CHARCOAL GAS-FUEL PRODUCER

TYPE S-7

STRUCTURES AND OPERATION MANUAL

DRAWINGS

PART' LIST

TECHNICAL COOPERATION
JICA
BY THE GOVERNMENT OF JAPAN

****

STRUCTURES AND OPERATION MANUAL

CHARCOAL GAS-FUEL PRODUCER, TYPE S-7

****

CONTENTS

I. PRINCIPLES AND STRUCTURAL CONCEPTS

A. General Principles

The world history shows that one of the most practical ways to run internal combustion engines on non-fossil fuel without major modification is to use gas-fuel composed of mainly carbon monoxide (CO), generated by wood-chips, charcoals or coal materials.

Nuclear energy, solar energy, and other various forms of natural energy have been under study and already been utilized in our daily life to some extent. It is, however, difficult to use them directly for current engines in our daily use with no or minimum modification of the engine structure. Alcohol from sugarcane and other plants, oil from red gum and other oil plants, coal liquefaction technology, biogas, and hydrogen which is expected to become our ultimate fuel, have also been studied, but none of them are immediate answer to local energy needs for driving existing engines without any modification of their main structures.

A system in which the engine is run on CO gas generated from wood-chips, coal or charcoal is quite simple compared with the future-oriented ones mentioned above, and will be manufactured easily by anyone who has cutting and welding technology for iron materials, even in rural area. The gas producer introduced herein is a charcoal gas-fuel producer of simple but practical structures, and it could be a basic model in technological meanings to be developed to further wood-chip gas-fuel producers if needed, and it can also compare favorably with the future-oriented energy system in terms of energy efficiency (calorific value available/calorific value input). In addition, although CO gas and CO_2 gas, breathed by human beings, are poisonous, CO gas is produced safely in the gas producer and burned in the engine, and turns into innocuous CO_2 gas exhausted to outside air.

Charcoal is produced everywhere in the world, and very popular in rural area as fuel for ironing and cooking etc. without smoke. It might not be so simple to draw a conclusion on the economy of a CO gas generator that depends much on social condition and wood resources, because the commodity prices vary depending on demand and other various marketing factors. If the country has rich wood resources, charcoal price can be economical enough to drive engines with the charcoal gas-fuel in general. If not, the charcoal gas-fuel system should be considered to be an emergency system to achieve national agriculture in petroleum-fuel shortage.

B. The Whole Structural Concept

As shown in the drawing of No. S7-01 and the actual device, the charcoal gas-fuel producer is consisted of a "Gas Producer" as a furnace of charcoal to produce burned gas, and the "1st Cleaner" to clean the burned gas exhausted from the furnace, and a "Cooling Cleaner" to make cool and clean fuel-gas to the engine. Then, the produced fuel-gas has to be mixed with the air by the "Mixer", connected to the inlet hole for the fuel-mixture to the engine, and led to the engine.

The gas producer is equipped with a "Hand Blower" which is used to blow burning charcoal in the furnace to boost at the starting stage of operation.

There is the "1st Check Valve" between the 1st cleaner and the cooling cleaner, and the "2nd Valve" at the outlet pipe of the cooling cleaner. The 1st valve is used for checking the quality of the produced gas from the 1st cleaner. The 2nd valve is used for leading or stopping the fuel-gas to the engine.

When charcoal is burned, it is converted usually into carbon dioxide gas as a result of chemical reaction between carbon, one of the main ingredients in it, and oxygen in the air.

$$C + O_2 = CO_2 \qquad (1)$$

However, if it happens for the charcoal to be burned with no sufficient oxygen in the gas producer, carbon monoxide gas (CO gas) is generated, as the following equation.

$$2C + O_2 = 2CO \qquad (2)$$

(As carbon monoxide gas is highly toxic especially because of the strong bondage with hemoglobin in the blood, and if it is inhaled by a person, it may cause even his death. Therefore, much attention has to be paid not to breathe incompiete burning gas from charcoal.)

When the carbon monoxide gas is mixed with sufficient air by the mixer and led to the engine, it is turned into harmless carbon dioxide gas (CO_2) after burnig and exhausted from the engine as follows:

$$2CO + O_2 = 2CO_2 \qquad (3)$$

These are the whole structural concept of operation.

C. Gas Producer (Furnace)

The processes of generating gas in the furnace are complicated, and various explanations on the process have been made by scientists. This is because the burning characteristics of charcoal change largely depending upon the characteristics of charcoal used, furnace structure, state of air supply, the volume and velocity of the generated gas, and so on.

The most widely accepted process of the burning in Japan might be as shown in the following formulas.

The temperature in the furnace is above 1000°C in the highest part, and the burning processes may be classified into following temperature layers.

1) Oxidizing (burning) phase from 1000°C to 1300°C :

In the case of sufficient oxygen is available for burning,

$$C + O_2 = CO_2 + 97\ 200 \text{ Kcal/mol.} \quad (1)$$

In the case of sufficient oxygen is not available for burning,

$$C + O = CO + 29\ 200 \text{ Kcal/mol.} \quad (2)$$

In the case of CO generated in the process given by the formula (2),

$$CO + O = CO_2 + 68\ 000 \text{ Kcal/mol.} \quad (3)$$

When the moisture in the fuel or air is heated to 990°C or higher,

$$H_2O + C = CO + H_2 - 28\ 400 \text{ Kcal/mol.} \quad (4)$$

When the steam is below 680°C,

$$2H_2O + C = CO_2 + 2H_2 - 18\ 000 \text{ Kcal/mol.} \quad (5)$$

These equations show us an important principle as follows : When the temperature in the gas producer becomes over 1000°C oxygen inevitably becomes deficient. As a result, the burning in the furnace becomes to generate carbon monoxide gas and at the same time to decompose moisture (H_2O) in the fuel or in the combustion air into hydrogen gas (H_2).

Since these two gases are useful for combustion in the engine, it becomes a basic technical know-how on a charcoal gas producer to manufacture and operate the furnace which can keep the burning temperature high enough. The furnace is recommended to have mortar structure in it to increase the thermal efficiency, and to be boosted well by the blower in the starting stage of operation.

It is also very important that the diameter of the bottom hole of the furnace mortar. The smaller the diameter of the hole is, the faster the velocity of current air to produce higher burning temperature of the charcoal is. Here is also another factor as the quality of charcoal. In general, soft charcoal needs higher blowing velocity of air to keep higher burning temperature than hard charcoal.

The author observed that the charcoal made in Sri Lanka is a little softer than charcoal made in Japan. The diameter of this model is 80 to 90 mm for 3 PS engines in Sri Lanka, while 100 to 120 mm in Japan for 3 to 4 PS engines. This means that this model is available to use for bigger engines by enlarging the diameter, e.g. 100 to 120 mm for 4 to 6 PS and 130 to 140 mm for 7 to 10 PS. The size of charcoal pieces is recommended to be about 3 to 4 cm cubic.

2) Upper layer of bellow 1000°C :

As is clear from the formulas (3) and (5), CO_2 gas is already useless as fuel, but is subjected to the following process in the reducing layer as temperature about 800 to 1000°C, lying over the burning layer as shown in the Fig. 1-1 :

$$CO_2 + C = 2CO - 38\ 000\ \text{Kcal/mol}, \quad (6)$$

where CO_2 gas is in contact with red-hot carbon.

Where CO gas is in contact with steam,

$$H_2O + CO = H_2 + CO_2 - 10\ 400\ \text{Kcal/mol}. \quad (7)$$

The gas generated after passing through the oxidizing and reducing layer presents a chemical composition which varies delicately depending on temperature conditions in the said phases, quality of charcoal, and other factors.

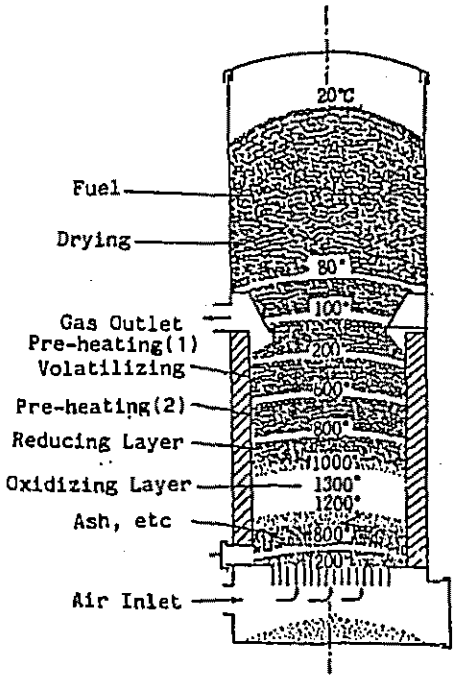


Fig. 1-1
Physical & chemical view

The generated gas is generally considered acceptable if it contains more than 30 % of CO, more than 10 % of H_2, and less than 60 % of other gases such as CO_2, O_2, CH_4 and N_2. In other words, the basic generator engineering technology dictates such furnace construction and furnace use as will always keep more than 40 % of CO, H_2, and other combustible gases in volumetric ratio in the generator output gas.

This model is made of an iron pipe of 35 cm in diameter and 3.2 mm in thickness according to the request from ATRDC, Sri Lanka, depending on their machine shop facilities. However, If such a facility of making iron tubes is not available in rural area, it is recommended to manufacture a square furnace made of rectangular steel sheets like the previous prototype dispalyed in ATRDC, Sri Lanka.

To tell the truth, the author had difficulty in designing the covers of the gas-fuel producer. Because the leakage of gas or air from this kind of gas generators brings poor performance. If the iron cover is square, it is easy to make but rather difficult to attain perfect gas-tightness because the square cover is not deformed uniformly when pressed at a certain point. After all, the author thought that a force acting at the center of a circular disk-cover distributes uniformly. This important know-how was applied to design the cover, and simple but sufficient sealing performance was obtained. This was applied not only to the furnace, but also to all sealing cover mechanisms including cleaners, cooler and joint pipes, and stable performance of the charcoal gas-fuel producer system was obtained.

D. The First Cleaner

The generated gas which just came out of the furnace is high in temperature and includes foreign matter such as fly ash. It is necessary to remove the foreign matter. Coke pieces of 2 to 3 cm^3 are used as a filtering bed of about 15 cm in thickness in this model. This is because coke is porous and excellent in cleaning ability. It is also effective in absorbing tar in high-temperature gas which is generated from charcoal of poor quality sometimes. If coke is difficult to be prepared, charcoal pieces are also available to be a cleaning element instead of cokes.

In the 1940's, not only coke or charcoal but also four to five layers of hemp cloths were used as a filtering medium of the gas generators. In the tropical zone, coir or the like may be useful as a filtering medium.

If the filtering medium is stuffed too tight in expectation of better cleaning performance, the filtering resistance might become too large and cause worse overall performance.

Easy maintenance of the cleaner is also very important. The top surface of the coke pieces can be checked easily by removing the top cover without any special tools. When the filtering medium is too dusty with foreign matter or tar in gas, coke pieces can be removed easily by removing the bottom cover and the net without any special tool also.

The vertical outlet pipe of the gas from the 1st cleaner can be also checked if necessary by removing top and bottom covers easily. The vertical outlet pipe has a valve which is used for checking the quality of gas generated in the previous stage of engine starting. The valve has to be perfectly closed after the checking of gas quality. If the valve is difficult to be prepared in manufacturing in rural area, a simple but perfect wooden plug can be available instead of the valve.

E. Cooling Cleaner

The gas from which large dust particles are removed in the 1st cleaner should be cooled down to normal temperature before being supplied to the engine, in order to increase the charging efficiency of the fuel gas into the engine.

The cooler can be made considerably small if its radiator pipe is made of a material of high thermal conductivity (usually non-ferrous metal) and has fins for wider heat transfer area. However, if the cooler is of a simple structure of steel pipes or steel sheets, it has to be inevitably larger. The model introduced here was designed to use ordinary water pipes of non-galvanized iron (SGP-black) or the similar iron pipes (STK). The galvanized SGPs are also applicable with a little difficulty in welding charactor.

As water becomes condensed from the cooled gas, the cooler is required to have a sump together with a drain mechanism at the bottom of the cooler for complete draining of condensed water if needed. As for this model, it can be done by removing the bottom cover without using any special tool. Antirust painting is perfectly applied to all the inside surface of the cooling cleaner for the sake of existing condensed water.

The cleaner at the top place of the cooling cleaner is the second and final cleaner for the gas. The filter element is recommended to be made of glass wool of about 7 cm in thickness. It is important that the element has to be held by the cleaner body because it is light and liable to be sucked into the outlet pipe of the cleaner to the engine. A net-coverplate has to be placed on the top surface of the element. If glass wool is difficult to be obtained in rural area, four or five layers of hemp cloths or coir is also useful as a filtering medium.

In addition to some technical know-hows, the element and the cleaner should be designed in order that easy inspection and replacement of the element can be secured and the cross-section area of the cleaner may be large enough to prevent excessive filtering resistance. Although oil-bath type air cleaners have become popular recently in the society, it should be kept in mind that this type is not suitable for these kinds of gas-fuel producers, as the oil volume increases with condensed water from gas, resulting in engine stopping.

F. Mixer

The generated and filtered gas has to be mixed with air at a volumetric ratio of 5 (gas) to 3 (air), and mixture is taken into the engine. As a rule, the engine performance is not so sensitive to the mixing ratio. Therefore, the mixing ratio should be determined in order that the engine can run at the fastest speed powerfully and smoothly. It is normal to be found about half opening of the air valve in the case of no air leaking trouble of the gas-fuel producer.

A research report in Germany said that there were no significant differences in engine output between various types of mixers. The author had also the same result in his experience. However, it is no wonder that the design of the mixer, particularly of its pipe leading to the engine, is required to fit the shape of engine inlet pipe structure of air or mixture. These structures are not shown in the shop manual. The auther expect the reader to make one on his own idea after good observation on our dispay model. Important technical know-hows of the mixer are as follows :

a) Weight

The mixer has to be installed instead of the air cleaner of the engine or directly to the engine without a carburator. If the mixer is heavier than the original air cleaner or a carburator with an air cleaner, excessive stress might happen and cause some trouble on it and the engine, because of its over hanging structure from the engine with vibration.

b) The overall length of air inlet pipe

The gas passing through the mixture intake system of the engine is always subjected to violent pulsation. If air inlet pipe is too short, the gas tends to be pushed out from the air inlet pipe with mixed air, because of pulsating motion, resulting in bigger fuel consumption.

If the air inlet pipe is too long, in other word, the distance from air inlet valve to the sparking point of the engine plug is too long, engine start may become very poor, because the mixture can not arrive to the sparking point within engine idling rotation by mannual rope starting operation.

In general, an air inlet pipe of 60 to 70 mm, or about 100 mm of overall length of the mixer was found to be practical good for 3 to 4 horsepower engine. Then engine can start easily.

G. Engine

The gasoline engine for agricultural or industrial use has a governor relating to the carburetor, though the one for automobile use has none. This means that the carburetor should not be dismantled, if loading condition is all the time variable. When a uniform load is expected like a water pump, the carburetor with a governor mechanism can be removed from the engine.

Generally speaking, engine horsepower based on charcoal gas is about 50 to 60 % of that based on gasoline. Attention has to be paid to engine adjustment to maximize the engine power. It is known that the flame velocity of CO gas mixture is slower than that of gasoline. Accordingly, engine adjustment in order to increase the engine output is as follows:

a) Advancing the ignition timing

The ignition timing varies depending upon the type of engines, and it is difficult to state the best recommended timing like so and so degrees ahead of the upper dead center. The author's experience shows that in the case of a gasoline engine, an advancement of ignition timing by 10° to 15 ° led to an increase of output by a little more than 10 %.

b) Increasing the compression ratio

It is difficult for an ordinary farmer to change the compression ratio of an engine. Even if a farmer has a lathe and can turn the cylinder head he will not be able to make it without measuring technique of the compression ratio precisely.

(According to the tests a compression ratio change from 6 to 6.5 increased the output by a little less than 5 %, but the change from 6 to 7 increased only 3 %.)

Engine horsepower with reasonable adjustment mentioned above and additional technology (refer to "b" in H) may become 60 to 70 % of that based on gasoline.

H. Other Technical Know-Hows

a) Air leak problem

The whole device must not have any gas or air leaking phenomenon. Air leaking-in produces poor gas and causes poor operation. When the producer set finished to be made, smoky materials such as newspaper, cloth or wood-chip could be burned in the furnace, and give breath pressure through any inlet hole to the whole inside space of the device. Then, a pin hole or clearance would show smoke leakage. Any pin-hole or clearance of the device has to be found and rewelded or repaired.

b) Dry gas and wet gas

Charcoal gas which is generated without adding water is called dry gas. On the other hand, the charcoal gas generated by injecting water into the generator to develop hydrogen gas (H_2) is called wet gas. The model in the drawings herein is a dry gas model. It is observed that, addition of water from a water tank into the air inlet for the grate at a rate of one to three droplets a second, increased the engine speed by 5 to 10 %, and also increased the output by 5 to 10 %. According to the past reports, it was said that many charcoal gas generators manufactured at the end of The World War II were equipped with a water drip-feed device. It was common that the drip rate was adjustable for a driver observing the conditions of engine and furnace. In those days, the standard drip rate was one to two drops a second.

In order to generate hydrogen gas (H_2) by decomposing water, energy is required as shown in the foregoing formulas (4) and (5). In other words, adding water to the generator reduces the burning temperature of charcoal. This means that the water drip rate should be determined in a manner that will not reduce the temperature of oxidizing phase (burning layer) in the furnace below the degree necessary for the generation of CO gas (1,000 °C to 1,300 °C).

The author found that the acceptable drip rate was 2 to 3 drops a second for the hard charcoal (e.g. for rotisserie) which is easy to rise temperature and also to keep it high. For soft charcoal, however, which is not easy to rise temperature, the rate was 1 to 2 drops a second. As explained above, generation of hydrogen gas from water by making use of heat of burning charcoal increase not only the flame velocity in the engine, but the energy efficiency. It is advised to try a water drip-feed system to meet individual engine, charcoal gas generator and charcoal available.

c) Start

The model has a big hole for removing ash at the bottom of the furnace. Bottom space has also a welded air inlet pipe which feeds air into the furnace even when the big hole is closed. If a quick start is needed, a manual fan at the outer end of the air inlet pipe has to be operated strongly. Then, the engine will be able to start after about 15 minutes' blowing. The fan has such a function as nothing wrong will happen concerning air intake through the air inlet pipe even after the fan stops running.

d) Calorific value of charcoal and fuel cost

Charcoal is generally classified into soft and hard types. Its quality varies widely depending on the kinds of wood from which the charcoal is made. In general, charcoal has a calorific value of 6,500 to 8,000 kcal/kg, while gasoline has a calorific value of about 10,500 kcal/kg.

The specific charcoal consumption G (i.e., consumption of charcoal kg/h/PS) is dependent largely on the quality of furnace and matches with an engine used. Specific charcoal consumption G, was in the range from 0.6 to 1.1 kg. It could be said that the special charcoal consumption coresponding to 1 liter of gasoline will be about 1.5 to 2 kg of charcoal on the average. The model is capable of running an engine of 3 PS in nominal rating for at least 3 hours.

e) Mortar

In case a charcoal gas generator is manufactured in a hurry, fuel burning temperature is liable to become lowered as its mortar is not dried and baked well. It is, therefore, recommended to dry up the mortar for more than 48 hours or one week if possible. After one day's drying, hit and press the mortar to fill cracks. Repeat it for two to three days. When the mortar is well hardened, put new soft mortar into cracks and make smooth surface. When all mortar is dried up, fill charcoal into the generator, and then carry out baking process thoroughly. The trial run should be done after such perfect preparation.

f) Clinker trouble on mortar

The clinker is glass like deposits on the hottest portion of the mortar. Clinker depositing is occasional. When clinker deposit is recognized in inspection anytime, it is advisable to remove it.

I. Machine Shop Facilities and Production Cost

The devices and tools necessary for the manufacturing of the models introduced here are a set of gas welding and cutting tool, drilling machine or hand drill, blacksmith tools, and threading tools and jigs. If there is a lathe available for machining a packing seat, the work will become easier. Without a lathe, the packing seat can be shaped by grinding.

If a rolling machine to make a iron tube is not available, please make a furnace of four rectangular plates as shown in ATRDC display.

As shown in the parts list, the materials required are mostly standard SS steel (in JIS). Bolts, nuts, and steel pipes are available easily in the market.

There are a few items which may be a little bit difficult to get. They include flexible pipes, mortar and asbestos gaskets. The materials necessary for one set of charcoal gas generator costed about $100 in 1985 in Japan.

It took about a month for two undergraduate students who have no experience in welding and spared 2 hours on the average every weekday to make a gas producer set. The author helped them a little for educational purpose in welding important parts. Another case was a team of 2 experts welding workers and about 12 unskilled students, led by the author. The team worked 8 hours a day according to a program, and could complete all welding a gas generator within 3 days. In the fourth day, after two days drying the mortar, the trial driving was ready. In the case of two part-time students engaged in manufacturing a charcoal gas generator, they worked 8 hours a day at a well-equipped shop. They completed it in a week.

In any case referred to above, all necessary preparations for materials and tooling were made in advance according to the drawings and parts lists. The materials cost plus labor cost actually required makes the production cost.

II. OPERATION INSTRUCTIONS

When everything is ready for starting an engine, the first thing to do is to put charcoal into the furnace. If a quick way of making a fire is needed, it may be recommendable to put a little amount of used or soft charcoal under the charcoal.

For a stationary charcoal gas generator of small horsepower less than 10 PS, the recommended average size of charcoal pieces was reported to be about 3 cm cubic according to many Japanese research papers, although much bigger size of it was recommended in some European papers. This may be for bigger horsepower driving devices.

In Southeast Asia, charcoal is generally made from natural wood, and normal kinds of charcoal available on the market can be used for the charcoal gas generator.

However, there is not applicable charcoal which is made from coconut shell and is used as activated carbon material. As this is too hard, it is slow in burning, which means slowness in producing gas and results in weak engine power, unless special engineering ideas are added.

The charcoal available at supermarkets in developed countries sometimes refers to briquette for barbecue, not to natural charcoal. The briquette is press-formed from charcoal powder with additives. The briquette generates tar-laden gas, which tends to cause valve stick, and produces plenty of ashes. Some briquettes made from chaffs are not easy to be broken into free ash. Therefore, these are not suitable for the charcoal gas generator. To sum up, except special charcoal of slow burning, all the charcoals are acceptable if they are proper in size and hardness.

After charging charcoal, open the top cover and the first valve, and close the second valve. Ignite the charcoal from below the grate. Close the grate cover. If an air blower is operated, the generator will start to produce combustible gas within about 15 to 20 min. This can be checked as follows:

Open the top cover of the furnace, and ignite the gas from the top. If the gas is good, it will burn very well. If not, repeat blowing. When the gas can burn well, close the top cover, and continue to operate the blower in the meantime. Ignite the gas from the first valve outlet. When good burning gas is recognized, close the first valve, and open the second valve.

Continue to operate the blower. Then, the combustible gas is delivered to the engine and flows out from the air inlet pipe of the mixer. When the producer gas of white colour from the air inlet pipe of the mixer is recognized, stop to blow and proceed to engine start. With the mixer air inlet about half open and the throttle valve fully open, run the starter. The engine will make a good start.

When the engine started, adjust the air inlet valve to a position where the engine runs best.

In about 30 minutes after engine starting, the entire generator will attain a thermal equilibrium state. (If the charcoal gas generator is equipped with a water drip-feed device to produce wet gas, adjust the water feed to a rate of 1 to 2 drops a second while taking care not to reduce the furnace temperature.) If an engine gets started at the time when the generator is almost full of charcoal, it may run in the best condition for 1 hour after the start.

It is important that the charcoal pieces should move down in the furnace depending on burning process at the bottom space of the furnace. However, it happens that the charcoal pieces cannot move down because of bridging phenomena hooked by side walls. Vacant space in the furnace will become the most critical reason to produce poor gas.

When engine running becomes irregular, vibrate the whole device or don't hesitate to open the cover of the furnace, and put and shake a stick into the chacoal. The engine can be started again.

When the charcoal left in the furnace becomes small in amount and the top layer of it becomes red, it is the time when charcoal should be recharged.

In order to stop the operation, fully open or close the air inlet valve of the mixer.

When the operator carelessly opens the generator cover during engine running or immediately after engine stopping, the combustible gas will make an explosive gas with air, and may burst into flame to burn his hair.

It is generally said that the charcoal gas producer should be inspected carefully and cleaned once every week if it is run everyday. It is recommended to inspect and clean it every day, especially for clinker and water deposit.

Literatures cited

1. Jerome Ames: "How to run your car on coal and charcoal", Detroit, Michigan, 1974, P. 34

2. H. Lutz: "Die Verbesserung des Farrzeug Holzgaserzeugers durch Warmetechnische Massnahmen", ATZ. Jg. 43, H. 23 10/XIT, 1940

3. Takeda, S., Sakai, J.: "Research on gas engine driving by agricultural waste", The Bulletin of the Faculty of Agriculture, Mie Univ., No. 53, pp. 187-203, 1977

4. Nagano, Fujio: "Lecture Notes on Internal Combusion Engines", pp. 723-724, Yokendo Publishing Co., Ltd., 1957

5. Miura, Ihachiro: "A Study on Firewood and Charcoal", p. 621, Kyoritsu Publishing Co., Ltd., 1943

6. Sakai, J., Shibata, Y.: "Alternative Gas-fuel Producer for Driving Gasoline Engines (part 1)", pp. 51-61, AMA, Shin-norinsha Co., Ltd., 1982

++

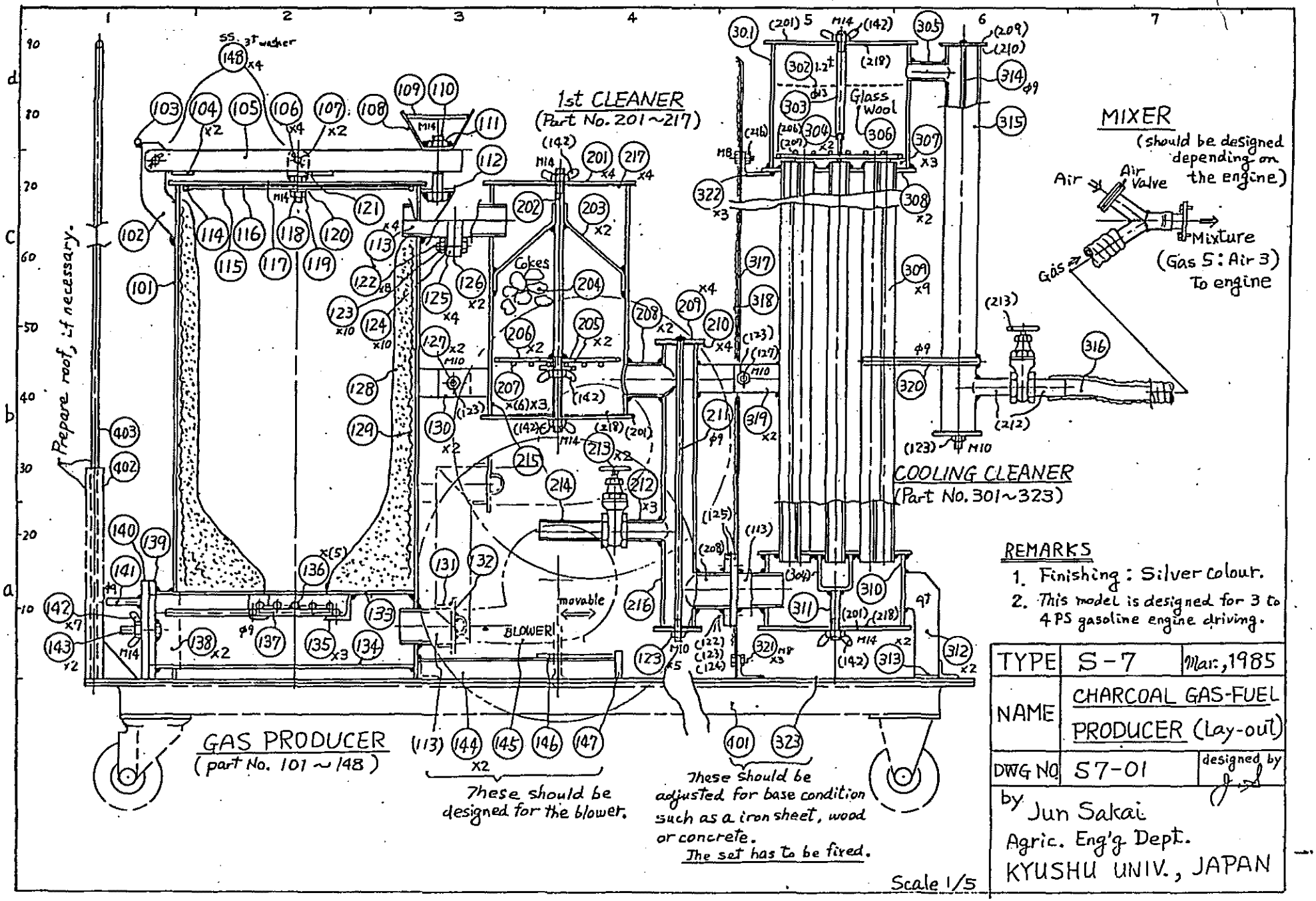
DRAWINGS

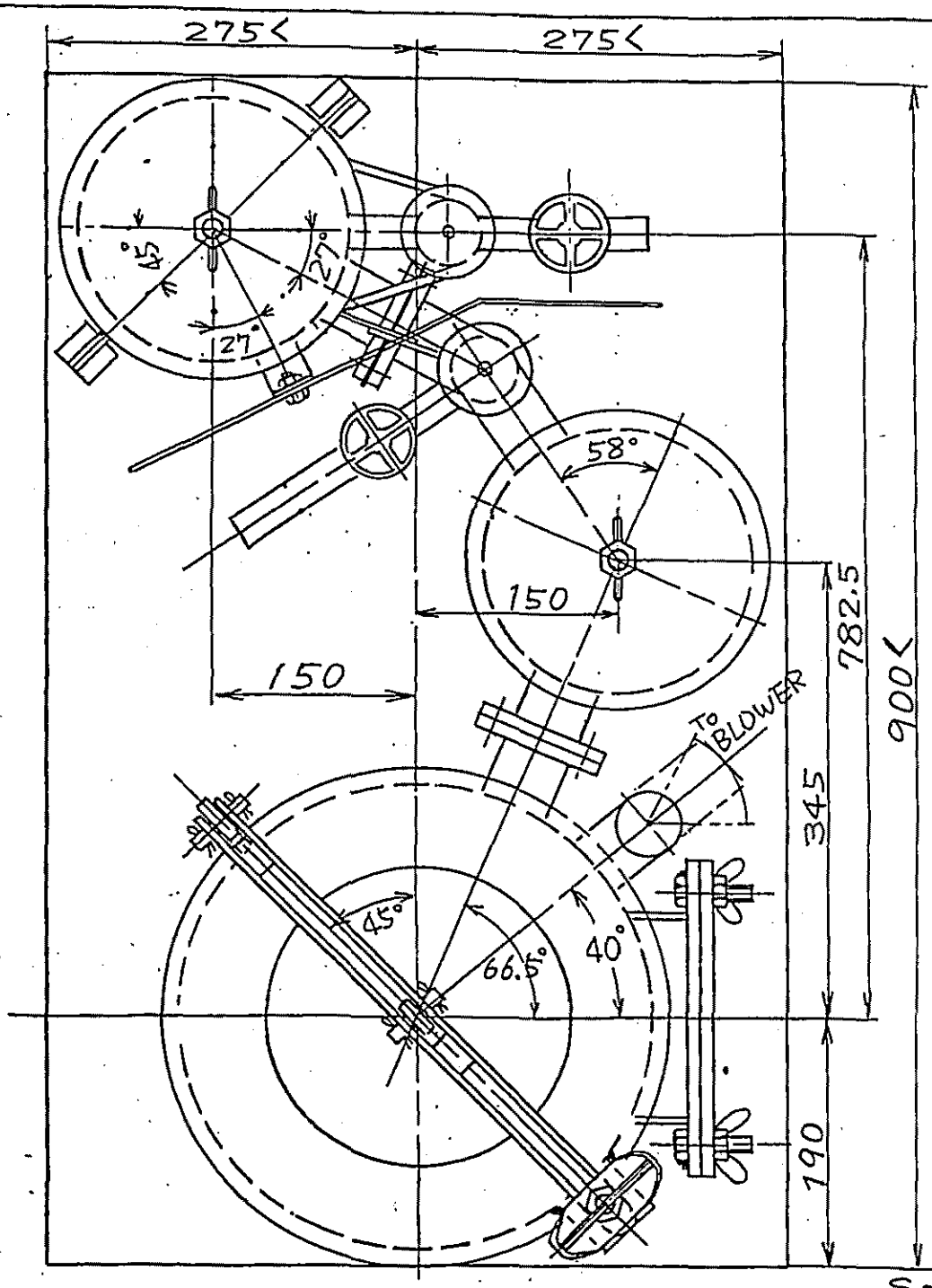
CHARCOAL GAS-FUEL PRODUCER, TYPE S-7

for driving 3 to 4 PS gasoline engines

++

(CONTENTS)


1st CLEANER
(Part No. 201~217)
COOLING CLEANER
(Part No. 301~323)
MIXER
(should be designed depending on the engine)
Air
Air Valve
Gas
Mixture
(Gas 5 : Air 3)
To engine
Glass Wool
Cokes
Prepare roof, if necessary.
BLOWER
movable
GAS PRODUCER
(part No. 101 ~ 148)
These should be designed for the blower.
These should be adjusted for base condition such as a iron sheet, wood or concrete.
The set has to be fired.
REMARKS
1. Finishing : Silver colour.
2. This model is designed for 3 to 4 PS gasoline engine driving.
TYPE S-7 Mar., 1985
NAME CHARCOAL GAS-FUEL PRODUCER (Lay-out)
DWG NO S7-01
designed by
by Jun Sakai
Agric. Eng'g Dept.
KYUSHU UNIV., JAPAN
Scale 1/5



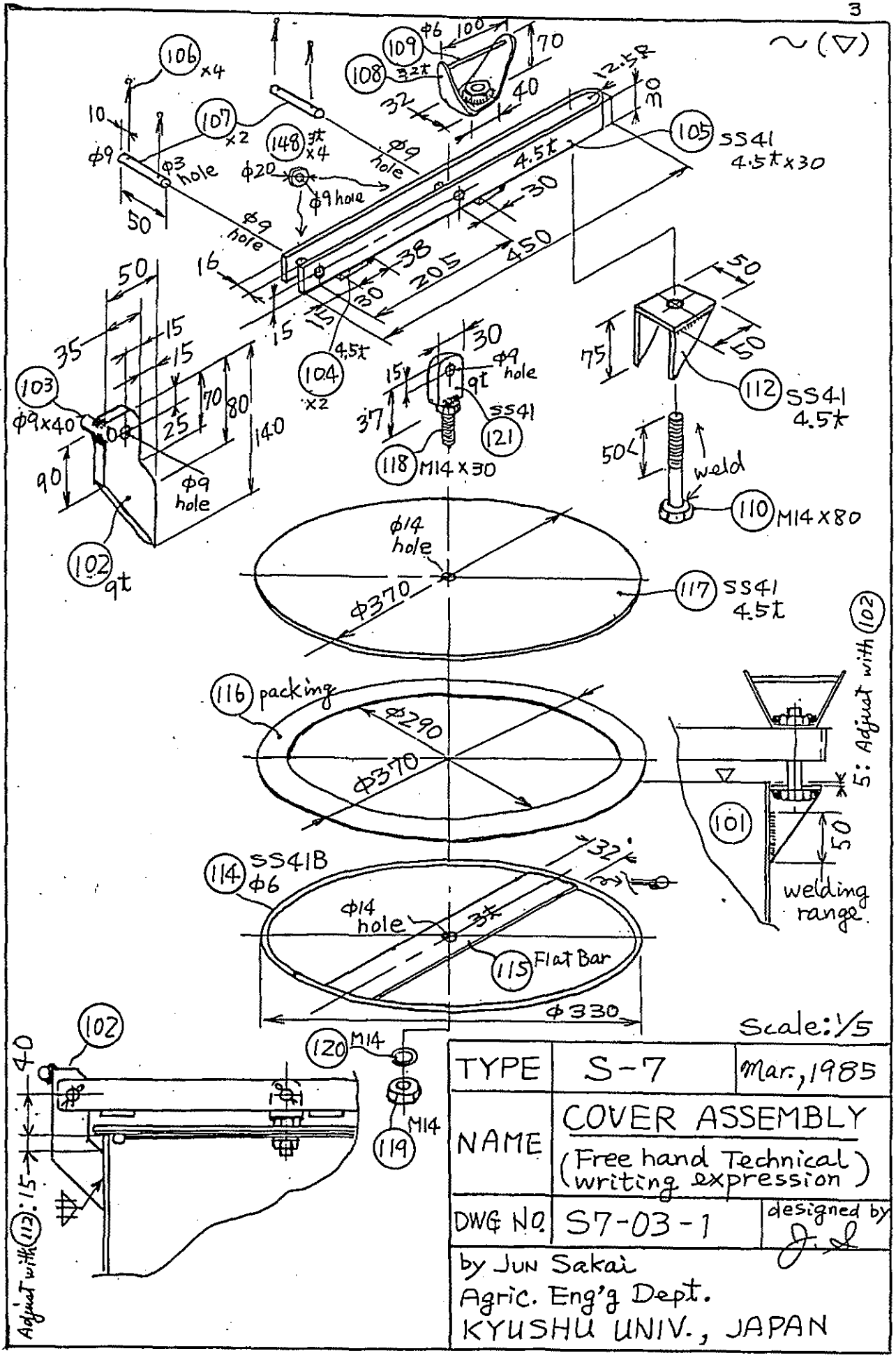
Scale: 1/5

TYPE	S-7	Mar., 1985
NAME	CHARCOAL GAS-FUEL PRODUCER (Lay-out)	
DWG NO.	S7-02	designed by J. S

by Jun Sakai
Agric. Eng'g Dept.
KYUSHU UNIV., JAPAN

Notice 1. Put on a carrier.

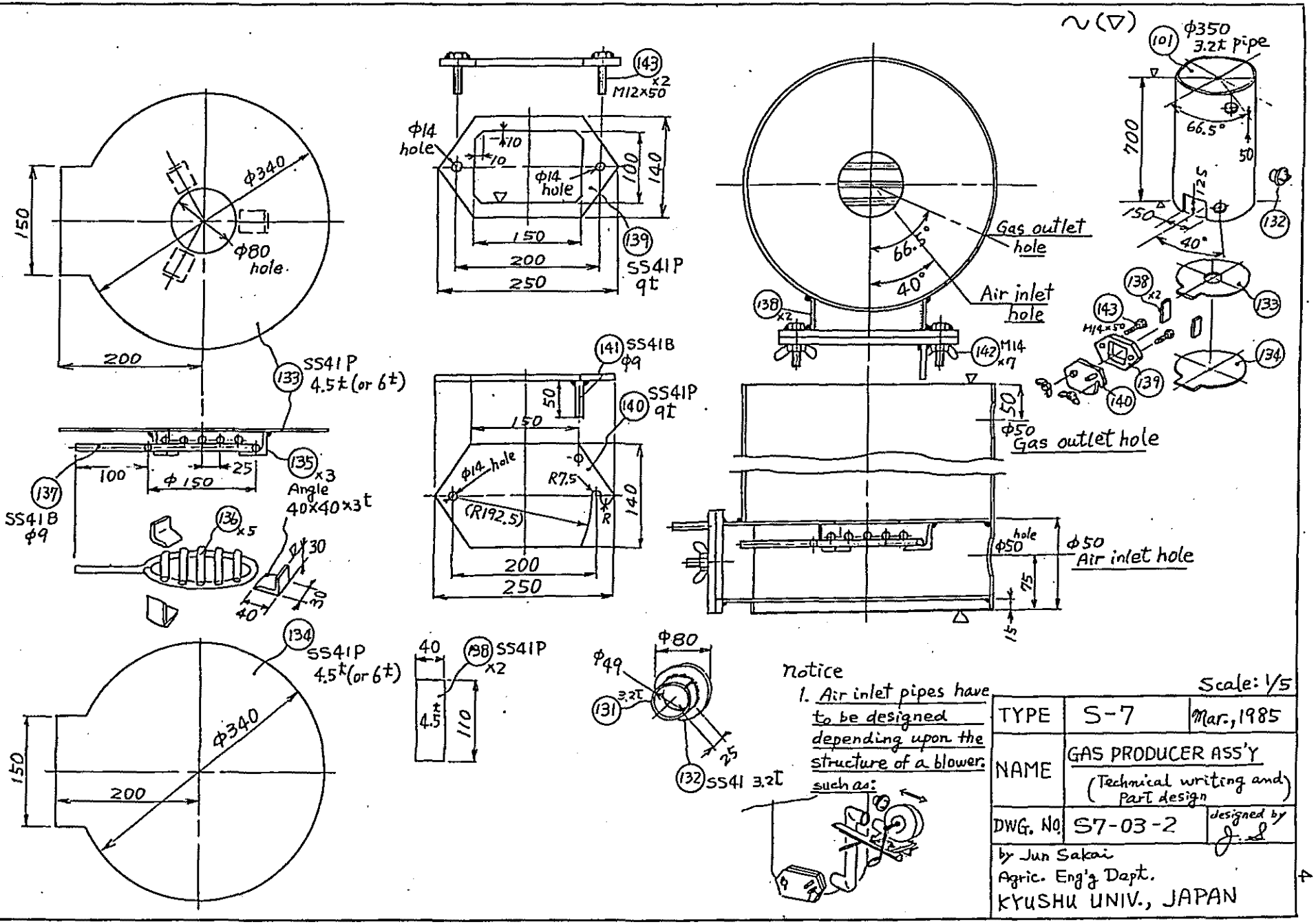
2. Blower direction should be adjusted depending upon blower structure.

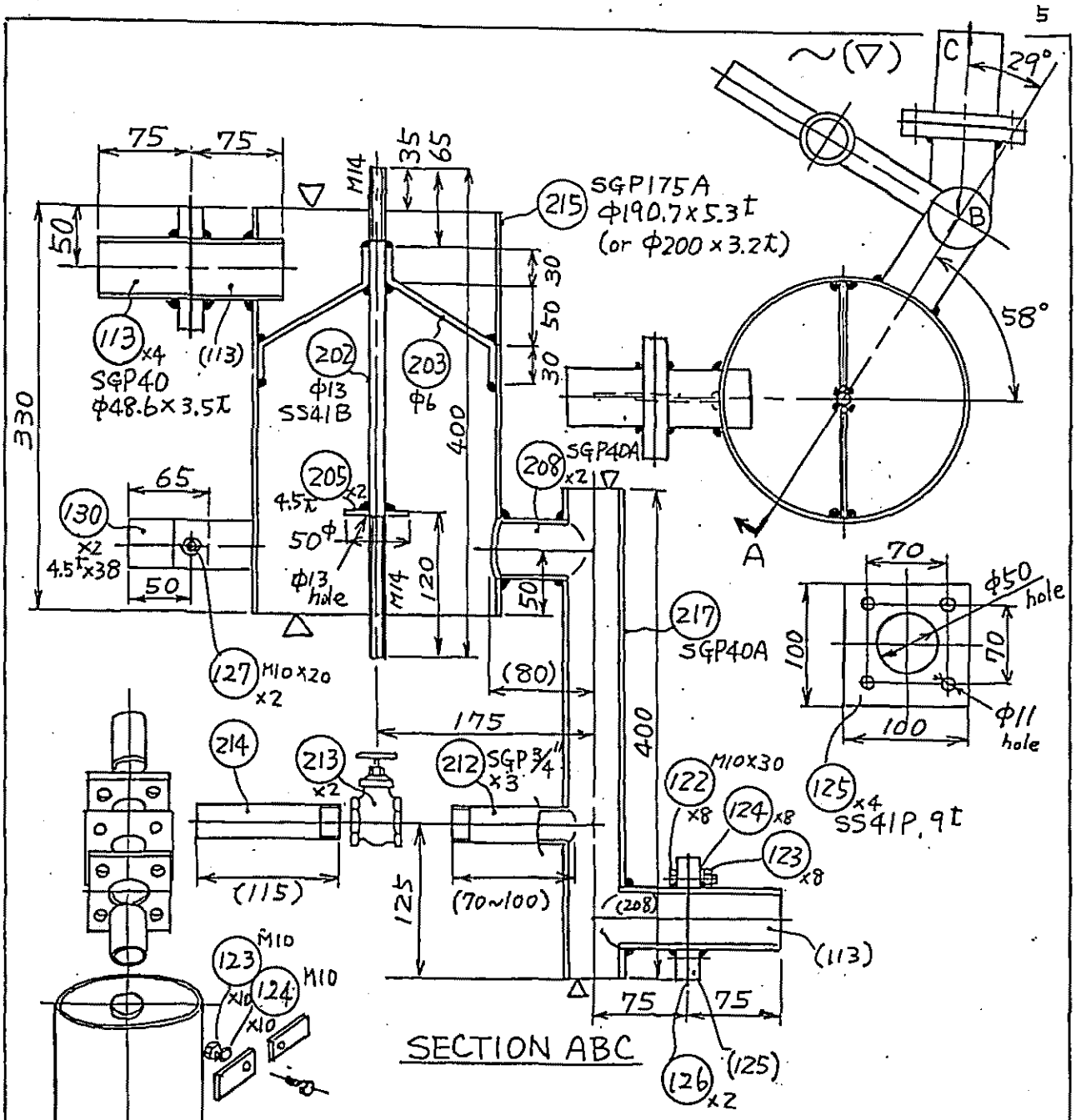


Scale: 1/5

TYPE	S-7	Mar., 1985
NAME	COVER ASSEMBLY (Free hand Technical writing expression)	
DWG NO.	S7-03-1	designed by J. S

by Jun Sakai
Agric. Eng'g Dept.
KYUSHU UNIV., JAPAN


~(▽)
φ350
3.2t pipe
700
66.5°
50
125
150
40°
Gas outlet hole
Air inlet hole
φ50
Gas outlet hole
φ50 hole
φ50
Air inlet hole
75
15
φ340
150
200
φ80 hole
SS41P
4.5t (or 6t)
φ14 hole
10
10
100
140
150
200
250
SS41P
9t
M12×50
SS41B
φ9
SS41P
9t
50
150
φ14 hole
R7.5
(R192.5)
R
140
200
250
100
25
φ150
Angle
40×40×3t
30
40
30
40
4.5t
110
φ80
φ49
3.2t
25
SS41 3.2t
Notice
1. Air inlet pipes have to be designed depending upon the structure of a blower such as:
Scale: 1/5
TYPE
S-7
Mar., 1985
NAME
GAS PRODUCER ASS'Y
(Technical writing and Part design)
DWG. NO.
S7-03-2
designed by
by Jun Sakai
Agric. Eng'g Dept.
KYUSHU UNIV., JAPAN



Notice

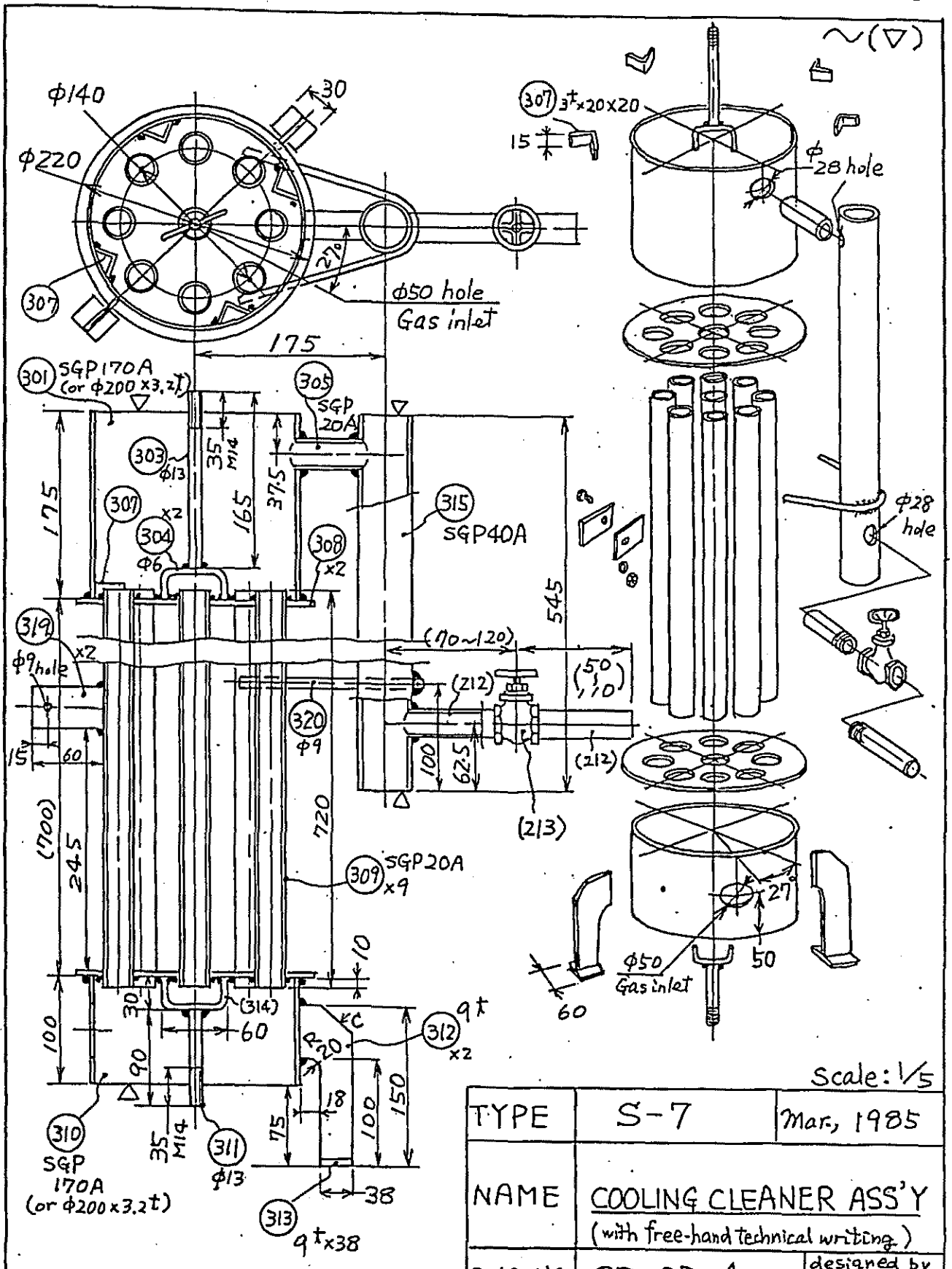
1. Welding (113) to (101) and (310), and (127) to (101) should be done in last completing.

Scale: 1/5

TYPE	S-7	Mar., 1985
NAME	FIRST CLEANER ASS'Y (with free-hand technical writing)	
DWG. NO.	S7-03-3	designed by J. S.

by JUN Sakai
Agric. Eng'g Dept.
KYUSHU UNIV., JAPAN

2. Lacqure finishing is applied to inside surface also.



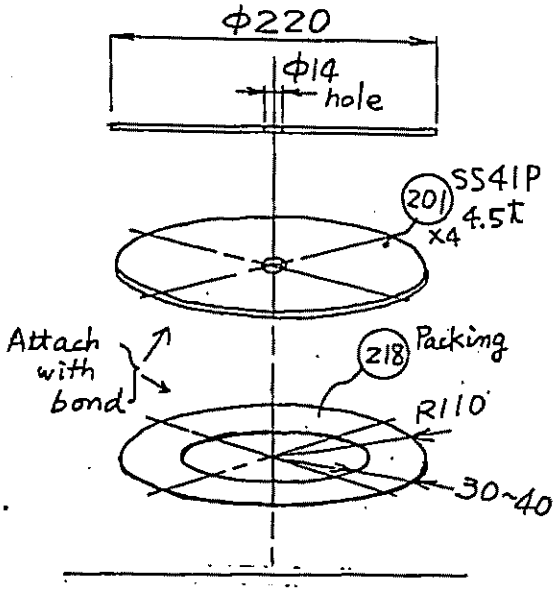
Scale: 1/5

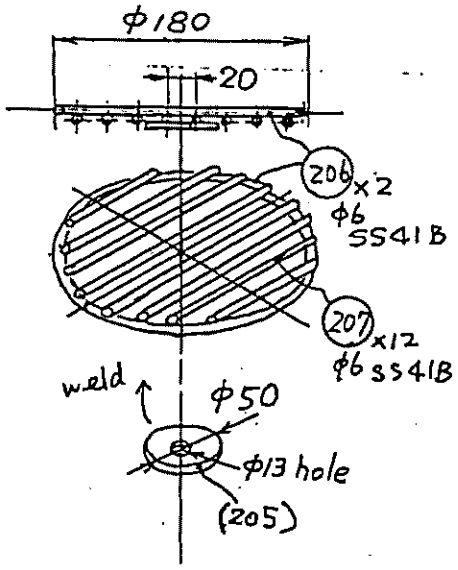
TYPE	S-7	Mar., 1985
NAME	COOLING CLEANER ASS'Y (with free-hand technical writing)	
DWG NO.	S7-03-4	designed by J. S

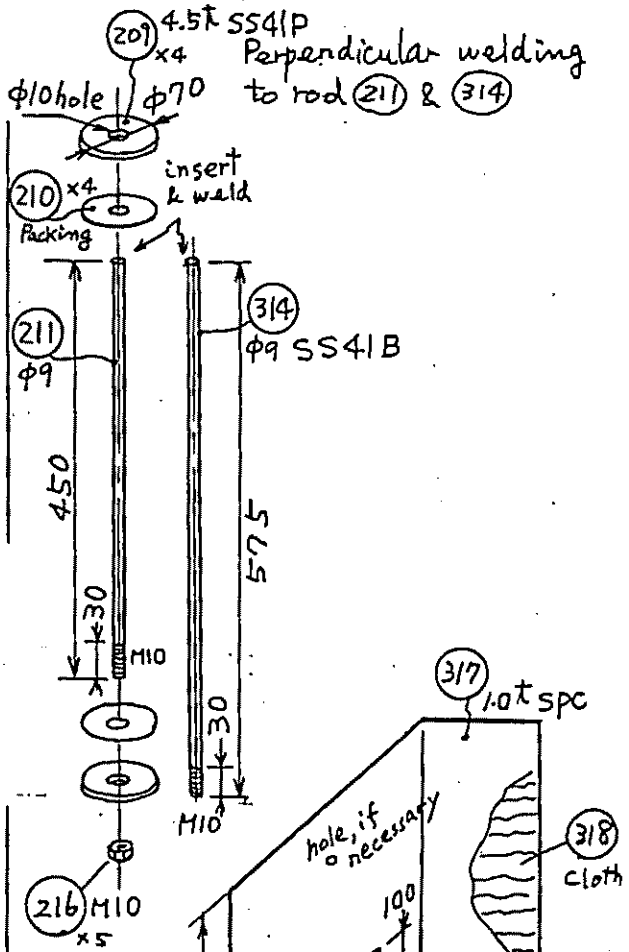
by Jun Sakai
Agric. Eng'g Dept.
KYUSHU UNIV., JAPAN

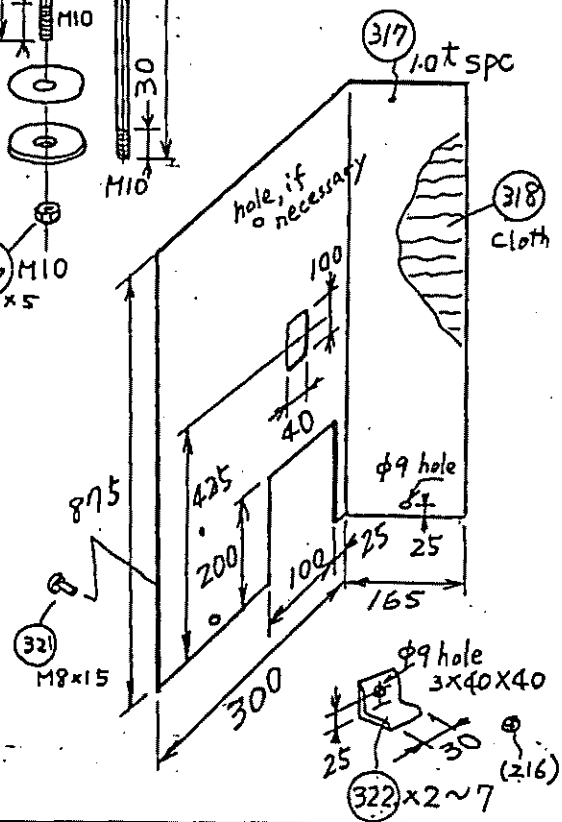
Notice

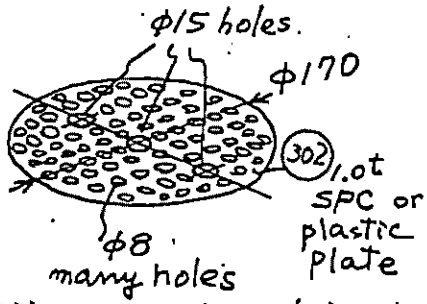
1. Lacquer finishing is applied to inside surface also.



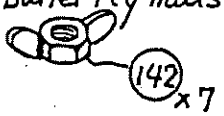








⑨ { If (142) can not be obtained, make 7 butterfly nuts of M14.

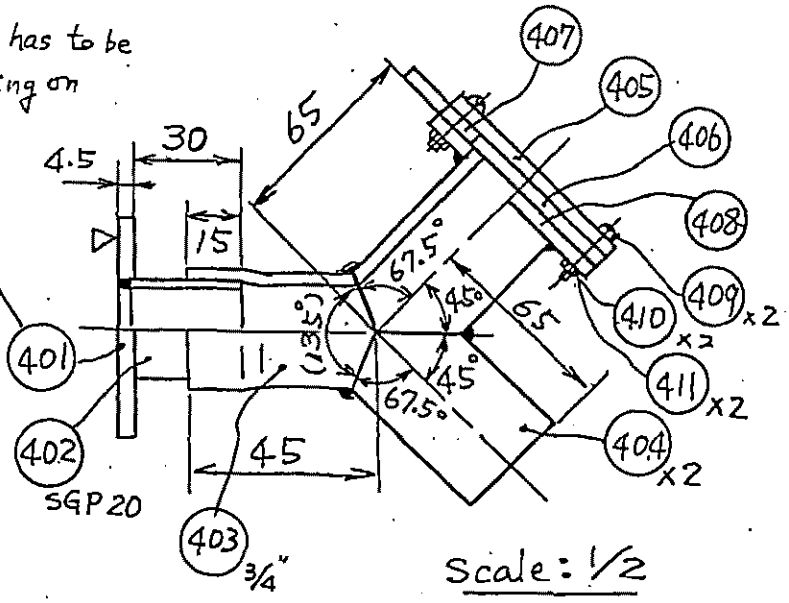


TYPE	S-7	Mar., 1985
NAME	PARTS	
DWG NO.	S7-03-5	designed by

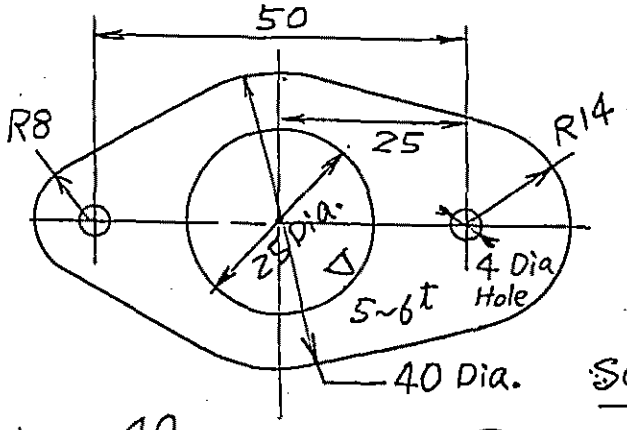
by Jun Sakai
Agric. Eng'g Dept.
KYUSHU UNIV., JAPAN

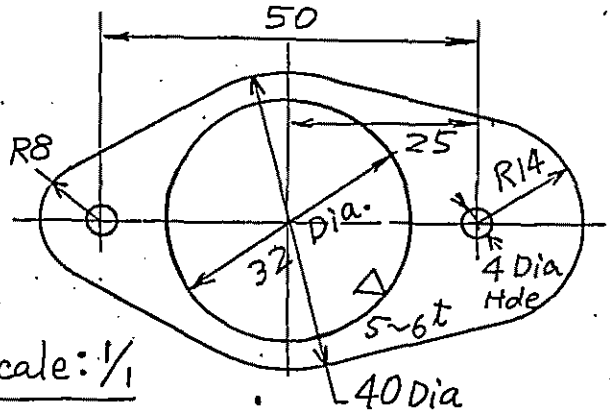
~(▽)

The shape of (401) has to be decided depending on each engine.

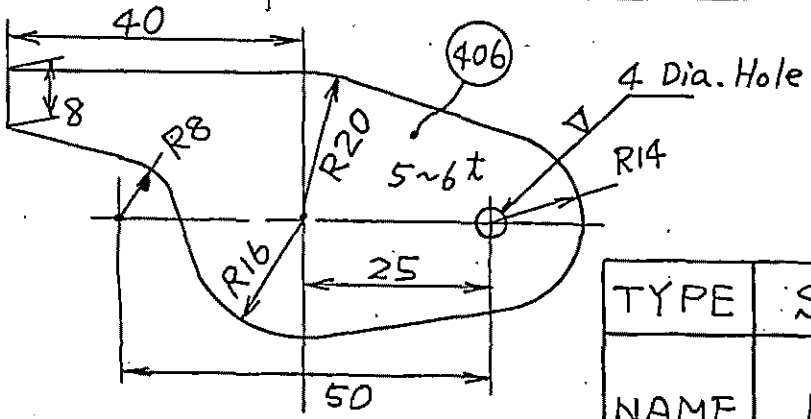


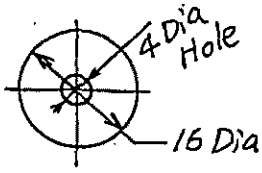
Scale: 1/2





Scale: 1/1





TYPE	S-7	Mar., 1985
NAME	MIXER	
DWG. No.	S7-03-6	designed by J. S.

by Jun Sakai
Agric. Eng'g Dept.
KYUSHU UNIV., JAPAN

PARTS' LIST

AND

RAW MATERIALS / SET

CHARCOAL GAS-FUEL PRODUCER, TYPE S-7

CONTENTS

I. GAS PRODUCER

Part No.	Part Name	QTY/Unit	Material & Remarks
101	Producer Pipe	1	SS41, 350 Dia. x 700 x 4.5t (or 3.2t)
102	Cover Support	1	SS41P, 9t
103	Stop Bar	1	SS41B, 9 Dia.
104	Connecting Plate	2	SS41, Flat Bar, 4.5t x 38
105	Cover Arm	1	SS41, Flat Bar, 4.5t x 38
106	Split Pin	4	for 9 Dia. Bar
107	Arm Pin	2	SS41B, 9 Dia.
108	Nut Wing	1	SS41, Flat Bar, 3t x 32
109	Bar	1	SS41B, 6t
110	Bolt, A	1	M14 x 80
111	Nut, A	1	M14
112	Nut Support	1	SS41P, 4.5t
114	Ring, A	1	SS41B, 6 Dia.
115	Push Plate	1	SS41, Flat Bar, 3t x 32
116	Packing, A	1	Asbesto Packing
117	Cover, A	1	SS41P, 4.5t
118	Bolt,B	1	M14 x 30, welded to (121).
119	Nut, B	1	M14
120	Spring Washer, B	1	M14
121	Cover Hanger	1	SS41P, 9t
128	Mortar	_	made of Unti-heat Cement & Sand
129	Iron Net	_	as Anchors for Mortar
131	Cap Ring	1	SS41, Flat Bar, 3t x 32
132	Cap	1	SS41P, 4.5t
133	Base Plate	1	SS41P, 4.5t
134	Bottom Plate	1	SS41P, 4.5t
135	Grate Guide	3	SS41, L-Angle Bar, 3t x 40 x 40
136	Grate Bar	5	SS41B, 9 Dia.
137	Grate Frame	1	SS41B, 9 Dia.
138	Side Plate	2	SS41P, 4.5t
139	Grate Gate	1	SS41P, 9t
140	Grate Cover	1	SS41P, 9t

141	Cover Handle	1	SS41B, 9 Dia.
142	Butterfly Nut	2	M14. Five for II & III.
143	Bolt, E	2	M14 x 50
144	Blower Slide	2	SS41, L-Angle Bar, 3t x 40 x 40, should be designed for the blower.
145	Blower	1	Find in local market.
146	Blower Base	1	SS41P, should be designed for the blower.
147	Stopper	1	SS41B, 9 Dia.
148	Spacer	4	SS41, 3t

113	Pipe, A	2	from II.
122	Bolt, C	4	from II.
123	Nut, C	5	from II.
124	Spring Washer, C	5	from II.
125	Flange	1	from II.
126	Packing, B	1	from II.
127	Bolt, D	1	from II.
130	Support Plate, A	1	from II.

A Blower Set and Installing Frange has to be made depending on local blower and engine structures.

Remarks:

The part numbers below "-------" show that the parts are manufactured or prepared by other assembling groups and obtained from them in manufacturing process.

II. FIRST CLEANER

Part No.	Part Name	QTY/Unit	Material & Remarks
201	Cover, B	2	SS41P, 4.5t. Two for III.
202	Center Rod, A	1	SS41B, 13 Dia.
203	Rod Support	2	SS41B, 6 Dia.
204	Elements, A	3.5[l]	Cokes or Charcoal , 2 to 3 cm^2/piece
205	Net Stopper	1	SS41P, 4.5t
206	Net Frame	1	SS41B, 6 Dia.. One for III.
207	Net Bar	6	SS41B, 6 Dia.. Six for III.
208	Pipe, B	2	SGP 40A, Black, 48.6 Dia. x 3.5t
209	Pipe Cover	2	SS41P, 4.5t. Two for III.
210	Packing, B	2	Two for III.
211	Tension Rod, A	1	SS41B, 9 Dia.
212	Nipple, Long	1	SGP 3/4". Two for III.
213	Valve	1	for SGP 3/4". One for III.
214	Outlet, A	1	SGP 3/4", White
215	Cleaner Pipe	1	SGP 175A, Black, 190.7 Dia. x 325 x 5.3t (or 200 Dia. x 325 x 3.2t)
216	Pipe, C	1	SGP 40A, Black, 48.6 Dia. x 3.5t
217	Packing, C	2	Attach to B-Cover with Bond. Two for III.
113	Pipe, A	4	SGP 40A, Black. Two for I & III.
125	Flange	2	SS41P, 9t. Two for I & III.
122	Bolt, C	4	M10 x 30. Four for I.
123	Nut, C	5	M10. Seven for I and III.
124	Spring Washer, C	4	M10. Five for I.
127	Bolt, D	1	M10 x 20. One for I.
130	Support Plate, A	1	SS41 Flat Bar 4.5t x 38. One for I.
---	---	---	---
319	Support Plate, B	1	from III.
142	Butterfly Nut	3	from I.

III. COOLING CLEANER

Part No.	Part Name	QTY/Unit	Material & Remarks
301	Strainer Pipe	1	SGP 175A, Black, 190.7 Dia. x 175 x 5.3t (or 200 Dia. x 175 x 3.2t)
302	Net	1	SPC, 1t, or Plastic Plate
303	Center Rod, B	1	SS41B, 13 Dia.
304	Leg	2	SS41B, 6t
305	Pipe, D	1	SGP 20A, Black, 27.2 Dia x 2.8t
306	Elements, B	2.3[1]	Glass Wool or Coconut-husk
307	Spacer	3	L-Angle Bar, 3t x 40 x 40
308	Cooler Plate	2	SS41P, 4.5t
309	Cooler Pipe	9	SGP 20A, Black, 27.2 Dia. x 2.8t
310	Tank Pipe	1	SGP 175A, Black, 190.7 Dia. x 100 x 5.3t (or 200 Dia. x 100 x 3.2t)
311	Center Rod, C	1	SS41B, 13 Dia.
312	Leg Plate	2	SS41P, 9t
313	Foot Plate	2	SS41, Flat Bar, 9t
314	Tension Rod, B	1	SS41B, 9 Dia.
315	Pipe, E	1	SGP 40A, Black, 48.6 Dia. x 3.5t
316	Flexible Pipe	1	Plastic Pipe, 27 Inner Dia., 1 m
317	Insulater, A	1	SPC, 1t, or Wooden Plate
318	Insulater, B	1	(Asbesto) Cloth for SPC.
319	Support Plate, B	1	SS41, Flat Bar, 4.5t x 38, One for II.
320	Support Rod	1	SS41B, 9 Dia.
321	Bolt, F	3	M8 x 15
322	Supporter	3	L-ANGLE BAR, 3t x 40 x 40

113	Pipe, A	1	from II.
123	Nut, C	2	from II.
124	Spring Washer, C	1	from II.
125	Flange	1	from II.
142	Butterfly Nut	2	from I.
201	Cover, B	2	from II.

206	Net Frame	1	from II.
207	Net Bar	6	from II.
217	Packing, C	2	from II.
209	Pipe Cover	2	from II.
210	Packing, B	2	from II.
212	Nipple, Long	2	from II.
213	Valve	1	from II.

IV. MIXER

The Mixer has to be designed and manufactured depending upon the individual engine. This list shows conceptional parts and their necessary quantities and materials for making a mixer to the engine of about 3 to 4 horsepower.

401	Mixer Flange	1	SS41P, 4.5t
402	Base Pipe	1	SPC 1t, or SGP 20A(3/4")
403	Center Pipe	1	Plastic Pipe of waterwork, 3/4" Dia.
404	Inlet Pipe	2	Plastic Pipe of waterwork, 3/4" Dia.
405	Inlet Flange, A	1	Plastic Plate, 5 or 6t
406	Inlet Valve	1	Plastic Plate, 5 or 6t
407	Spacer	1	Plastic Plate, 5 or 6t
408	Inlet Flange, B	1	Plastic Plate, 5 or 6t
409	Bolt, Inlet	2	M4 x 20
410	Nut, Inlet	2	M4
411	Spring Washer, Inlet	2	M4

V. NAME AND CAUTION PLATES

A metal (copper, if possible) plate of showing manufacturer's name and adress, the type and main specifications and year should be prepared.

Any caution plate to show the methods of safety operation and driving should be prepared, for example, for dangerous CO gas as follows:

DON'T BREATHE CO GAS. CO gas is polsonous.

DON'T PEEP IN FURNACE,
WHEN TOP COVER IS OPENED IN BURNING.

VI. OPTIONAL PREPARATION (if necessary)

323 Floor Plate, SPC 1.2t or SS41P 3.2t	1 m^2
Roof, SPG (Galvanized Sheet)	1 to 2 m^2
Roof Support, STKM, 19.1 Dia x 1.0t	6 m
Pole, SGP-20A-Black or Wood	4 m
Carrier or Trailer	1,
etc.	

RAW MATERIALS / SET (JIS expression)

1.	IRON TUBES	
	350 Dia. x 700 x 4.5t (or 3.2t)	1
	SGP 175A, Black, 190.7 Dia. x 5.3t (or 200 Dia. x 3.2t)	
	x 325	1
	x 100	1
	x 175	1
	SGP 40A, Black, 48.6 Dia x 3.5t	2 m
	SGP 20A, Black, 27.2 Dia. x 2.8t	8 m
2.	IRON BARS	
	SS41B, 6 Dia.	4 m
	SS41B, 9 Dia.	3 m
	SS41B, 13 Dia.	1 m
3.	FLAT BARS	
	SS41, 3t x 32	0.5 m
	SS41, 4.5t x 38	2 m
4.	IRON SHEETS, 914 x 1829	
	SPC, 1.0t	1
	SPC 1.2t or SS41P 3.2t (for floor condition as (321))	1
	SS41P, 4.5t	1
	SS41P, 9t	1/5
5.	L-ANGLE BAR, 3t x 40 x 40	1 m
6.	BOLTS	
	M8 x 15	3
	M10 x 20	2
	M10 x 30	8
	M14 x 20	1
	M14 x 50	2
	M14 x 80 (effective thread length 50)	1
7.	NUTS	
	M8	3
	M10	12
	M14	1
	Butterfly Nut, M14	7
8.	SPRING WASHER, M14	1

9.	IRON NET, for Mortar	1 m^2
10.	Lacquers	
	Silver colour, Anti-heat for Gas Producer	4 m^2
	Silver colour, for others	6 m^2
11.	(ASBESTO) CLOTH, with alminume film, if possible.	1 m^2
12.	ASBESTO PACKING	1 m^2
13.	VALVES, 3/4"	2
14.	PLASTIC FLEXIBLE PIPE, 27 Inner Dia. (Adjust for engine)	1 m
15.	COKES (or CHARCOAL)	3.5 l
16.	GLASS-WOOL	2.3 l
17.	CAUTION PLATE	1
18.	MORTAR POWDER (heat resist.)	30 kg
19.	MIXER MATERIALS (preparation depending on engine)	
	Plastic Plate, 5t	0.2 m^2
	Plastic Pipe of waterwork, 3/4"	0.3 m
	M4 Bolt, Nut, Spring Washer	2
	SGP 20A(3/4"), or SPC Pipe 1t	5 cm

OTHERS (as Optional Preparation, if necessary)

	323 Floor-Plate, SPC 1.2t or SS41P 3.2t	1 m^2
	Roof	
	Roof Support	
	Pole	
	Pole Support	
	Carrier,	
	etc.