

# **Building Instructions for a Propane Gas Forge (Burner System)**

## **Technical Drawing**

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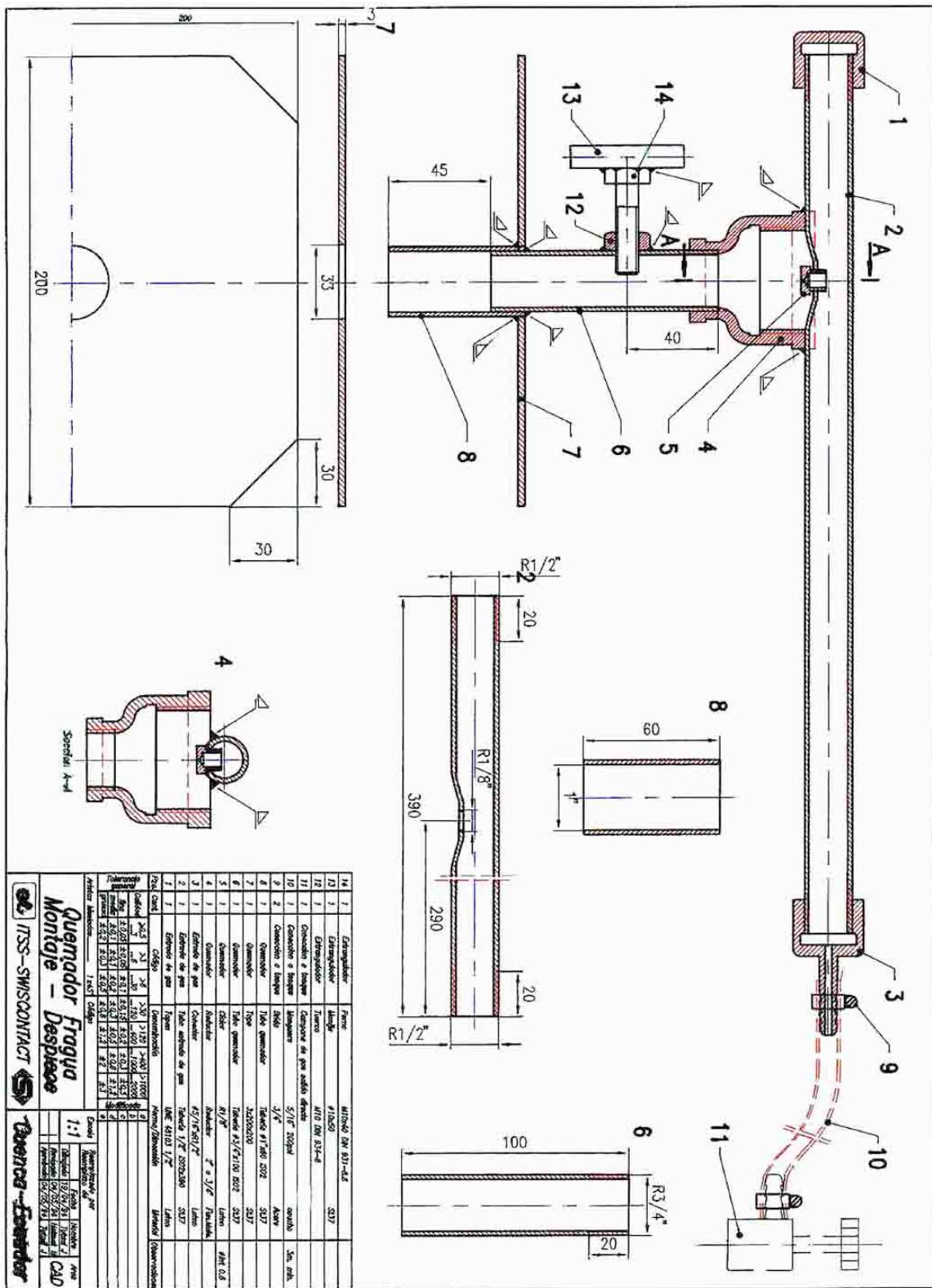
**composed by Helmut Hillenkamp**

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(Remark: This forge system has been used as described in Ecuador. To use in your country, you must check and comply with applicable local and national safety codes.)

## Parts List

1. One 1/2" pipe cap (all pipe and fittings are to be unplated).
2. 17" of 1/2" pipe, threaded on both ends.
3. Coupling, 1/2" pipe thread to hose fitting connector.
4. One 2" to 3/4" bell reducer.
5. One brass orifice fitting drilled with a: #66 drill for sea level operation. #67 drill for 3,500 ft. elevation operation. #68 drill for 7,000 ft. elevation.
6. One piece of 3/4" pipe 4" long, threaded on one end.
7. One piece of mild steel 1/8" x 8" x 8".
8. One piece of 1" pipe 2 1/2" long
- 9.&10. 20 feet of 350 PSI 1/4" propane hose with appropriate end couplings.
11. One 0-100 PSI gas pressure regulator or POL fitting with excess flow restrictor.
12. Nut, 3/8" NC (unplated).
13. Scrap to provide handle for turning the 3/8" bolt.
14. One 3/8" bolt, 2 1/2" long.



14	1	Estrangulador	Perno	M10x40 DIN 931-8.8				
13	1	Estrangulador	Manija	Ø10x50				St37
12	1	Estrangulador	Tuerca	M10 DIN 934-8				
11	1	Conección a tanque	Campana de gas salida directa					
10	1	Conección a tanque	Manguera	5/16"	200psi		caucho	3m. min.
9	2	Conección a tanque	Brida	3/4"			Acero	
8	1	Quemador	Tubo quemador	Tubería Ø1"x60 ISO2			St37	
7	1	Quemador	Tope	3x200x200			St37	
6	1	Quemador	Tubo quemador	Tubería Ø3/4"x100 ISO2			St37	
5	1	Quemador	Ciclor	R1/8"			Latón	Ø int 0.8
4	1	Quemador	Reductor	Reductor 2" a 3/4"			Fun. Male.	
3	1	Entrada de gas	Conector	Ø5/16"xR1/2"			Latón	
2	1	Entrada de gas	Tubo entrada de gas	Tubería 1/2" ISO2x390			St37	
1	1	Entrada de gas	Tapon	UNE 48103 1/2"			Latón	
Pza.	Cant.	Código	Denominación	Norma/Dimensión			Material	Observaciones
Tolerancia general	Calidad	>0,5 ...3	>3 ...6	>6 ...30	>30 ...120	>120 ...400	>400 ...1000	>1000 ...2000
	fina	±0,05	±0,05	±0,1	±0,15	±0,2	±0,3	±0,5
	media	±0,1	±0,1	±0,2	±0,3	±0,5	±0,8	±1,2
	gruesa	±0,2	±0,3	±0,5	±0,8	±1,2	±2	±3
	Modificado	a	b	c	d	e		
Aristas biseladas.. 1x45°			Código	Escaia Reemplazado por Reemplazo de				
<p><b>Quemador Fragua</b> <b>Montaje – Despiece</b></p>				1:1	Fecha	Nombre	Area	
				Dibujado	19/04/94	Tutasi J		CAD
				Revisado	04/05/94	Helmut H		
				Aprobado	04/05/94	Tutasi J		
				<p><b>Cuenca-Ecuador</b></p>				

## I. General Description

We are presenting a furnace system whose only fuel is Propane/Butane. It was developed in adaptation of a type of forge furnace as it has been used in the USA in recent years mainly by horseshoers. It can be taken in the back of a pick-up truck right to the stable of the customers to shoe their horses. No electricity is needed for its use. Because of its high performance and clean combustion, artists blacksmiths too are using it more and more instead of the coal forge.

It would probably be ideal to have both systems available and to have the choice to use one or the other according to the job requirements. With the gas forge it is easier to obtain long uniform heats than with the coal forge, 8 in. with one burner and 4 in. more with each additional burner. The temperature can be adjusted so as to be able to keep allways several irons in the fire without burning them. With sufficiently high gas pressure and adequate layout of the combustion chamber (insulating firebricks or ceramic fiber), it is easily possible to achieve the high temperatures needed for forge welding. Using only cheap red construction bricks we reached a temperature of 2880 F in the test forge in Cuenca. We are not talking about a scientific high performance device here, but about a practical tool for daily use in the hot iron shop. All parts from which it is composed are available in the country (Ecuador), mostly from national production. For a handy craftsman it should be relatively easy to copy, once the mode of functioning is understood.

## II. Mode of Functioning

The gas (Propane, Butane, or a mixture of both - here called cooking gas) streams under pressure out of the orifice 5.

According to the principle of Venturi a depression takes place inside the bell reducer 4 which leads to the suction of air into it. The gas/air mixture then streams through a 3/4" burner pipe 6 that expands to 1", 8, into the combustion chamber. There it burns with a hot flame. To do this it needs a baffle plate at a distance of 5 in. or more, so a back pressure gets created and the flame does not blow itself out. The floor of the furnace normally serves as this baffle plate. During operation it gets particularly hot, and the heat radiated from the walls and floor helps to warm up the iron more rapidly. Similarly to the coal forge the rule is: "No cold iron into a cold forge."

First let the forge heat up well, then place the iron in it. For the combustion only the air entering through the burner pipe 6/8 gets used.

The only possibility to change the fuel/air ratio during operation consists in reducing the air flow. This can be done using the choke 12/14. The choke eases the lighting and warming up of the forge, similar to a car engine. It is also used to reduce the forming of scale on the iron. In a reducing atmosphere the iron does practically not oxidize and can be kept hot for long periods of time without volume losses through scaling. A reducing flame produces less heat though, and there is also the danger of poisonous carbon monoxide mixing with the shop air (see chapter V. Safety).

During normal use some scale will form and jump off when hammering on the anvil. This can lead to burns. **ALLWAYS WEAR SAFETY GOGGLES WHEN WORKING.** Leather gloves are recommended.

### III. Building Advise

The connection to the gas tank consists of a direct outlet without pressure regulator 11. With it the flow can be adjusted to a certain degree. A rubber hose 10 is attached to it by hose clamps 9 and leads the gas to the burner. This hose should be as strong as possible. In no case should it consist of plastic or PVC, because this would soften and weaken with heat. The best is a quality of 350 psi pressure resistance (printed on the side of the hose). I strongly recommend using a pressure regulator (0-100psi) or an excess flow shutoff valve as supplied with weed burners on the cylinder. Also use at least 10ft of hose to keep tank and forge at a minimum distance from each other. From the hose 10 the gas streams into the gas entry pipe 2 which is plugged on the far end 1. On its belly it has a hole into which the suitable thread for the orifice 5 is tapped. Before tapping the thread this spot may be flattened with the hammer a little bit. This improves gas tightness, since the orifice will not seat in a rounded section but in a flat one instead. If this spot is not tight, additional gas will stream out here in an uncontrolled manner and lead to an overly rich mixture and to malfunctioning.

Centered over the orifice 5 a bell reducer 4 of 2" x 3/4" is welded. A 3/4" pipe 6 is threaded on one end and its other end is welded to a piece of 1" pipe 8. The inside gets smoothed from cutting burrs with a round file. A hole is drilled from the side and a nut 12 of 3/8" welded to it. This nut gets retapped after welding so that the adjustment bolt 14 of the choke can be easily screwed into it. All pipes and fittings should be black (not galvanized).

Depending on the thickness of the used bricks, a square plate 7 with hole gets welded to the burner pipe 8 so that this pipe does not protrude into the combustion chamber. The actual nozzle of the burner is formed by the canal rasped into the brick. Thus overheating and burning of the pipe is avoided. The plate supports the burner mechanically and makes the canal airtight against secondary air. Therefore the weld needs to go completely around the pipe.

The combustion chamber itself is formed in the most simple case from piled-up bricks. The red construction bricks bought and made in Cuenca stood up to daily use for about four weeks before some of them had to be replaced. Firebricks are here about 20 times as expensive as construction bricks, and their use in the small shop is rarely justified. Lightweight firebricks and ceramic fiber have better insulating properties and allow a more rapid heating up of the forge and attainment of higher temperatures. If forgewelding is desired, the floor material of the forge should not be from lightweight firebricks, because they dissolve with Borax and heat (eutectic reaction). Ceramic fiber with a 3/4" kiln shelf laid on top works very well. You can coat the walls with ITC 100 to gain additional efficiency and use ceramic pebbles in the floor that will soak the heat up faster with their larger surface. Best is to start out simple and then experiment with improvements.

The distance from the burner nozzle (ceiling of combustion chamber) to the baffle plate (floor of combustion chamber) should be large enough for the flame to have space for complete combustion before hitting the floor (min. 5 in.) Otherwise a round dark spot will appear in the center where the flame hits the floor. It is a cold spot and means that the forge is not working efficiently. Right at the end of the freeburning flame is its hottest spot and its cleanest place to heat. To judge the flame properly the forge must have had enough time to warm up (see chapter IV. Operation).

What goes in must come out. Make sure to provide enough opening for the hot gases to escape (at least 10 sqin. per burner). For that reason never try to seal the doors of the forge hermetically.

## IV. Operation

To light the furnace, a piece of newspaper is lit and placed into it. Then the gas valve is opened. If the mixture does not want to ignite, the choke can be closed a little bit. The gas flow is adjusted, so that the flame is leaping out of the forge front opening 2 - 4 in. This leaping should be blueish initially and after warming up see-through orange. It should be in the shape of a stream rather than clouds. Blue cloudy flames mean a rich mixture (too much fuel or too little air). No flames coming out of the forge door mean gas pressure too low. The gas may be used up; the tank freezing; the valve not be opened right; or the orifice may be plugged up.

Through the high volume flow of consummated gas, small or near empty tanks can “freeze”. This can be avoided by placing them in a water bath with as little additional air space on top of the water level as possible (danger of explosion, see chapter V. Safety). Also make sure the tank is secured in the water bath in an upright position, so that no liquid fuel gets pushed into the hose. Otherwise sudden big flames might leap out of the forge and lead to burns. How much gas can be taken out of a tank hourly depends on its size. A 6 1/2 gal. tank in a water bath is able to run a one burner forge uninterruptedly for allmost one working day. Larger industrial size tanks can run units with two or four burners.

The used orifice size #68 (American Standard) with a diameter of 1/32" (0.8 mm) has worked well both in Santa Fe, USA (elevation 7000 ft above sea level) with pure Propane and in Cuenca, Ecuador (elevation 8500 ft above sea level) with a mix of 2/3 Butane and 1/3 Propane.

At lower elevations the air contains more oxygen and the diameter of the orifice is to be increased slightly. The right diameter for optimal operation (as lean as possible) is to be determined experimentally by slightly varying it. Thus the orifice itself has to be accessible and changeable with a wrench. Orifices with a hex

head are most practical. Also sometimes the orifice has to be taken out for cleaning purposes, when particles of dirt have plugged up the small opening. The symptom then is that the forge does not heat up well, even though there is enough gas pressure.

During operation there may be a sudden change of the combustion sound to a more gurgling tone. This indicates a flashback of the flame and its burning already inside the burner pipe instead of only in the combustion chamber. A short covering of the air inlet with the hand or an increase of the gas flow may help the problem to go away. Under no circumstances should the burner be used with a flashback over longer periods. It would overheat.

The rubber hose always is connected to the forge from the side in such a way that it does not heat up too much or even start to burn. After closing down the operation and turning off the gas, the outlet is taken off the tank so that no further gas can stream out here.

If operation is to be resumed shortly after, special care is mandatory. The heat contained in the bricks can make the gas/air mix ignite surprisingly and cause an explosion. Use a burning newspaper placed in the forge to avoid bad news.

## V. Safety

The use of gas always implies certain risks. **THE PROPOSED BURNER HAS NO SAFETY DEVICES**, because we wanted to keep it simple and inexpensive. It requires special care and attention while in use. Never leave it burning unattended. Wear eye protection, leather gloves and work clothes not from synthetics.

Propane as well as Butane is heavier than air. Escaping gas collects like water in the lowest spots, except that it is invisible and can explode. Do not use in basements. Always work with a vent hood. Keep gas tanks outside the shop (outdoors).

All parts are to be tested under pressure for gas tightness. Soapy water can help you find leaks in installations. Repair leaks before using the burner. If you smell gas, find the reason first, fix it, vent the shop, and only then use the forge.

Enough distance should be kept from low ceilings and wood beams. When in doubt use the forge outdoors. A fire extinguisher (foam or powder) is a good investment.

As employer you are responsible for the safe operation of your tools and machinery. Allow only well trained personnel to use them and insist on compliance with the safety rules. In that manner you can work efficiently and ecologically with your gas forge and probably save quite some money and time as compared to coal. The costs of materials for the simplest model one burner forge amount presently (1994) in Ecuador to about 20.- US\$ without the gas tank. A 6 1/2 gal. tank filling will last for an average of 10 hours of operation (longer with ceramic fiber, ITC 100 etc.).

It is my hope that by adapting to new requirements of economy and ecology hot ironwork will be able to assert its place in a changing world. Most important for this is not the tool but the creativity of its user and the spirit that can express itself through it.