Applications for Gold-Base Brazing Alloys

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The advantageous properties of gold-based brazing alloys have found a number of uses in the construction of aero-engines and space craft, in nuclear engineering and in the electrical and electronic industries. After reviewing the characteristics of a number of commercially available brazing alloys this paper details some performance data that have governed the choice of alloy for specific applications.

Gold filler metals for brazing are being used at an increased rate every year, largely in the assembly of aircraft engine, aerospace and nuclear components. Some of their primary advantages are:

1. resistance to high temperature oxidation,
2. operating temperatures of 1000°F (538°C) or slightly over,
3. very little erosion attack to base metals (stainless steels, super alloys and refractory metals), and
4. free-flowing characteristics in hydrogen or vacuum brazing.

As a class they have better properties than the silver brazing alloys and they are without some of the deficiencies associated with the nickel alloy brazing materials.

In situations where intergranular penetration of the base metal cannot be tolerated, and where high strength and excellent oxidation resistance are required at temperatures around 1600°F (870°C), there is a strong interest in gold alloys. To be sure, the high gold content makes these alloys expensive on a per-ounce basis, but in most cases the value of the assembly and the extreme importance of reliable high-temperature performance outweigh by far the cost of the small amount of alloy needed to make the joint.

Compared with the high-nickel alloys, the gold alloys have lower hardnesses, better ductility and less tendency toward intergranular penetration. They can be produced in any variety of wrought forms, in

Fig. 1 A number of assemblies in aircraft engines, constructed in stainless steels and high temperature nickel-base alloys, are brazed with gold-based brazing alloys. This fuel manifold assembly from a Pratt and Whitney engine has been brazed with an 82 per cent gold-12 per cent nickel alloy

Table I
Industrial Gold Brazing Alloys

No.	Composition, weight per cent						Melting Range			
	Au	Cu	Ni	Ag	Pd	Other	Liquidus °C	Liquidus °F	Solidus °C	Solidus °F
1	92				8		1240	2264	1200	2192
2	50		25		25		1121	2050	1102	2016
3	35	62	3				1030	1886	1000	1832
4	82		18				950	1742	950	1742
5	81.5	16.5	2				925	1697	910	1670
6	60	20		20			845	1553	835	1535
7	30		36		34		1169	2136	1135	2075
8	41		22		27	10 Cr	1110	2030	1054	1930
9	70		22		8		1037	1899	1005	1841
10	20	78				2 In	1025	1877	975	1787
11	35	65					1010	1850	990	1814
12	37.5	62.5					1005	1841	985	1805
13	40	60					1000	1832	980	1796
14	72		22			6 Cr	1000	1832	975	1787
15	80	20					910	1670	908	1666
16	60	37				3 In	900	1652	860	1580
17	75	20		5			895	1643	885	1625
18	88					12 Ge	356	673	356	673
19	50	50					970	1778	955	1751
20	5				20	75 Pt	1695	3083	1645	2993
21	65				35		1440	2624	1428	2601
22	75				25		1410	2570	1380	2516
23	75					25 Pt	1410	2570	1210	2210
24	87				13		1305	2381	1260	2300
25	65		35				1075	1967	965	1769
26	30	70					1035	1895	1005	1859
27	32	65	3				1025	1877	990	1814
28	94	6					990	1814	965	1769
29	51.7	45.5		2.8			963	1765	924	1695
30	58.3	39.6		2.1			921	1690	906	1660

contrast to nickel-boron-silicon alloys which are available only in powder tape, sintered powder, or cast forms. In addition, they have excellent wetting and flow characteristics.

The Selection of Brazing Alloys

Most of the commercially available brazing alloys listed in Table I contain gold, palladium and copper as their principal constituents. Several of the more prominent and widely used gold alloys are described in more detail below:

(1) **92 gold – 8 palladium** is a very low vapour pressure, non-oxidisable alloy of palladium and gold which will wet and flow well on tungsten,

molybdenum, stainless steel and nickel. Its low vapour pressure and high melting range make this alloy useful for brazing of cathode structures.

(2) **50 gold – 25 palladium – 25 nickel** is an alloy with excellent strength at elevated temperature. It wets and flows well on molybdenum, tungsten, stainless steel and nickel.

(3) **35 gold – 62 copper – 3 nickel** has better wetting and flow characteristics on iron alloys, nickel and molybdenum than the binary gold-copper alloys, and does not penetrate the grain boundaries of the glass sealing alloys such as Kovar and Rodar as readily; hence it is widely used for brazing these materials. It has a considerably

smaller grain size, higher strength and is less subject to hydrogen embrittlement than the gold-copper alloys, thereby reducing the possibility of very slow "leaks" through the grain boundaries.

(4) **82 gold – 18 nickel** is a very high strength alloy, possessing excellent corrosion resistance. Due to its favourable melting point and exceptional wetting and flow characteristics on tungsten, molybdenum and stainless steel, it is widely used for brazing these metals to copper, nickel and the glass sealing alloys, Kovar and Rodar. Because its solidus and liquidus are at the same temperature, this alloy is of particular value for brazing metals having widely different thermal expansions; for example, copper to Kovar or molybdenum. The alloy wets a wide range of high temperature iron- and nickel-base alloys such as the stainless steels, A286 (super iron-base alloy), and various Inconels very well. It does not alloy excessively with these materials, nor does it produce the severe intergranular penetration normally associated with the nickel-based brazing alloys containing boron. A minimum brazing temperature of 1800°F (982°C) is suggested for furnace brazing in hydrogen or dissociated ammonia having a –40°C dew point or drier on 300 or 400 series stainless steels which do not contain additions of titanium or aluminium. Stainless steels of the 17-7 PH variety require dew points of –70°F (–57°C) or drier for furnace brazing. Brazing has also been conducted in inert atmospheres and in vacuum. For torch brazing, protection with a high temperature flux is recommended. Where base metals containing elements which produce refractory oxides are encountered, such a flux with boron added will promote better wetting.

(5) **81.5 gold – 16.5 copper – 2 nickel** was developed specifically to fill the need for a ductile, low vapour-pressure, non-silver-bearing alloy having a melting range below that of alloys 3 and 4 above. It has the excellent wetting and flow characteristics of No. 3 and, being far less brittle than the conventional 80 gold-20 copper alloy, it is there recommended as a replacement.

(6) **60 gold – 20 copper – 20 silver.** Its low and very short melting range makes this alloy useful for brazing of components previously brazed with one of the higher melting alloys or for those applications in which higher brazing temperatures are undesirable.

(14) **72 gold – 22 nickel – 6 chromium** is a high-temperature, gold-base brazing filler metal designed particularly for joining heat-resistant base metals where elevated temperature service is to be encountered. A minimum brazing temperature of

1950°F (1065°C) is recommended. This alloy wets a wide variety of heat-resistant base metals such as stainless steels, Hastelloys and René 41 and the brazing temperature is ideal for the solution heat treatment of René 41. The alloy can also be used for brazing carbon, graphite and diamond.

This alloy is most commonly employed in very dry reducing or inert atmospheres or vacuum, but can be used in torch brazing with a high temperature flux (boron-modified). It is much less aggressive on many heat-resistant base metals than the high nickel-base filler metals containing chromium, silicon and boron.

The Properties of Brazed Joints

Results of limited short time elevated temperature tensile tests on Type 304 stainless steel butt joints using the 72 gold – 22 nickel – 6 chromium brazing alloy are as follows:

Test Temperature		Tensile Strength		
°F	°C	(psi)	(kg/mm ²)	(N/m ²)
Room	20	62,000	45.3	4.3×10^8
800	427	50,000	36.5	3.4×10^8
1200	649	40,000	29.2	2.8×10^8
1600	871	20,000	14.6	1.4×10^8

Joints tested at the above temperatures, after seven days exposure to oxidising conditions at 1600°F (871°C), showed virtually no loss in tensile strength. From an oxidation resistance standpoint this alloy is recommended for service temperatures up to 1500°F (816°C).

Lap joints between Inconel and stainless steel, brazed in a helium atmosphere at 1900°F (1038°C) without flux, were exposed to air at 1600°F (871°C) for a period of 88 hours with no adverse effect. Photomicrographs of other joints in Inconel and stainless steel assemblies show only slight grain boundary attack in the stainless steel, but the extent was negligible considering the long brazing cycle employed. Nor was there any intergranular penetration in the Inconel part of the assembly.

This alloy is not recommended for brazing joints that may come in contact with liquid metals such as sodium and potassium which are used in some types of nuclear reactor heat exchangers.

The 82 gold – 18 nickel joints provide much greater oxidation resistance than the silver-base brazing alloys and compare favourably in this respect to the nickel-silicon-boron and nickel-chromium-silicon-boron brazing media. This alloy is also not recommended for applications involving contact with liquid metals such as sodium and potassium.

This alloy offers good room temperature strengths on stainless steels and results similar to those for 72 gold – 22 nickel – 6 chromium at limited short time elevated temperature tests can be obtained.

Fig. 2 A stainless steel air duct, also from a Pratt and Whitney engine. The tubular assembly is brazed with a gold-nickel alloy

From an oxidation resistance standpoint, this alloy is recommended for service temperatures up to 1500°F (816°C).

From the previous data it can be concluded that the gold-base filler metals are used to produce strong ductile joints whose resistance to oxidation is considerably better than that which can be obtained with the silver-base filler metals. Chang (1) has investigated the room-temperature and elevated-temperature strength, ductility, impact properties and oxidation resistance of stainless steel joints brazed with gold-base and nickel-base filler metals. Sloboda (2), and Zimmerman and Colbus (3) have also concluded that joints made with the 82 gold-18 nickel brazing alloy possessed excellent strength, ductility and oxidation resistance; however, the service temperature of 1500°F (816°C) for joints brazed with this filler metal is limited, since it melts at a relatively low temperature (1742°F, 950°C). Other gold-base filler metals that can be used at considerably higher temperatures are shown in Table I (e.g. 92 gold-8 palladium, 75 gold-25 platinum and others).

Some recently completed test work by an aircraft manufacturer on Inconel 718 relates to vane fabrication for engine components such as those shown in Figure 3. Excellent shear-tensile and rupture and fatigue results from room and elevated temperature testing of the 82 gold-12 nickel brazing alloy were obtained. The results of overlap shear-tensile tests in 0.032 inch Inconel 718 indicate the following; at room temperature shear load in ksi was 90.2 while at 800°F (427°C) the shear load was 58.6 and at 1200°F (649°C) the tests showed 44.1 ksi. In overlap shear rupture of 0.032 inch Inconel 718 sheet at 1200°F (649°C) all failures occurred in the braze joints with

Fig. 3 High temperature operation, mechanical strength and economics have also determined the use of gold-nickel brazing alloys in the assembly of the vanes in aircraft engines

Fig. 4 A nickel alloy after-burner spray manifold with the brazed fittings again assembled with 82 per cent gold - 18 per cent nickel alloy by vacuum brazing

joint stress running 5 to 8 ksi and life in hours from 0.8 to 33.1. Finally in 0.030 inch Inconel 718 sheet at room temperature, high cycle fatigue in axial-axial mode showed failures occurring in the braze affected zone (failure in base metal through or adjacent to the fillet). The joint maximum stress ($A=0.95$) in ksi ranged from 10 to 20 with a 2T nominal overlap and the cycles ranged from 94 to 2263×10^3 .

General Uses and Applications

The gold-copper alloys are the most widely used for brazing temperatures above the silver-copper alloy limits. They have good wetting action on pre-metallised ceramics. In joining electronic components, the various gold-copper brazing alloy compositions are used for step-brazing or where low vapour pressure alloys with higher brazing temperatures are required for service in vacuum applications. Steel, stainless steel, copper, copper alloys, nickel, and nickel alloys are readily brazed with gold-copper compositions. Most applications of these alloys are for controlled atmosphere procedures without use of a brazing flux. However, the alloys also are suitable for flux brazing. Gold-copper alloys with about 40 to 90 per cent gold are subject to ordering which reduces the ductility of the alloys. It is desirable to cool rapidly from 1000°F (538°C) to room temperature to obtain maximum ductility in the alloys.

Aircraft Engines

The 82 gold-18 nickel braze alloy has found numerous uses due to its excellent properties in the

aircraft engines of today. Selected components of stainless steel and nickel-base superalloys have been utilised by Pratt & Whitney in many aircraft in current service. In Figures 1, 2, and 4, are several of these components where temperatures, mechanical properties, and economics have dictated the use of the 82 gold-18 nickel braze alloy. All brazing of these components was performed in vacuum or in dry hydrogen.

Aerospace Engineering

To develop improved connectors for tubing, NASA researchers originated a diffusion bonding process that

produced strong, leaktight joints (4). The process used an intermediate metal system of gold-copper-gold to promote bonding. Bonding conditions of one hour at 500°F (260°C) with 30,000 psi (21.9 kg/mm² or 2.07×10^8 N/m²) in air produced leaktight joints with bond tensile strengths greater than 20,000 psi (14.6 kg/mm² or 1.38×10^8 N/m²). The research programme was conducted on connectors of Type 347 stainless steel (5).

The connector was pressurised to an internal pressure of 6000 psi (4.4 kg/mm² or 4.14×10^7 N/m²) and leak-checked at room temperature and at -320°F (-196°C). No leaks were found with a leak detector that had a sensitivity of 10^{-7} atm cm³/sec. The connector was then subjected to a vibration test of 200,000 cycles with a maximum fibre stress of 10,000 psi (7.3 kg/mm² or 6.89×10^7 N/m²) at a rate of 87 cps. No leakage was detected during the test nor during a subsequent leak check with an internal pressure of 9000 psi (6.6 kg/mm² or 6.20×10^7 N/m²).

The next test was a shock test designed to produce a maximum fibre stress of about 10,000 psi (7.3 kg/mm² or 6.89×10^7 N/m²). The shock load was applied so as to introduce bending stresses across the joint. The test was made, but strain gauges attached to the connector showed that a 35,000 psi (25.6 kg/mm² or 2.14×10^8 N/m²) fibre stress was produced. This was about three times the planned level and produced a leak in the bonded joint. However, the entire joint was not destroyed.

In a subsequent tensile test, a load of 15,200 lb (6.89×10^3 kg) was required to separate the connector.

This is a stress of 9000 psi based on the initial bond area, but is about 15,000 psi (10.95 kg/mm^2 or $1.03 \times 10^8 \text{ N/m}^2$) based on an estimate of the bonded area after the shock.

Since the actual bonds are formed between the intermediate materials, the bond system and bonding parameters should be satisfactory for the gold that can be electroplated. Since the joint is made in air, with low temperatures and with the bonding pressure produced by tightening the connector bolts, it should readily lend itself to use in field applications.

The gold-copper-nickel alloys are a modification of the gold-copper alloys with nickel to improve wetting. The nickel content increases the erosion of pre-metallised surfaces if temperature and brazing time are not properly controlled.

The ability of nickel to increase flow characteristics has led to the development of a family of gold-nickel brazing alloys. Probably the most popular of these during the past few years has been the 82 gold-18 nickel composition. This alloy has found wide usage in ceramic-to-metal joints, such as in electronic tubes.

Perhaps its most outstanding application to date has been its use by an aerospace company to join 304L corrosion-resistant tubular steel in the space programme's Lunar Excursion Module (LEM). More than 1000 joints, in various diameters and combinations were brazed on each LEM Reaction Control System used by the astronauts to manoeuvre the craft.

Nuclear Engineering

The fabrication of heat exchangers for nuclear applications has been discussed by Slaughter et al. (6). These units were composed of a multitude of thin-walled, small-diameter Inconel 600 or Hastelloy N tubes assembled in suitable headers. The tube-to-header joints were welded with the gas tungsten-arc process, and back-brazed with 82 gold-18 nickel filler metals to reduce the notch at the root of the weld. This procedure prevented the formation of cracks that previously initiated at these notches during thermal cycling.

Table II
Room Temperature Tensile and Shear Strengths of Alloy 718 Joints
made using various brazing joints alloys, brazing times and temperatures. 0.002 inch joint gap
(Kirby and Hanks (7))

Alloy type	Joint preparation	Joint type	Brazing temp. °F	Time at temperature, min.	Failure stress, psi
82Au-18Ni	Bare	Shear	1830	—	57,000
Au-8Pd-22Ni	Bare	Shear	1980	—	71,000
Au-8Pd-22Ni	Bare	Shear	2130	—	88,000
70Au-8Pd-22Ni	Bare	Tensile	1925	5	170,000
82Au-18Ni	Bare	Tensile	1800	5	148,000
82Au-18Ni	0.005 Ni	Tensile	1800	5	143,000
82Au-18Ni	(0.0001 in.) strike Ni	Tensile	1800	5	155,000
82Au-18Ni	Strike	Tensile	1832	5	160,000
82Au-18Ni	Strike	Tensile	1832	15	156,000
82Au-18Ni	Strike	Tensile	1800	5+ reheat to 1720° F for 5 min.	145,000
Au-16.5Cu-2Ni	Strike	Tensile	1720	5	162,000
Au-16.5Cu-2Ni	(0.001 in.) Ni-plate	Tensile	1745	5	131,000
Data on non-heat-treated specimens					
82Au-18Ni	Strike	Tensile	1800	5	127,000
82Au-18Ni	0.0005	Tensile	1800	5	124,000
82Au-18Ni	Strike	Tensile	1800	10	118,000
82Au-18Ni	Strike	Tensile	1800	15	104,000
81.5Au-16.5Cu-2Ni	Strike	Tensile	1720	5	110,000
81.5Au-16.5Cu-2Ni	0.0005	Tensile	1720	5	Plate pulled loose ~20,000

Kirby and Hanks (7) studied the brazing of Inconel 718 tubular assemblies for an application in the Phoebe-2A reactor. Nickel-base alloys containing boron and silicon were not considered for this application because of the high neutron capture cross-section of boron and of the possibility that boron and silicon would diffuse into the grain boundaries and reduce joint ductility. Also, the temperature required for brazing with nickel-base alloys might adversely affect the basis metal properties. For example, when Inconel 718 was heated above 1900°F (1038°C), there was a marked increase in grain size that resulted in reduced tensile and yield strengths. Several gold-base alloys were evaluated for this application. It was found that specimens could be brazed in a dry argon atmosphere if the combined content of water and oxygen did not exceed 2 p.p.m. (about 1×10^{-3} torr). If the specimens were plated with nickel, good flow of the braze filler metal occurred in argon with impurity contents as high as 5 p.p.m. oxygen and 8 p.p.m. water. The 82 gold-18 nickel alloy was selected for structural brazing applications on the basis of the data shown in Tables II and III.

Brazing of Corrugated Panels

In a recently completed programme by an aerospace firm, a series of corrugated L-605 cobalt-base superalloy panels was brazed with the 82 gold-18 nickel braze alloy. One half of the test panels were subsequently diffusion-heat-treated to evaluate brazing versus diffusion. The tensile tests were performed at room temperature (68°F or 20°C), 1000°F (538°C), and at 1200°F (649°C). Room temperature tests included the use of universal joints above and below the test specimens. Tests at elevated temperatures employed only one spherical joint below the test specimen to allow a limited universal effect and to minimise twisting and shearing of the samples during testing. The test rig is shown in Figure 6, and Table IV shows the tensile test data and bonding cycles for each specimen. Examination reveals that, for given test temperatures, diffusion-heat-treated samples exhibited higher ultimate loads than the brazed-only samples. The bond strengths of brazed-

Table III
Room Temperature Tensile Properties of
Brazed and Heat Treated Alloy 718
Assemblies
(Kirby and Hanks (7))

	UTS ksi	Prop Limit, ksi	0.2% offset yield strength ksi	Total permanent elongation, % of total length
Group I	190.7	83.2	152.6	13.4
	178.2	93.8	146.0	8.3
	188.7	113.0	165.9	8.7
Group II	207.9	124.7	175.7	10.4
	192.9	135.4	163.6	7.4
	206.3	136.8	169.9	15.2
	205.5	125.2	167.8	14.5
	205.4	120.8	166.8	13.4
	205.0	123.7	168.7	14.3

only samples decreased more rapidly with increasing temperatures than the bond strengths of diffusion-heat-treated samples.

All of the brazed-only samples failed predominantly through the brazed joints. Diffusion-heat-treated

Fig. 6 The elevated temperature test rig for tensile testing of gold alloy brazed corrugated panels made in a cobalt-base superalloy and brazed with a gold-nickel alloy in a cold wall vacuum furnace

Table IV
Bonding Cycles and Ultimate Tensile Loads for Corrugated Sheet Specimens

Test No.	Braze cycle	Diffusion heat treat cycle	Tensile test temperature	Ultimate (Pounds)	Tensile (kg)	Load (Newton)
1	30 Min at 1850°F (1010°C)–30 psi	None	1000°F (538°C)	2,643	1199	11757
2	30 Min at 1850°C (1010°C)–30 psi	None	Ambient (20°C)	5,060	2295	22508
3	30 Min at 1850°F (1010°C)–30 psi	None	1200°F (649°C)	1,923	872	8554
4	30 Min at 1850°F (1010°C)–30 psi	6 h at 2000°F (1094°C)	Ambient (20°C)	5,175	2347	23020
5	30 Min at 1850°F (1010°C)–30 psi	6 h at 1950°F (1066°C)	1000°F (538°C)	3,143	1426	13981
6	30 Min at 1850°F (1010°C)–30 psi	4 h at 2050°F (1121°C)	1200°F (649°C)	2,714	1231	12072

samples failed only in the base metal sheet at room temperature, through the joints and through the L-605 sheet at 1000°F (538°C), and predominantly through the bonded joints at 1200°F (649°C).

Stress levels were not obtained because the cross-sectional areas of the test specimens were not readily calculated and because all of the specimens exhibited a tendency to twist and to fail in shear. It was estimated that diffusion-heat-treated specimens experienced substantially higher stress levels than brazed-only specimens at 1000°F (538°C) and less.

Metallographic examinations of brazed-only samples showed the gold alloy filler to be generally confined to the brazed joints themselves. Diffusion heat treated specimens exhibited gold alloy filler on all sheet surfaces and penetration of the alloy as deep as 0.005 in. (0.113 mm) into the base metal sheet near bonded joints.

Coffey (8) also investigated the use of gold-base brazing alloys 82 gold-18 nickel and 72 gold-22 nickel-6 chromium for fabricating Inconel 718 honeycomb structures.

The Brazing of Graphite

Alloys in the gold-nickel-molybdenum ternary system have been developed and found satisfactory to braze graphite to graphite joints. Alloys in the system containing low percentages of molybdenum can be used for graphite to molybdenum joints, whereas alloys with greater percentages of this carbide former can be used to braze graphite-to-graphite joints as well.

Alloys in the gold-nickel-tantalum system have also been developed that have satisfactorily flowed on graphite. Compositions suitable for brazing graphite

to graphite joints (60 gold-10 nickel-20 tantalum) sometimes exhibited fillet cracking, but compositions containing lower percentages (less than approximately 30 weight per cent) of tantalum have been satisfactory for brazing graphite to metal joints.

The 35 gold-35 nickel-30 molybdenum alloy is especially attractive, for it can be used to braze both graphite to graphite and graphite to metal joints with high integrity. It is attractive as a general-purpose alloy and, in addition, it possesses good corrosion resistance to molten fluoride salts. It can be used to braze both low and high porosity grades of graphite in which the joints have strengths at least as great as that of the graphite (9).

In Electrical Construction

A brazing alloy for nickel, with a brazing temperature range from 1680 to 1720°F (916 to 938°C), has been developed and used for brazing of nickel-clad silver electrical conductors operating at 1200°F (649°C). The alloy composition is 77.9 gold-17.1 nickel-5 indium.

This alloy was developed for brazing the ends of nickel-clad silver stator coils in an electromagnetic boiler feed pump which operates with a hot spot temperature of 1200°F (649°C). The operating environment prohibited the presence of silver either in the brazed joint or on open surfaces within the pump. Therefore the brazing filler metal could not contain silver, and the brazing temperature was kept below the melting point of the conductive silver cores to prevent alloying with the braze metal. To prevent corrosion by residual flux, no flux was used in the brazing operation.

A review of brazing filler metals and techniques

indicated the need for a gold-base alloy and brazing in an inert gas atmosphere.

Available gold-nickel alloys met the requirements except for their high melting points. A review of additives for the depression of melting points resulted in the selection of indium. Indium has good solubility with both gold and nickel, and the liquidus temperatures of gold-indium and nickel-indium binary systems can be substantially reduced by small increases in the indium content. The low content of indium in the selected brazing filler metal minimizes the effect of indium's high vapour pressure. This brazing alloy may be used in high temperature electrical systems in lieu of conventional gold-nickel, gold-copper or silver brazing filler metals; it has low electrical resistivity, does not require a flux, and is less corrosive than other gold-nickel and gold-copper alloys.

The Future

The gold-nickel and gold-copper brazing alloys have found wide usage in the aerospace, nuclear and electronics industries. This is based on the enviable properties that these alloys exhibit. The gold-nickel alloy has a sharp solidus/liquidus transition; both gold-nickel and gold-copper have reasonable flow in varying gap situations without excessive "flashing";

both have strength and ductility, and the gold-nickel alloy possesses good resistance to oxidation at elevated temperatures.

Thus the gold-base brazing alloys are widely used and have been able to fill an important gap in the brazing alloy spectrum.

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Gold Inlaid Contacts in New Edge Connectors

Already established with a range of interconnection systems, Texas Instruments has now introduced a new series of printed circuit edgeboard connectors in which a hard gold inlay is confined to the actual contact area.

Thirty standard types based upon 0.100 inch and 0.125 inch centres, in both wire wrapped and solder tail pin construction, have been made available to meet commercial applications.

The use of the gold inlay technique as opposed to gold plating for the contacts enables a relatively thick layer of gold to be located only where it is needed—where low contact resistance and good wearing properties are essential. The spring material used is a corrosion resistant copper alloy containing 9 per cent nickel and 2 per cent tin, and in the course of manufacturing the strip a continuous narrow stripe of a hardened gold alloy is inlaid and firmly bonded to the base metal along its base and edges. The thickness of the gold alloy is 100 microinches, and the inlay technique eliminates wastage of gold.

Texas Instruments is one of the leading producers of bi-metals for contacts and other purposes at its main plant in Attleboro, Massachusetts. This technique makes it possible to select any desired combination of width and thickness of gold or gold alloy inlay, and to produce more than one stripe—or stripes on both faces—in a base metal alloy for contact purposes.