehen, daß die Verschleißhülse 11 aus einem keramischen Sonderwerkstoff, insbesondere Bornitrid, besteht, und zwar aus einem Werkstoff der die physikalischen Eigenschaften hohe Temperaturfestigkeit, gute Wärmeleitfähigkeit, hoher spezifischer Widerstand und geringer dielektrischer Verlustfaktor hat und der von vornherein ein Anbacken von Schweißspritzern an der Verschleißhülse 11 verhindert. Damit ist gewährleistet, daß Arbeitsunterbrechungen aufgrund von an der Stirnseite der Isolierhülse anhaftenden Schweißperlen ausbleiben.

Diesem sonderkeramischen Konstruktionswerkstoff entsprechend kann auch die Oberfläche der Schutzgasdüse 1 im Bereich ihrer freien Stirnseite mit einem Oberflächenschutz versehen werden, der als Verschleißschutz dient und Schweißspritzer abweist. Ein derartiger Oberflächenschutz kann beispielsweise ebenfalls durch eine Beschichtung aus Bornitrid oder aus chemischer Vernickelung oder mittels einer plasmaphysikalischen Oberflächenbehandlung erreicht werden.

Gegebenenfalls kann in die oder an die Stirnseite der Schutzgasdüse 1 auch ein deren Form angepaßtes Formteil aus dem genannten keramischen Sonderwerkstoff, z.B. Bornitrid, eingefügt werden. Dieses Formteil weist dann eine Zentralbohrung für die Draht-Elektrode 7, sowie eine Mehrzahl randseitiger und innenliegender Durchgänge für das Schutzgas auf. Dieses Formteil kann gegebenenfalls mit der Verschleißhülse 11 einstückig ausgebildet sein.

In Weiterbildung der vorliegenden Erfindung kann - insbesondere bei Schutzgasdüsen für normale Schweißanwendungen - d.h. für runde Schutzgasdüsen an der Stirnseite auch ein separater Verschleißeinsatz 14 eingesetzt werden - vergleiche Fig. 3. Dieser Verschleißeinsatz 14 besteht dann ebenfalls aus z.B. Bornitrid, d.h. einem Werkstoff mit den vorgenannten physikalischen Eigenschaften, so daß im Kreisring zwischen der Verschleißhülse 11, der Isolierhülse 4 und der Innenseite der Schutzgasdüse 1, d.h. ihrer Stirnseite, à priori keine Schweißspritzer anbacken können. Dieser Verschleißeinsatz 14 wird - wie in Fig. 3 dargestellt - vorzugsweise über zueinander komplementäre Rast- und Federmittel 15/16 eingesetzt. Der genannte Verschleißeinsatz 14 kann in Verbindung mit der Verschleißhülse 11 auch als eine Art Topfeinsatz realisiert sein, wobei dann der Verschleißeinsatz 14 ein innenliegendes Bodenteil aufweist, das die Verschleißhülse 11 trägt.

In Verbindung mit Schutzgasdüsen der gattungsgemäßen Art traten bei längeren Stromkontaktrohren, die wie bereits erwähnt, den Stromübergang für die axial schiebende Draht-Elektrode 7 vermitteln, Probleme aufgrund der inneren Reibungs-Widerstände an den Berührungspunkten zwischen der Drahtoberfläche und der Rohrwandung des Kontaktrohrs auf. Dies führt hin und wieder zu Störungen des Drahtvorschubes in der inneren Kanalbohrung, und damit beispielsweise zum Stottern der Draht-Elektrode. Dieses Problem wird - vergleiche Fig. 2 - in weiterer Ausgestaltung der vorliegenden Erfindung dadurch gelöst, daß im Zuführungsteil des Stromkontaktrohrs 6 eine größere Bohrung vorgesehen ist, in die eine weitere isolierende Hülse 19 aus technischem Keramikwerkstoff eingeführt und arretiert (vergleiche 13') ist. Dadurch ergibt sich innerhalb des Stromkontaktrohrs 6 ein längerer isolierender Weg, der eine optimale Führung der Draht-Elektrode 7 gewährleistet.

Eine weitere Verringerung des Reibungswiderstands zwischen der Draht-Elektrode 7 und dem Stromkontaktrohr 6 ist dadurch ferner dadurch erreichbar, daß in den Verlauf zwischen der isolierenden Hülse 19 und der der Verschleißhülse 11 gegenüberliegenden Stirnseite eine Aussparung 20 vorgesehen ist. Damit kann in diesem Bereich der zur Stromübertragung vom Stromkontaktrohr 6 zur Draht-Elektrode 7 vorhandene und erforderliche Krümmungsradius der Draht-Elektrode 7 besser, weil eben wesentlich reibungsfreier, vorbei gleiten.

Ansprüche

1) Schutzgasdüse für einen Schutzgasschweißbrenner, mit einem sich bis in die Nähe einer abschmelzenden Draht-Elektrode erstreckenden und diese führenden Stromkontaktrohr, und einer auf dem Stromkontaktrohr vorgesehenen Isolierhülse
dadurch gekennzeichnet,
daß die Isolierhülse zweigeteilt ist, und zwar in Form
einer an das abschmelzende Elektrodenenede anschließenden auswechselbaren Verschleißhülse und einem zum Inneren der Schutzgasdüse hin liegenden, an die Verschleißhülse anschließenden zweiten Isoliermantel.

2) Schutzgasdüse nach Anspruch 1
dadurch gekennzeichnet,
daß die Verschleißhülse aus einem Keramikwerkstoff mit hoher Temperaturfestigkeit, guter Wärmeleitfähigkeit, hohem spezifischen Widerstand und geringem dielektrischen Verlustfaktor, insbesondere aus Bornitrid, besteht, der von vornherein ein Anbacken von Schweißspritzern nicht zuläßt.

3) Schutzgasdüse nach Anspruch 1 oder 2
dadurch gekennzeichnet,
daß die Verschleißhülse und der Isoliermantel lösbar miteinander verbunden sind.

4) Schutzgasdüse nach Anspruch 1 oder 2
dadurch gekennzeichnet,
daß die Verschleißhülse lösbar mit der Schutzgasdüse verbunden ist.

5) Schutzgasdüse nach einem der Ansprüche 1 bis 4
dadurch gekennzeichnet,
daß zumindest im Bereich ihrer die Draht-Elektrode freigebenden Stirnseite eine Schweißspritzer abweisende Oberflächenbeschichtung aufgebracht ist, die beispielsweise in Form einer chemisch aufgebrachten Vernickelung oder einer plasma-physikalisch vergüteten Oberfläche vorliegt.

6) Schutzgasdüse nach einem der Ansprüche 1 bis 4
dadurch gekennzeichnet,
daß an der freien Stirnseite ein Verschleißeinsatz aus einem Keramikwerkstoff mit hoher Temperaturfestigkeit, guter Wärmeleitfähigkeit, hohem specifischen Widerstand und geringem dielektrischen Verlustfaktor, insbesondere aus Bornitrid, vorgesehen ist, der von vornherein ein Anbacken von Schweißspritzern nicht zuläßt.

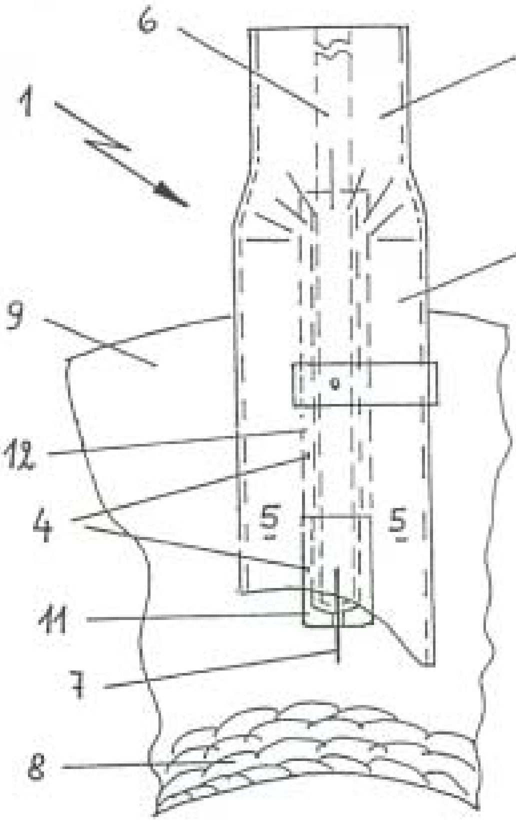
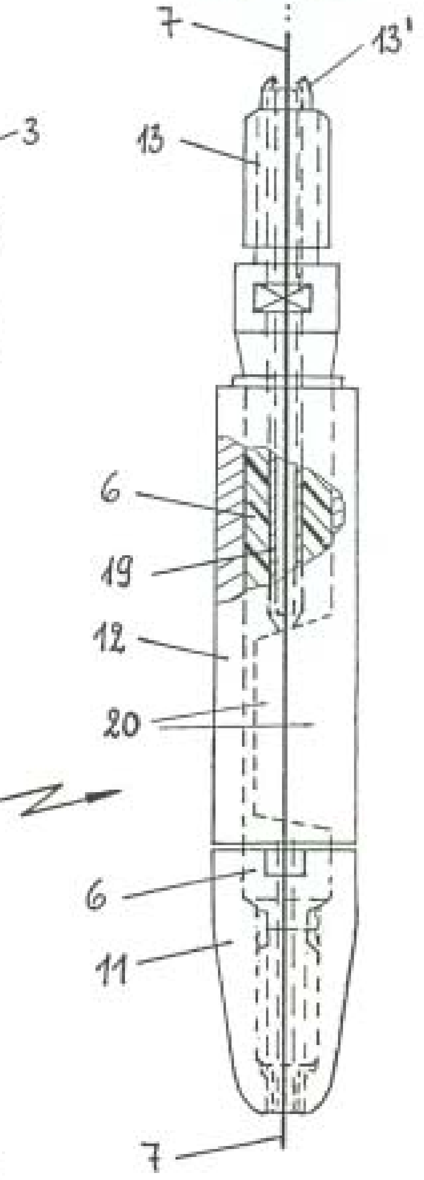


Fig. 1

Fig. 2



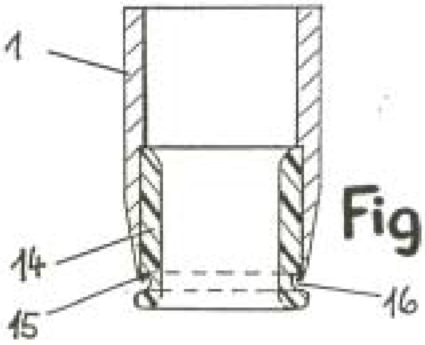


Fig. 3

Appendix F

Gas-Metal-Arc Welding Contact Tip

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(57) Abstract

A contact tip for use in an electric welding torch includes an electrically conductive component or tube including a mounting end and a distal contact end extending along a longitudinal wire feed axis. The conductive component is made of copper, copper alloys or mixtures of copper powder and conductive ceramic materials synthesized by powder metallurgy methods. The size of the conductive component has been enlarged to minimize operating temperatures. The mounting end of the conductive component includes a high heat transfer mounting surface. The conductive component includes a through-bore having a large diameter portion extending from the mounting end and a small diameter portion, sized for guiding the welding wire, proximate to the distal end and extending along the wire feed axis. The outlet of the small diameter portion has no chamber but clean right-angle corners around the outlet. An elongated high temperature resistant, ceramic insert is coaxially mounted in the large diameter portion of the electrically conductive component and includes a corresponding through-bore also sized for guiding the welding wire. The insert through-bore and conductive component small diameter portion define a wire feed passageway for supporting the welding wire.

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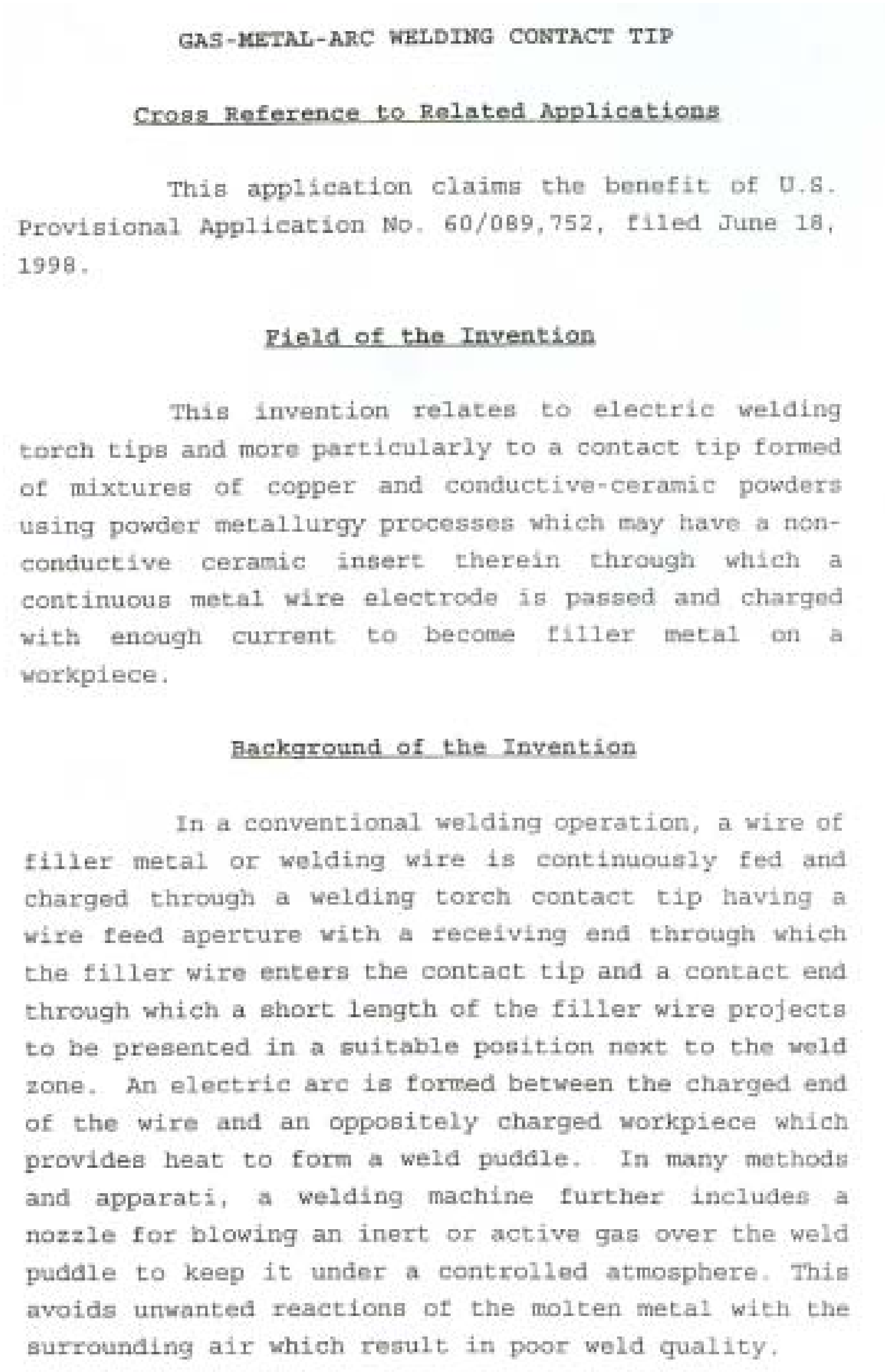

GAS-METAL-ARC WELDING CONTACT TIP

Cross Reference to Related Applications

This application claims the benefit of U.S. Provisional Application No. 60/089,752, filed June 18, 1998.

Field of the Invention

This invention relates to electric welding torch tips and more particularly to a contact tip formed of mixtures of copper and conductive-ceramic powders using powder metallurgy processes which may have a non-conductive ceramic insert therein through which a continuous metal wire electrode is passed and charged with enough current to become filler metal on a workpiece.

Background of the Invention

In a conventional welding operation, a wire of filler metal or welding wire is continuously fed and charged through a welding torch contact tip having a wire feed aperture with a receiving end through which the filler wire enters the contact tip and a contact end through which a short length of the filler wire projects to be presented in a suitable position next to the weld zone. An electric arc is formed between the charged end of the wire and an oppositely charged workpiece which provides heat to form a weld puddle. In many methods and apparati, a welding machine further includes a nozzle for blowing an inert or active gas over the weld puddle to keep it under a controlled atmosphere. This avoids unwanted reactions of the molten metal with the surrounding air which result in poor weld quality.

In welding methods of this general category, the welding wire is unwound from a spool and automatically fed into the welding assembly as the welding wire is consumed. The welding wire has a cast, which is arcuate in nature, as it is formed and wound on the spool. It is desirable to maintain good electrical continuity between the wire and the contact tip. Drive rollers are often used to feed the wire off the spool and into the welding torch. The wire must be moved through the wire feed aperture smoothly, without jerking, for accurate and high performance welding to be satisfactorily achieved.

Welding methods of this type, measure process efficiency by the percentage of arc-on time during production. Manual, mechanized, automatic or robotic systems using these welding methods often deliver efficiencies of less than 50%. The time during which a laborer or machine is not welding is generally attributable to operational difficulty of the welding apparatus which is often related to the performance of the contact tip.

Contact tips are traditionally fabricated as cylindrical tubes made of pure copper or high copper content alloys which have high electrical and thermal conductivity. Under normal service conditions, contact tips may be exposed to operating temperatures well above 400°C (752°F). Operating temperature is critical in determining the performance of contact tips. Higher temperatures degrade the material properties and accelerate failure of contact tips. Heat is mainly transferred by conduction from the contact tip to the welding torch.

Under normal service conditions, contact tips are subject to systematic accumulation of debris carried by the wire surface into the contact tip wire feed aperture. These debris are burnt during the welding operation leaving refractory non-conductive byproducts. Contact tip wire feed apertures are fabricated with a dimensional tolerance to minimize friction to the passage of the welding wire. In such contact tips, true electrical contact is only possible at discrete points along the wire feed aperture, and depends on wire feed aperture tolerance and the cast in the welding wire. The presence of non-conductive material inside the wire feed aperture causes electrical contact to become unstable, which results in contact tip failure. Also, the presence of additional material inside the wire feed aperture increases the likelihood of wire choking due to repetitive expansion and contraction cycles which may prevent regular feeding causing bad weld starts or burnback, a condition in which the wire melts to the end of the contact tip.

In welding methods of this kind, there are sporadic liquid metal bursts originated at regular disruptions of the molten wire/puddle bridge or by regular perturbations to the puddle surface. Bursts of this nature result on liquid metal being regularly expelled from the weld zone as miniature droplets or spatter which binds and builds up on the contact end of the contact tip on the inside of the wire feed aperture around the outlet. Excessive spatter accumulation at the front of the contact tip creates a metal bridge between the moving welding wire and the contact tip which eventually causes feeding fluctuations and may bring the process to a halt. Also, spatter buildup in and around the wire feed aperture outlet produces choking of the filler wire leading to similar feeding problems. Feeding instability leads to contact tip failure by burnback or bad weld starts.

Furthermore, the contact wire feed aperture is subject to wear damage by abrasion or electrical erosion caused by the sliding friction between the charged wire feed aperture surface and the moving welding wire. Excessive unidirectional wearing of the wire feed aperture outlet or "keyholing" causes the wire to miss the target seam resulting in misplaced welds. This is critical to robotic welding in which program schedules are not designed to compensate for such source of variation.

It is known in the art relating to continuous feed welding torches to use replaceable contact tips that have an insert disposed in the contact tip distal end proximate the workpiece. Typically these inserts are of a harder material than the copper of the tip. These inserts are claimed to extend the contact tip life by reducing wear as the welding wire is fed through the tip. However, these inserts, and other inserts so positioned, inhibit current transfer close to the arc where it is more efficient for arc stability and welding soundness.

Copper-carbon "alloys" have been suggested to improve lubricity and reduce coefficient of expansion of the contact tip wire feed aperture. This previous art also refers to copper-carbon "alloys" that provide high electrical conductivity while having low thermal conductivity and high melting point. This art refers to the fabrication of cylindrical contact tips by injection molding or traditional machining.

Copper-carbon "alloys" are not possible since carbon is immiscible in copper. However, copper and carbon can be integrated into a single material by powder metallurgy methods which involve pressure-die molding followed by controlled sintering. Carbon comes in many different crystallographic groups including diamond, graphite, amorphous and buckyballs. Each one of these groups exhibits contrasting mechanical and physical properties. Furthermore, within each group specific mechanical and physical properties depend on the level of impurities and orientation of the crystal structure with respect to applied external forces. Diamond exhibits the highest thermal conductivity and hardness of any material while possessing the lowest electrical conductivity of any material. Graphite exhibit limited electrical and thermal conductivity depending on crystal orientation. The good lubricity of graphite results from the hexagonal arrangement of layer planes. Each plane is free to slip or slide past one another. Amorphous carbons have smaller monoplanes piled in turbostatic stacks which have a variety of properties including small expansion coefficient with a variety of thermal and electrical conductivities. Buckyballs are special "soccer-ball" configurations of carbon which exhibit special electrical and other properties.

Powder metallurgy (P/M) materials have certain percentage of undesirable porosity which is inherent to the P/M process. A challenge of every P/M process is to minimize porosity so that the density of the P/M material is as close as possible to its theoretical density.

Summary of the Invention

The present invention provides an improved contact tip for gas-metal-arc welding wherein a continuous wire of filler metal or welding wire is passed through an electrically charged contact tip which passes its charge to the welding wire while the workpiece is oppositely charged.

As is hereinafter more fully described, the contact tip that minimizes friction in its wire feed aperture, display high thermal diffusivity, possess high electrical conductivity, provide permanent anti-spatter protection, stabilizes the location of the current transfer point (insert), minimizes operating temperatures and eliminate excessive wearing of the wire feed aperture.

More specifically, the present invention provides a contact tip for use in a welding torch that guides a welding wire toward a workpiece and transfers welding current from a torch to the welding wire. The contact tip comprises an electrically conductive component including a mounting end and a distal contact end extending along a longitudinal wire feed axis. The conductive component includes a through-bore or wire feed aperture that may have a large diameter portion extending from a mounting, wire receiving, end and a small diameter portion, sized for guiding the welding wire and transferring the welding current, proximate to the distal end and extending along the wire feed axis.

In one embodiment of the invention, an elongated high temperature resistant, ceramic insert including a corresponding through-bore sized for guiding the welding wire, is coaxially mounted in the large diameter portion of the electrically conductive component. Therein, the insert through-bore and conductive component small diameter portion define a wire feed passageway for supporting the welding wire.

Preferably the small diameter portion of the conductive component proximate its distal end extends less than 100% the length of the through-bore extending through the tip. The small diameter portion of the conductive component exhibits a smaller tolerance between wire size and bore size so that true electrical contact is improved.

One end of the insert through-bore may be tapered. This tapered end is the end mounted adjacent the conductive component mounting end to facilitate introduction of welding wire through the insert portion of the contact tip. Preferably the tapered end includes a sidewall disposed generally at an angle of about 30 degrees to the longitudinal wire feed axis.

The front-end outside geometry of the tip comprises an enlarged outside diameter at the front end which enhances the ability of the tip to diffuse heat thus lowering operating temperatures.

Another feature of the front-end geometry is the lack of chamfer at the outlet part of the wire feed aperture. A right angle corner edge provides enhanced current transfer, lowers operating temperature and prevents microspatter from entering the wire feed aperture.

Another feature of the tip front-end geometry comprises an enlarged radius of curvature and bulbous shape which maximizes metal mass at the front end lowering operating temperatures at the wire feed aperture.

Another feature of the front-end may be a coating of an extra-hard protective film of diamond-like carbon which enhances the ability to reject spatter buildup.

The mounting end of the contact tip includes a connector that provides high heat transfer. In one embodiment, the mounting end comprises a frusto-conical surface and taper-lock thread arrangement which enhances the ability of conducting heat transfer away from the contact tip.

In one embodiment of the invention, the conductive component comprises copper or a high copper content alloy. The invention also comprises a conductive component made of a composite material consisting of sintered powders of high purity copper and conductive ceramic particles. Conductive ceramic particles include special crystalline forms of carbon including but not limited to graphite. Specially oriented graphite particles in sufficient density enhance anti-spatter properties of the material and increase lubricity in the wire feed aperture. P/M Copper-graphite composites exhibit lower electrical and thermal conductivity than pure copper. Therefore excessive amounts of graphite (above 20%) may preclude the principal function of the contact tip leading to catastrophic failure. P/M Copper-graphite composites must have a density higher than 80% of the ideal densities of their solid counterparts.

In another embodiment of the invention, the conductive component may comprise a cylindrical insert made of a ceramic material including, but not limited to, aluminum oxide, boron carbide, silicon carbide, silicon oxide, aluminum nitride, zirconium oxide, boron nitride or any mixture of these substances. The ceramic insert limits current transfer to the front end of the contact tip which minimizes burnback occurrences.

These and other features and advantages of the invention will be more fully understood from the following detailed description of the invention taken together with the accompanying drawings.

Brief Description of the Drawings

In the drawings:

FIG. 1 is a sectional view of a welding torch contact tip constructed in accordance with the present invention; and

FIG. 2 is a sectional view of a welding torch contact tip constructed in accordance with the present invention and including a ceramic insert at a welding wire receiving end.

Detailed Description of the Invention

Referring now to FIGS. 1-2 in detail, numeral 10 generally indicates a contact tip for use in a continuous feed welding torch, not shown. Contact tip 10 feedingly guides a welding wire, as is known, toward a workpiece and transfers welding current from the torch to the wire.

Referring to FIGS. 1-2, the contact tip 10 includes an electrically conductive component 12 including a mounting end 14 and a distal contact end 16 extending along a longitudinal wire feed axis 18. The conductive component 12 includes a through-bore 20 having a large diameter portion 22 extending from the mounting end 14 and a small diameter portion 24 sized for guiding welding wire, proximate the distal end 16 and extending along the wire feed axis. Mounting end 14 includes a connector that provides high heat transfer. In the embodiments shown, mounting end 14 is a frusto-conical surface and taper-lock thread arrangement for attaching the tip 10 to a cooperating surface on a welding torch.

Outlet 30 of the small diameter portion 24 contains no chamfer and the edge around the outlet and forms generally a right angle with no metal debris or inconsistent sharp edges. As illustrated, the radius of curvature of the front end 32 or contact end of the tip is increased and has a bulbous shape which lowers operating temperatures around the outlet 30 of the small diameter portion 24.

Where applicable, an elongated high temperature resistant ceramic insert 26 is coaxially mounted in the large diameter 22 of the conductive component 12. Insert 26 includes a through-bore 28 corresponding to the small diameter portion 24 and is sized for guiding welding wire therethrough. The insert through-bore 28 and conductive component small diameter portion 24 define the wire feed passageway for supporting the welding wire.

In the embodiment illustrated, the conductive component 12 comprises copper, a high copper content alloy, or sintered mixtures of copper and conductive ceramic particles including composite materials made of copper and certain forms of graphite with final density higher than 80%. The ceramic insert 26 comprises ceramic material including but not limited to one of aluminum oxide, boron carbide, silicon carbide, silicon oxide, aluminum nitride, zirconium oxide, boron nitride or any mixture of these substances.

With continuing reference to FIG. 1, the small diameter portion of the conductive component 12 proximate the conductive component distal end 16 has a length in the range of 100% the length of the contact tip wire feed aperture. It is at this portion 24 that the welding current is transferred from the welding torch to the welding wire.

In FIG. 2, the small diameter portion 24 of the conductive component 12 proximate the conductive component distal end 16 has a length of 50% the length of the contact tip through-bore. The limited length of the small diameter portion 24 provides for better arc

Reference Numerals

10. contact tip
12. conductive component
14. mounting end
16. distal contact end
17.
18. wire feed axis
20. through-bore
22. large diameter
24. small diam. portion
26. ceramic insert
28. through-bore
30. outlet
32. front outside corner
34.
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What is claimed is:

1. A contact tip for use in a welding torch that feedingly guides a welding wire toward a workpiece and transfers welding current from the torch to the wire, the contact tip comprising:

an electrically conductive tube including a mounting end and a distal contact end and extending along a longitudinal wire feed axis;

said conductive tube including a through-bore extending along said axis through which said welding wire is fed; and

said conductive tube distal end has an increased outside diameter and bulbous shape.

2. The tip of claim 1 wherein said conductive tube comprises copper material.

3. The tip of claim 2 wherein said copper material comprises one of copper, copper alloy, and sintered copper with conductive ceramic particles.

4. The tip of claim 3 wherein said sintered copper with conductive ceramic particles comprises 99.5 to 80% Cu and 0.5 to 20% ceramics.

5. The tip of claim 3 wherein said sintered copper with conductive ceramic particles comprises 95.0 to 90% Cu and 5.0 to 10% ceramics.

6. The tip of claim 3 wherein said sintered copper with conductive ceramic particles comprises 99.0 to 85% Cu and 1.0 to 15% ceramics.

15. The tip of claim 14 wherein said ceramics material comprises one of aluminum oxide, boron carbide, silicon carbide, silicon oxide, aluminum nitride, zirconium oxide and boron nitride.

16. The tip of claim 13 wherein said small diameter portion proximate said conductive tube distal end extends less than 100 percent of the length of said through-bore.

17. The tip of claim 13 wherein said insert through-bore includes a tapered end at one end adjacent said conductive tube mounting end.

18. The tip of claim 17 wherein said tapered end is defined by a sidewall disposed generally at an angle of about 30 degrees to the longitudinal wire feed axis.

19. The tip of claim 13 wherein said through-bore generally forms a right angle corner at the distal contact end.

20. The tip of claim 13 wherein said mounting end includes a high heat transfer surface that maximizes contact area.

21. The tip of claim 20 wherein said high heat transfer surface is a frusto-conical surface and taper-lock thread arrangement.

22. The tip of claim 13 wherein said bulbous distal end includes an anti-spatter coating.

23. The tip of claim 22 wherein said coating comprises a diamond-like carbon material.

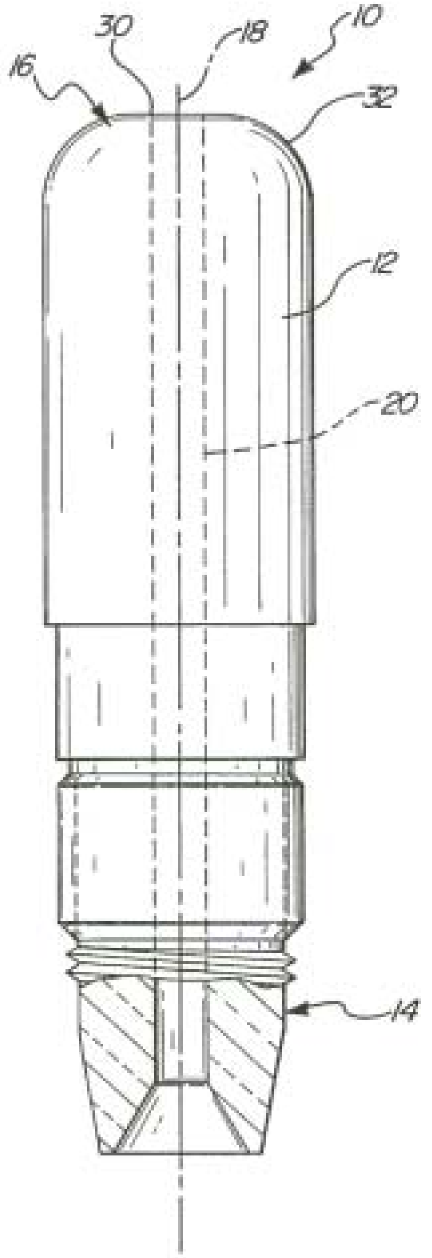


FIG-1

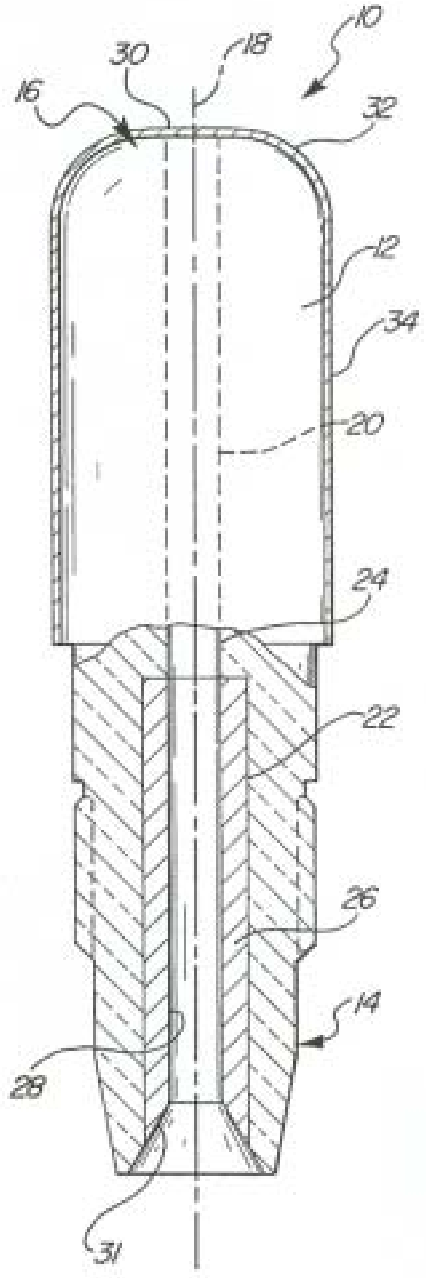
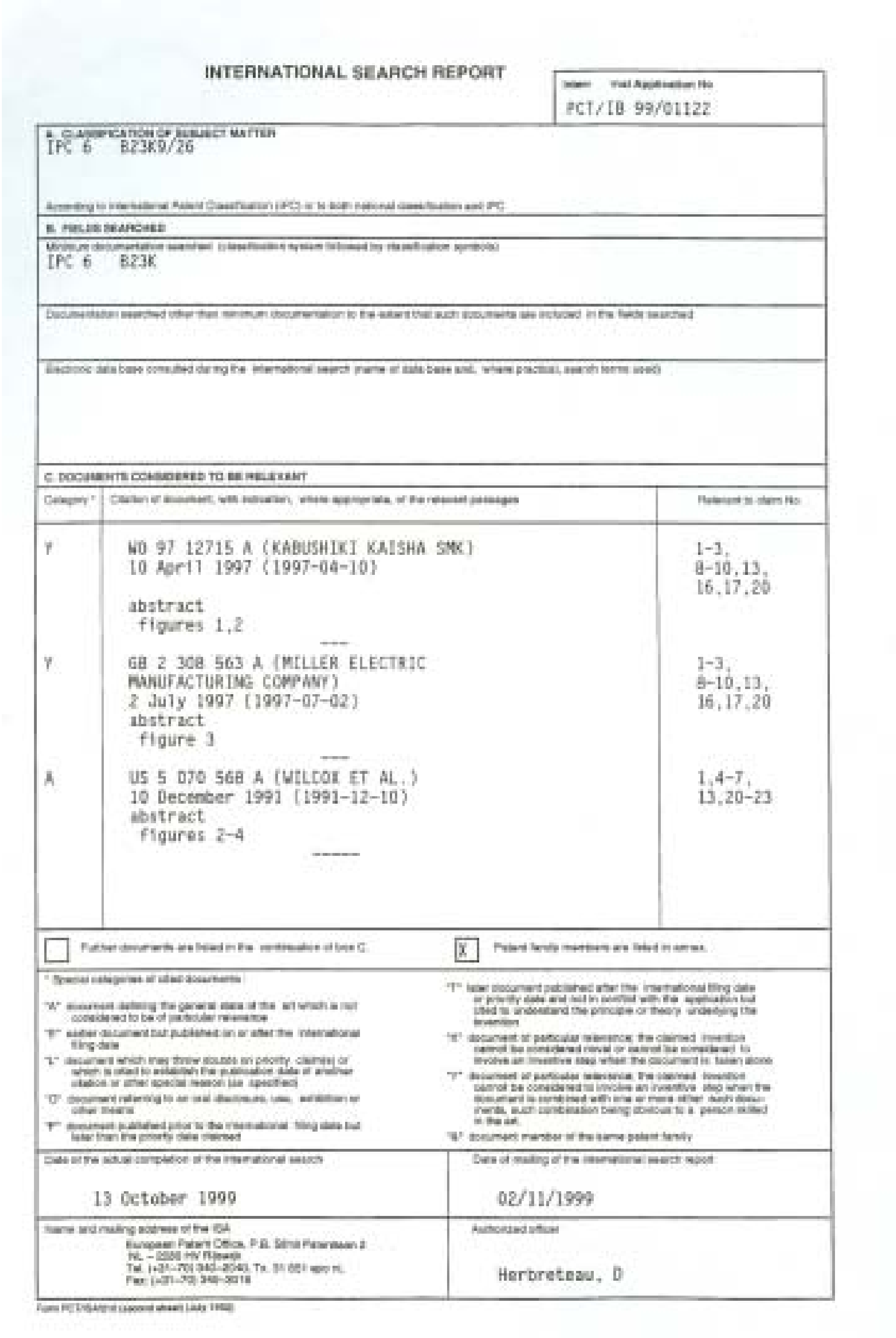


FIG-2



INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 99/01122

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B23K9/26

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)
IPC 6 B23K

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 97 12715 A (KABUSHIKI KAISHA SMK) 10 April 1997 (1997-04-10) abstract figures 1,2 ---	1-3, 8-10,13, 16,17,20
Y	GB 2 308 563 A (MILLER ELECTRIC MANUFACTURING COMPANY) 2 July 1997 (1997-07-02) abstract figure 3 ---	1-3, 8-10,13, 16,17,20
A	US 5 070 568 A (WILCOX ET AL.) 10 December 1991 (1991-12-10) abstract figures 2-4 -----	1,4-7, 13,20-23

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

☒ Patent family members are listed in annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

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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

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"&" document member of the same patent family

Date of the actual completion of the international search 13 October 1999	Date of mailing of the international search report 02/11/1999
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Herbreteau, D

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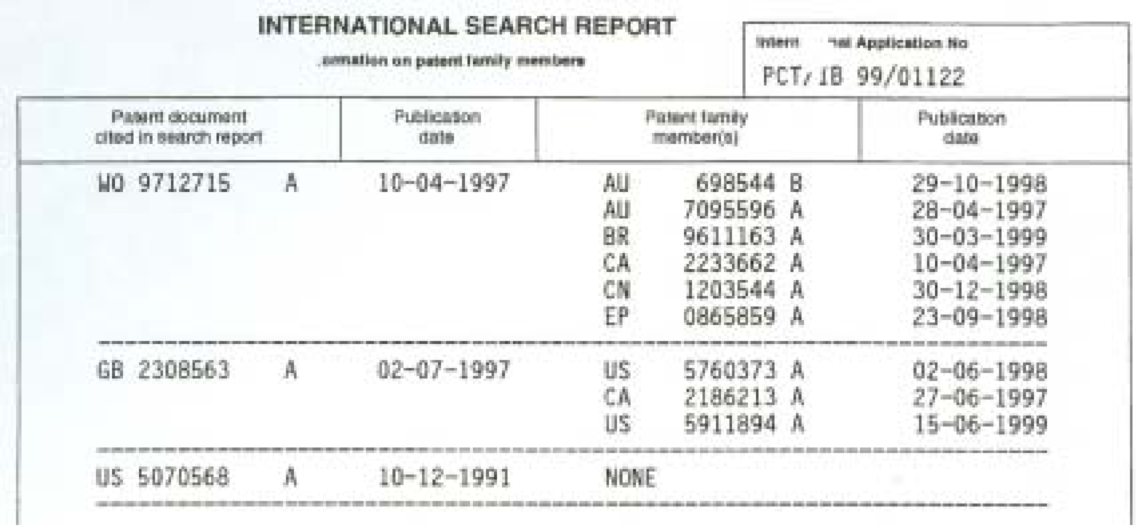

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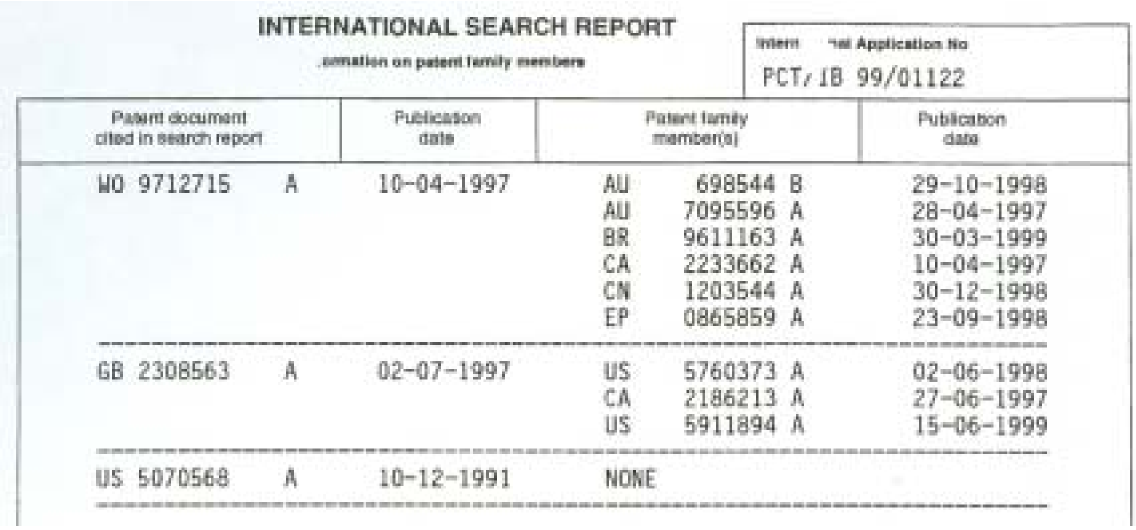
			AU	7095596	A	28-04-1997
			BR	9611163	A	30-03-1999
			CA	2233662	A	10-04-1997
			CN	1203544	A	30-12-1998
			EP	0865859	A	23-09-1998
GB 2308563	A	02-07-1997	US	5760373	A	02-06-1998
			CA	2186213	A	27-06-1997
			US	5911894	A	15-06-1999
US 5070568	A	10-12-1991	NONE			



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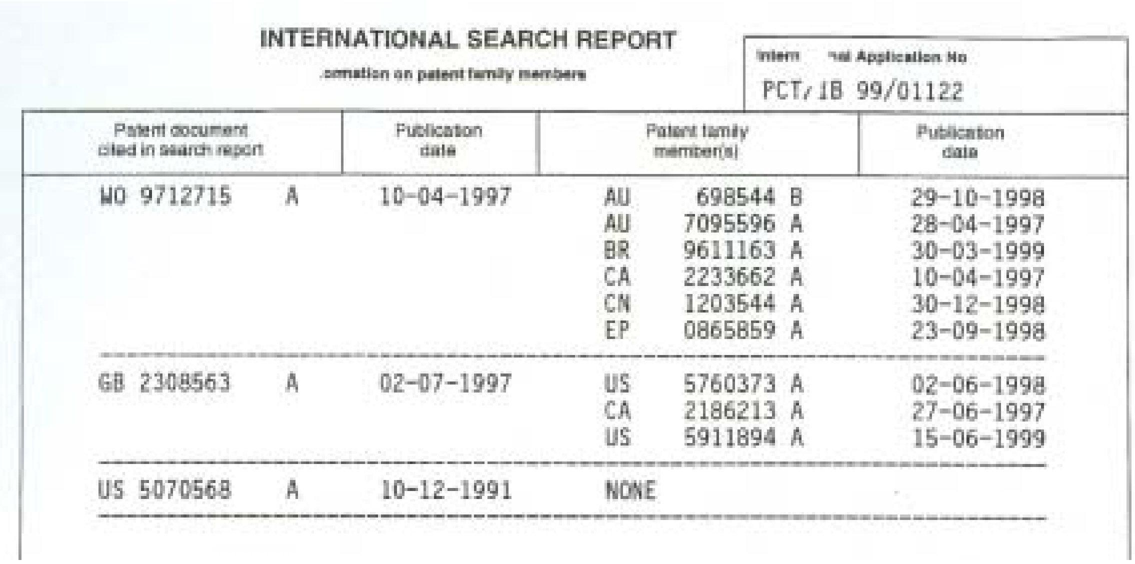

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