Subject: Engine temperature too high

Affected: All variants of the following models:

L1700
L2000
L2400

Background information: Oil and/or cylinder-head temperature too high.

This technical bulletin should be used to assist in troubleshooting and repair.

Priority: As required, when converting to unleaded fuel.

Explanations: Engine temperatures above those which are recommended in the operating manual can result in a reduction in the life of the engine. At a temperature of approximately 200 °C, the microstructure of aluminium begins to change. The change become even quicker with the increase in temperature. This will eventually result in leakage and loss of pressure. At a low operating temperature the build up of sediment and valve wear is greatly reduced.

On conversion to unleaded fuel, a reduction of the temperature is urgently required.

Only a small proportion (approximately 30%) of the available energy contained in the fuel is transferred as mechanical power to the propeller shaft. The remainder is released to atmosphere in approximately equal proportions from the exhaust and through cooling. The exact proportions are determined by the design of the engine and they only vary within very small tolerances.

The observance of higher temperatures can only have three causes:

- excessive generation of heat
- insufficient heat transfer
- the temperatures are incorrectly indicated.

Excessive generation of heat: This cause is the most common recorded, but in the majority of cases is responsible for only a small proportion of high engine temperatures. This is because of the reasons mentioned above regarding the conversion of energy. To enable an increase in the generation of engine heat, either the engine performance must be improved or the losses incurred during the conversion of energy must be increased.The following table shows the relationship between engine faults, the performance, the fuel consumption and the temperature. The table is based on the assumption that there is only a minimal deviation from the optimal condition:

Cause	Engine power	Fuel Consumption	Temperature
Carburetter setting too rich	Reduced	Increased	Lower
Carburetter setting too lean	Reduced	Reduced	Higher
Incorrect fuel	Reduced	Same	Higher
Diesel or kerosine in fuel	Reduced	Same	Higher

Cause	Engine power	Fuel Consumption	Temperature
Leakage in the induction system	Reduced	Reduced	Higher
Blockage in the fuel system	Reduced	Reduced	Higher
Blocked air filter	Reduced	Increased	Lower
Leakage at the exhaust valve	Reduced	Constant	Higher
High deposits in the combustion chamber	Possible increase	Constant	Higher (engine knocking)
Ignition timing advanced	Reduced	Constant	Higher
Ignition timing retarded	Reduced	Possible increase	Lower
Defect spark plug	Reduced	Same	Higher
Damage to engine (seizure of bearing or piston)	Reduced	increased	Higher (oiltemperature)

As can be seen from the table, it is possible to influence the engine temperature by setting a rich mixture, whereby two effects occur simultaneously:

- the calorific value of the mixture reduces and the combustion temperature reduces
- the unburnt fuel vapourizes and draws the heat from the walls of the combustion chamber (known as internal cooling).

Setting a rich mixture is not recommended on environmental grounds and because of the reduction in range.

Recently there has been cases where incorrect fuel has been used, either fuel which has been stored for an excessive period, or where fuel has contained too much diesel. This can result in knocking on combustion and a drastic increase in temperature. A minimal quantity of diesel in the fuel would greatly reduce the octane value. Knocking on combustion leads to greatly increased loads on the engine and could result in major damage to the engine.

The diagnosis of an internal engine problem is not valid if parts replaced due to overheating damage have to be replaced repeatedly.

For cruising, the recommended cylinder-head temperature is between 150 and 170 °C (refer to the operating manual). The temperatures actually attained are, however, often significantly much greater (200 °C and above). Such differences in temperature can no longer be explained by a malfunction within the engine. When cruising at 75% power, the conditions for engine cooling are much better and engines, which attain a temperature of 250 °C when climbing, maintain with ease the recommended temperature of between 150 and 170 °C. Troubleshooting in the cooling system promises to be much more successful.

Modifications to individual aircraft have resulted in a reduction in the cylinder-head temperature to less than 170 °C, even when climbing.

Insufficient heat transfer:

The cooling process in an air-cooled engine is dependent on the heat produced in the engine passing to the air, which flows over the surface of the cooling fins. This is conditional upon a positive temperature drop (the temperature of the cooling fins must be greater than the ambient temperature). For a given

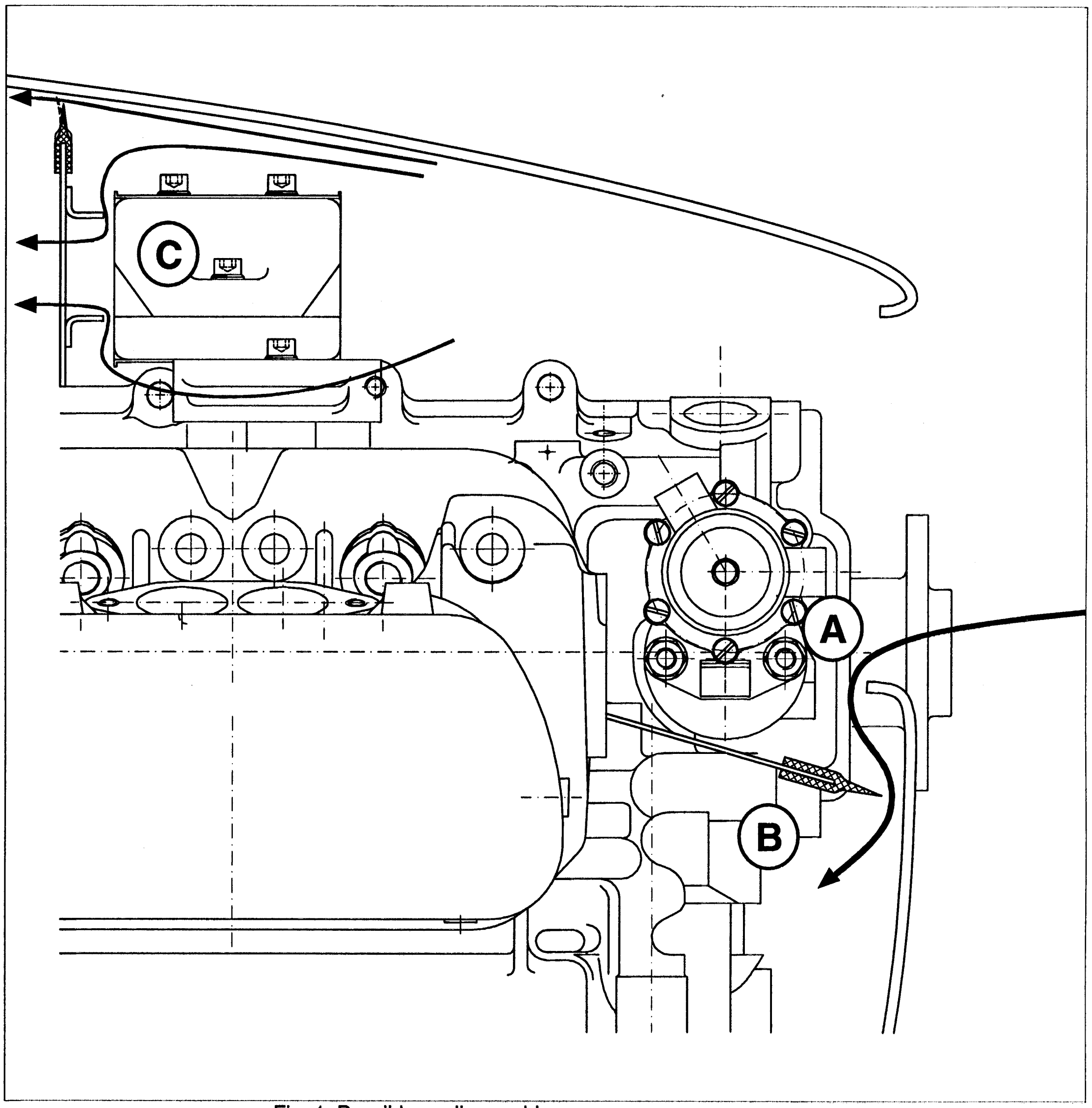

Fig. 1 Possible sealing problem zones

engine series, the surface area of the cooling fins is constant. The quantity of heat which can be transferred can only be affected by the difference in temperature and the velocity of the flow of air. For a certain flight condition, the power setting always has a constant figure. The heat to be dispersed is, therefore, also more or less a constant. If less air flows past the fins than is required for the optimal operating temperature, the temperature will increase until a new equilibrium condition is achieved between generated and dissipated heat, but at a much greater temperature level. The new equilibrium condition often lies above the permitted temperature. To complicate the matter even worse, during the start and climbing phases of a flight, when the most engine power is required, the lowest speed is attained and therefore the ram pressure is low and therefore the conditions for optimal cooling are bad.

Operation of the cooling system:

Most engines are installed at the front of the aircraft. The cooling air flows through the inlets at the front of the aircraft. Cooling baffles inside the engine cowling then guides the air to the cooling fins on the engine. The air extracts the heat from the engine and flows into the atmosphere through the outlet openings. To utilize the little energy in the airflow, the cooling air must be used fully and as loss free as possible. Small obstructions at the inlet, leaking baffles and bent or damaged edges at the outlet noticeably impairs the efficiency of the cooling system and leads to higher temperatures.

Effect of leaking and/or damaged cooling baffles:

For an engine which is correctly cooled, there is a characteristic pressure loss for a certain engine performance by the flow of cooling air through the gaps of the fins. In other words, a specific pressure difference between the inlet and outlet guarantees that the required quantity of cooling air flows over the fins. If there are leaks in the baffles, the pressure drop decreases because the cross-section for the air flow increases and the air can exit easier through a plain hole than through the small gaps between the fins. NASA carried out a comprehensive study on engine cooling and ascertained that even with new baffles the leakage rate from the cracks and holes was approximately 50%. In a poorly maintained system, we estimate that only 20% of the cooling air actually reaches the cooling fins. An example of possible problem zones is shown in Fig. 1. Sealing of the cooling system is not only important at the engine cowling but also, as shown in the figure, between the engine and the cooling baffles. The areas (A) in front of the engine are not visible when installed and are often overlooked when troubleshooting. On aircraft with mechanical propeller adjustment, the area (B) below the propeller boss is often completely without sealing. Also around the oil cooler (C), there are deficiencies in the sealing that are quite often not immediately apparent. On aircraft with twin carburetters, special attention must be paid to the metal sheeting in the area of the intake manifold.

Typical pressure losses in the cooling system are between 1500 - 3000 Pa. The ram pressure at 80 km/h is, however, only 300 Pa, as shown in Fig. 2. Control of the cooling can only be achieved if all of the other conditions, like the energy of the propeller slipstream and the pressure differences along the fuselage, are utilized.

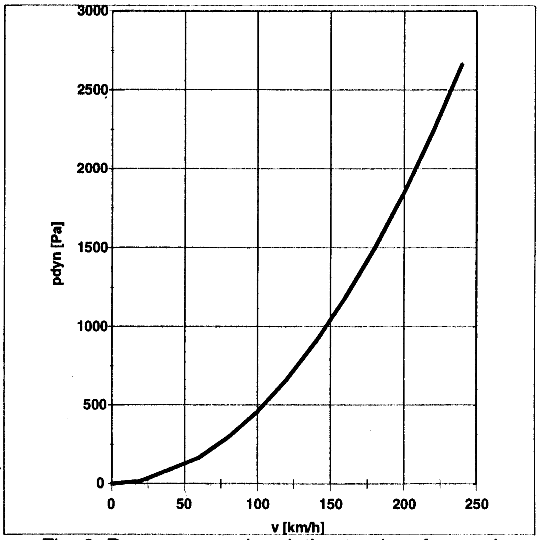

Fig. 2 Ram pressure in relation to aircraft speed

Dynamic leakage: The action of the forces of the air in the engine compartment are often under valued. The force created when cruising has an action on the engine cowling of approximately 1000 N. Connected with this, dynamic leakage could occur, e.g. turning up of the edges of the sealing strips, bending of the cooling baffles and disformation of the engine cowling. The effects of a sealing strip which is badly seated is shown in Fig. 3 and a sealing strip which is correctly seated is shown in Fig. 4.

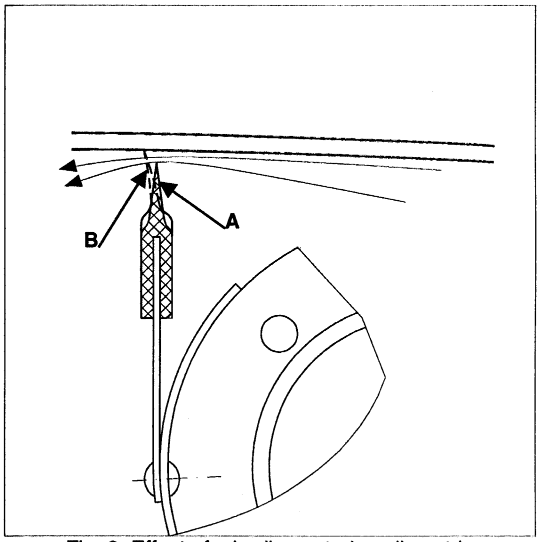

Fig. 3 Effect of a badly seated sealing strip

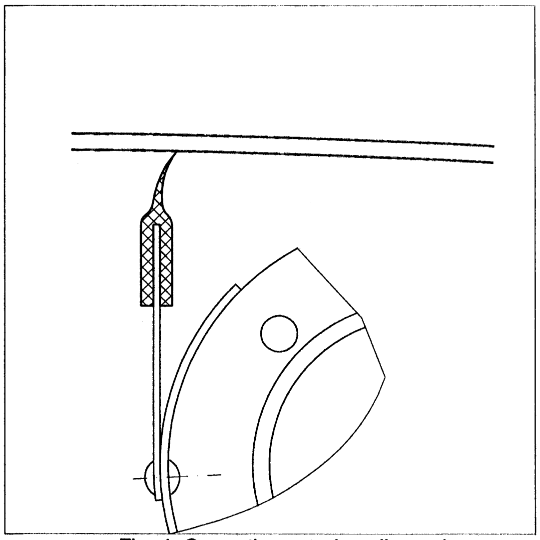
Fig. 4 Correctly seated sealing strip

Induction losses: As described in the previous section, the energy in the flow of the cooling air is, in a critical case, minimal. Induction losses are therefore damaging. Turbulence, as shown in Fig. 5, reduces the effective cross-section and energy is lost, which is not restorable. Even under the condition that the engine temperature remains below the recommended limit, air resistance is present which produces a higher fuel consumption. Filling the dead room behind the intake edge (Fig. 6, Area A) has proved to be effective in certain cases.

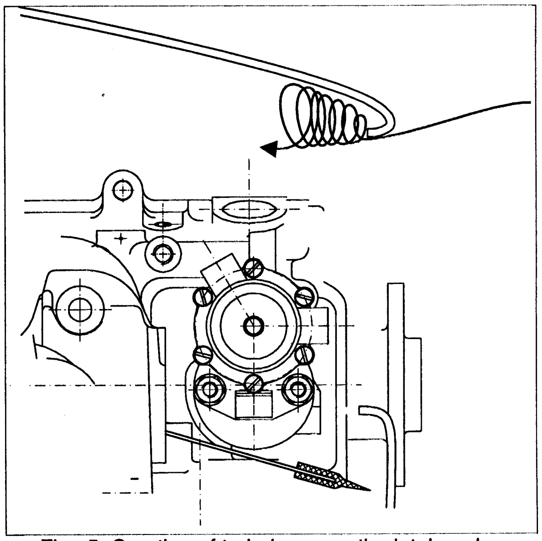

Fig. 5 Creation of turbulence on the intake edge

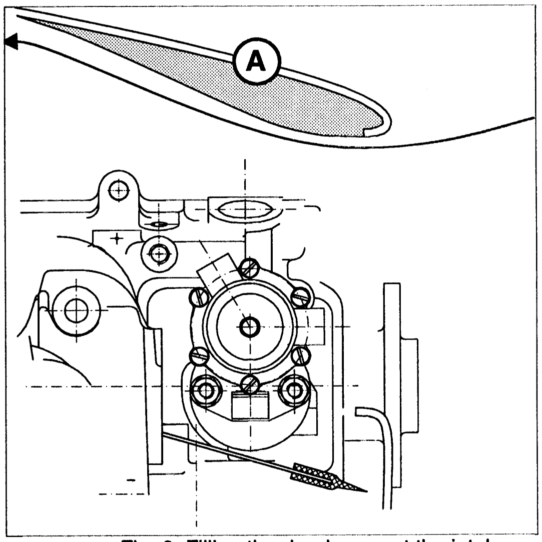

Fig. 6 Filling the dead room at the intake

Restriction of the outlet flow: In this respect the air outlet has a special signifigance. If the losses incurred by the cooling air entering and leaving the engine cowling are neglected, it can be shown that the air throughflow is less dependent on the absolute cross-section of the openings than on the relationship of the size to each other. An outlet with a cross-section approximately double that of the inlet is advantageous. Here only the flow cross-section counts, which, according to the angle of incidence, can be much smaller than the size of the opening. Increasing the cross-section of the outlet, or re-establishment of the outlet opening to the original size, may have the greatest effect on the engine temperature. Changing the cross-section of the outlet can be caused by, for example, an incorrectly carried out repair after an accident. Also, flaps for the drawn-air that do not, or do no longer fully open, may cause the cross-section to change.

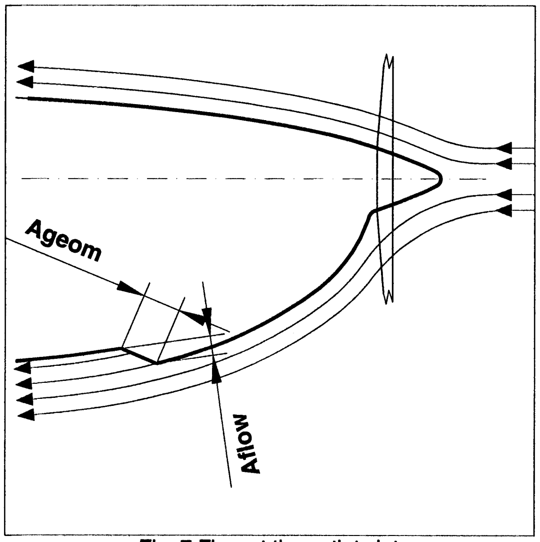

Fig. 7 Flow at the outlet slot

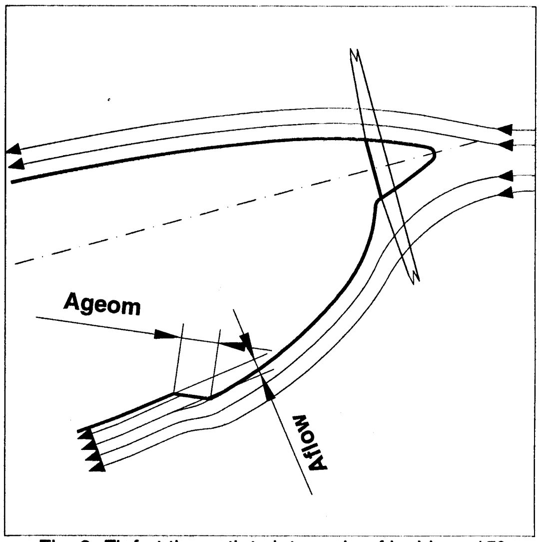

Fig. 8 Flof at the outlet slot, angle of incidece 15°

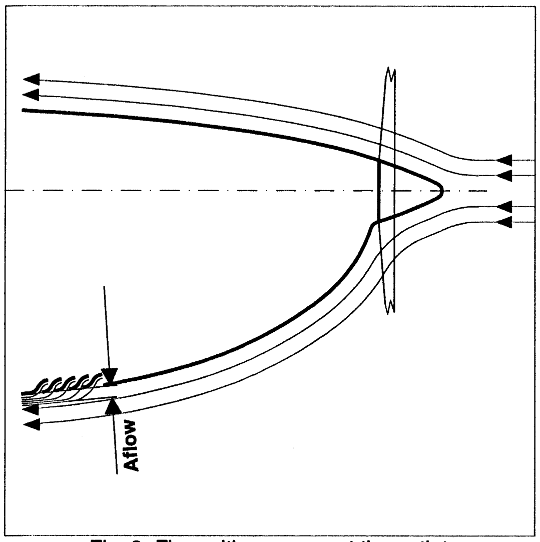

Fig. 9 Flow with a screen at the outlet

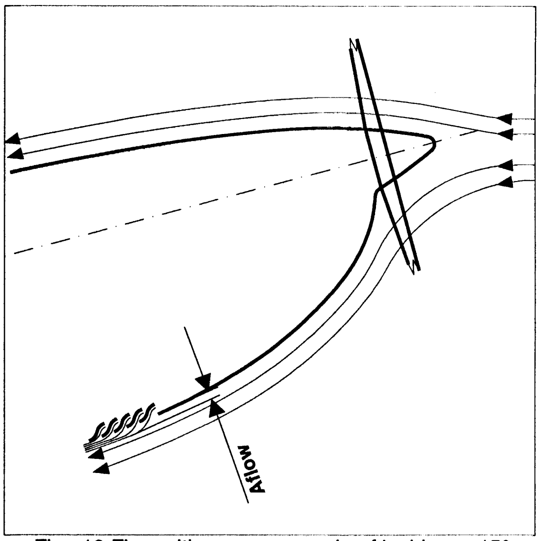

Fig. 10 Flow with a screen, angle of incidence 15°

The quantative difference between the geometrical cross-section (Ageom) and the flow cross-section (Aflow) at the outlet opening are shown in Fig. 7 to Fig. 10. Compared to the normal flight condition and the flight condition at an angle of incidence (climbing) there are differences in the flow cross-section (Aflow). The design also has an influence on the flow cross-section. The design using an outlet screen, as shown in Fig. 9 and Fig. 10, offers a smaller flow cross-section than the other outlet openings. The screen configuration also offers a greater air resistance for the cooling air and is much more susceptible to damage.

The screens at the outlet are mostly installed further forward in the direction of flight, so that when climbing, the additional ram pressure can have an effect on the outlet and further obstructs the flow.

A joggle at the air outlet, as shown in Fig. 11, can increase the cross-section of the effective flow.

It has been proved advantageous to have the cross-section of the outlet (flow cross-section) larger than the cross-section of the inlet (approximately twice the size). In practice these advantageous conditions are often not realised.

According to measurements, the actual flow processes appear to be so complex that the considerations presented here are not sufficient to explain all of the effects. Measurements on a test aircraft have shown, for example, that contrary to all assumptions, the cooling performance at higher speeds actually reduces.

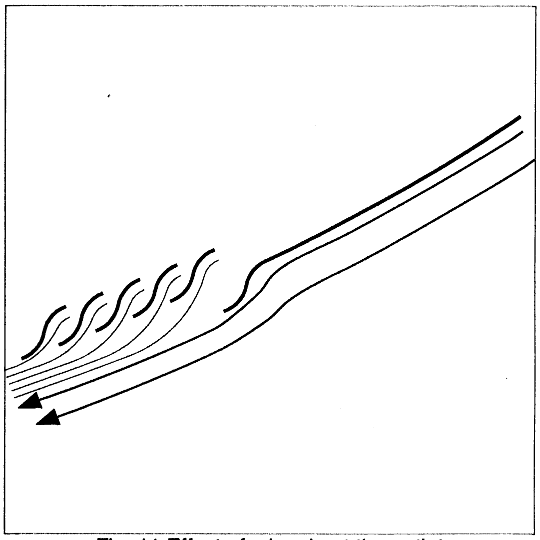

Fig. 11 Effect of a joggle at the outlet

Additional entry of cold air

The cooling is also obstructed by additional entry of cold air on the outlet side of the engine cowling. After tests and the implementation of a few small measures, a big reduction in the engine temperature could be made. These include, for example, a joggle on the muffler exit which can reduce the oil temperature by up to 15 °C (Fig. 12 and Fig. 13).

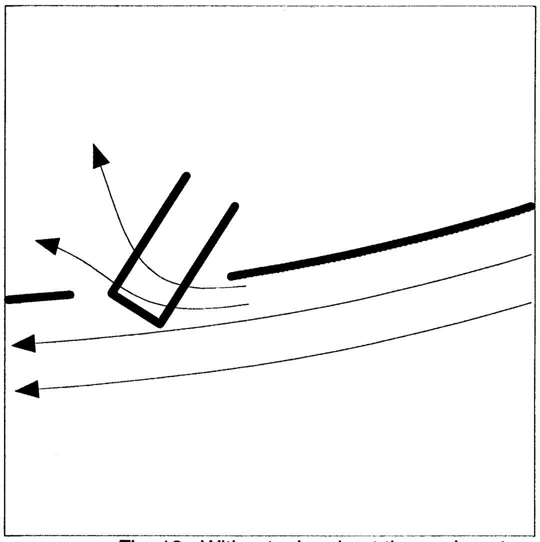

Fig. 12 Without a joggle at thge exhaust

Additional sources of heat

Many mufflers have so called heating jackets, which not only supplies heat to the cockpit but also warms the air for pre-heating of the carburetter. Sometimes the hoses transporting the warm air are defect. The warm exhaust air from the heating jackets sometimes escapes into the engine compartment and not into the atmosphere. The effect is double so damaging because as opposed to the entry of cold air, the warm air requires a greater volume and therefore blocks the path of the cooling air.

When starting the engine, the muffler attains a temperature of 800 °C and more. A heating selector valve, which does not permit full flow, can increase the amount of radiant heat in the engine compartment.

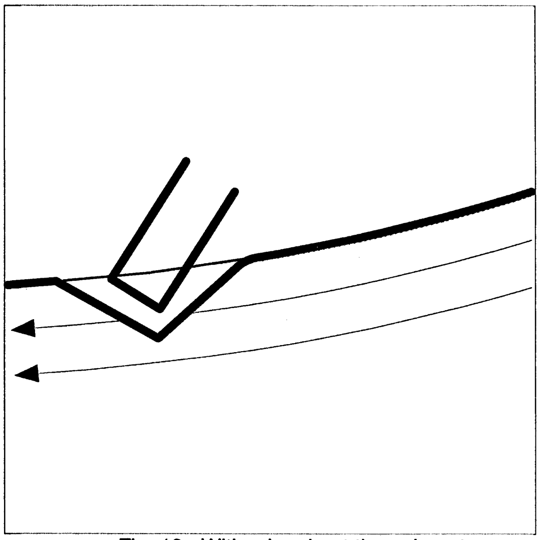

Fig. 13 With a joggle at the exhaust

Use of the surface of the cooling fins

A further consideration in the design and maintenance of the cooling baffles is the most efficient use of the available surface of the fins. Complete flow around the cylinder reduces the dead water areas and increases the number of fin surfaces for heat transfer. The effect of missing or poorly positioned cooling baffles is shown in Fig. 14. The hatching indicates a relatively large dead water area which can only transfer a small amount of heat. The variant with "shell" type baffles, as shown in Fig. 15, offers optimum use of the fin surface (L 2400 engine without inter-cylinder baffles). There is, however, a higher pressure loss within the cooloing system because the cooling air must travel a longer distance. Enclosure of the cylinder is also taken into account by conventionally designed cooling baffles. However, production tolerances, material fatigue and the deficiency in maintenance act against the ideal condition. In most cases the cooling baffles are bent around the cylinders. Because it is only in one plane, bending is the easiest form of production, but is very instable. After a relatively short period of time, the baffles move away from the fins on the cylinder so that there is no longer the required flow around the cylinder.

When the cooling baffles are tightly fitted and with the same cooling performance, special careful sea-

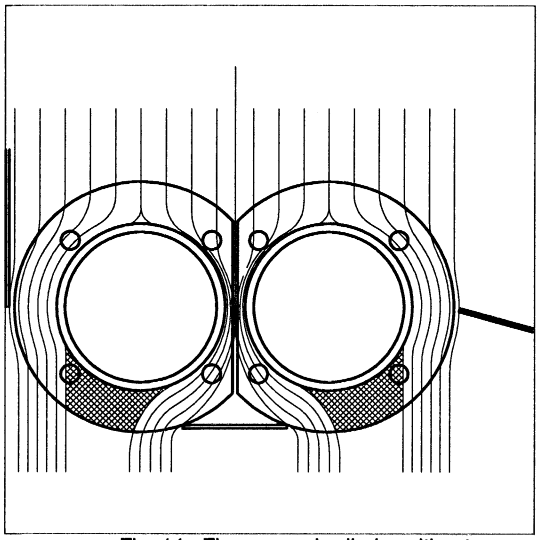

Fig. 14 Flow around cylinder without "shell" type baffle

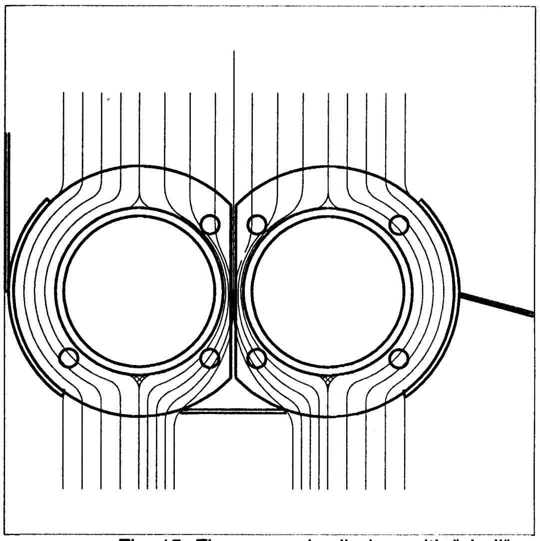

Fig. 15 Flow around cylinders with "shell" type baffles

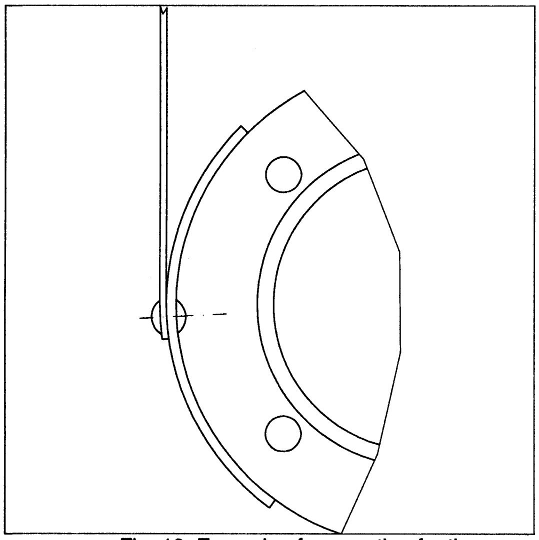

Fig. 16 Example of connection for the rear baffle

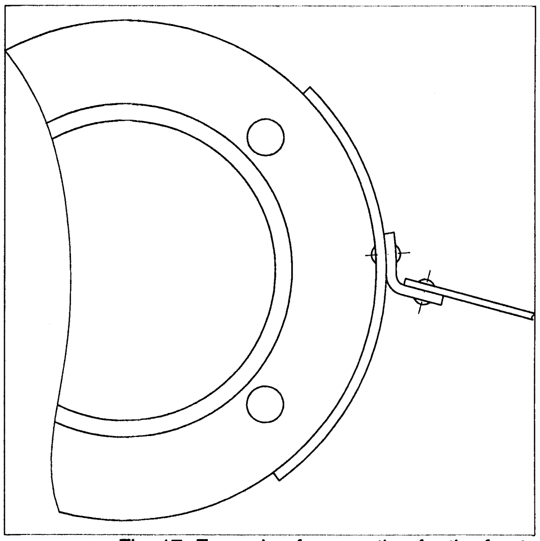

Fig. 17 Example of connection for the front baffle

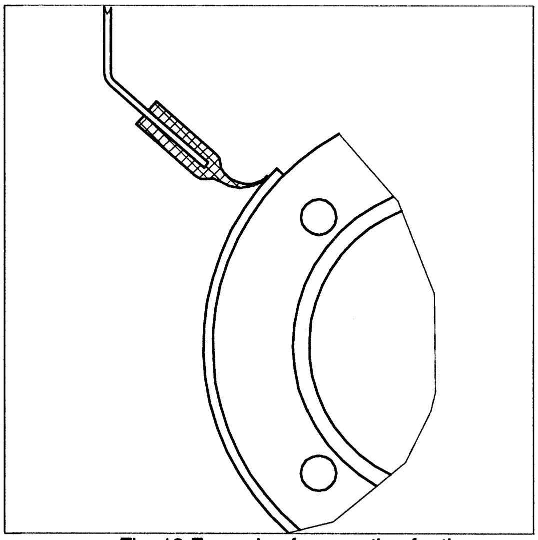

Fig. 18 Example of connection for the rear baffle

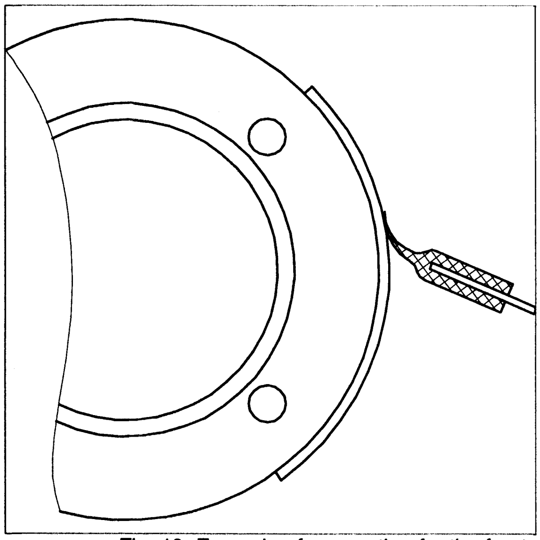

Fig. 19 Example of connection for the front baffle

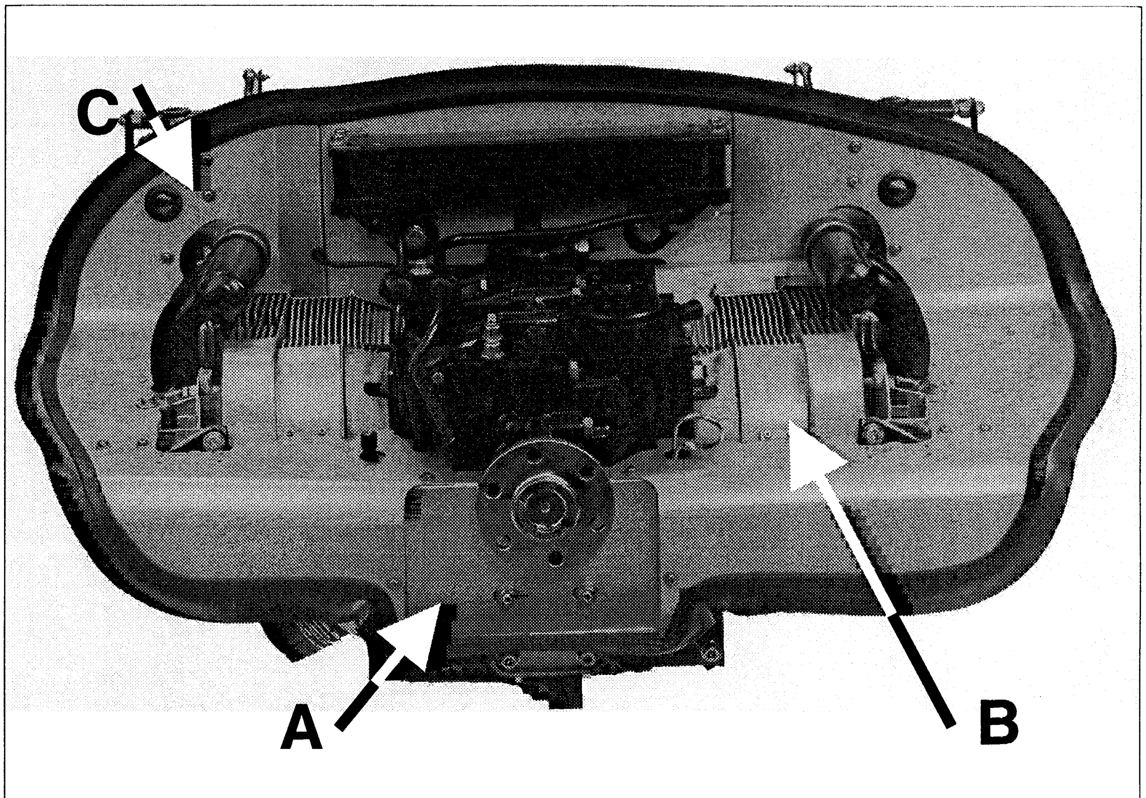

Fig. 20 Example of a good design for the casing

ling is required and will be rewarded by a low cooling resistance (tests were successfully carried out on a Taifun 17E). Examples for connecting the shell type baffles to the other baffles are shown in Fig. 16 and Fig. 17. Alternatively, the other baffles can be sealed against the shell type baffles using a sealing strip (Fig. 18 and Fig. 19). The shell type baffles are connected to one another around the cylinder using long hose clamps (Fig. 21, Item 3).

Practical design example

A good design for sealing is shown in Fig. 20. The edges are provided with a sealing strip which provides a seal with the engine cowling. The perfect seal under the propeller boss (A) can be seen and the attachment of the shell type baffles. The casing is divided on both sides of the intake pipes (C) to make the installation easier and also, because of the design, to minimize the gap around the intake pipes and at the oil cooler.

Oil temperature too high after modification

The complete sealing of the cooling baffles can result in a higher oil temperature. The reason is because the oil sump is often cooled by the leakage at the cooling baffles. There are several solutions to solve this problem:

1. Improvement of the airflow through the oil cooler. There is often leakage from points in the cooling system around the oil cooler. The sealing on the top of the oil cooler is often mechanically instable, so that the sealing strip does not fit, or is a bad fit on the cover. The resulting gap offers the air a small flow resistance. Sometimes the contact pressure of the sealing strip is too low to resist the ram pressure (refer also to Fig. 1 and Fig. 3).

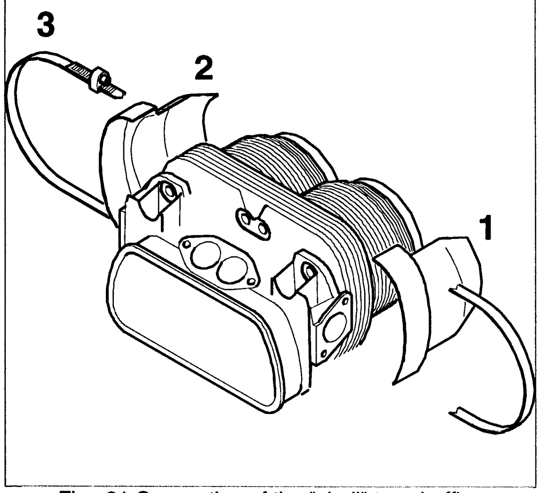

Fig.: 21 Connection of the "shell" type baffles

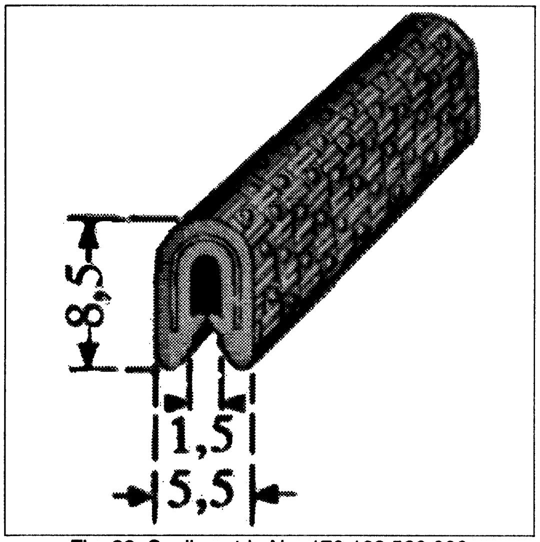

Fig. 22 Sealing strip No. 170.163.520.000

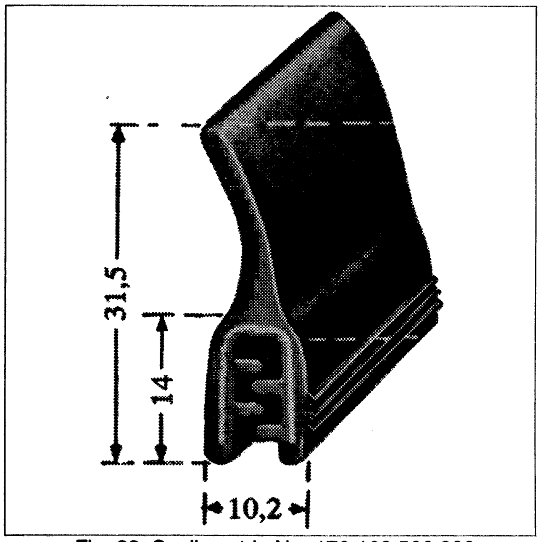

Fig. 23 Sealing strip No. 170.163.500.000

2. Installation of a separate sealed cooling passage for the oil sump, as opposed th the system for the cooling of the cylinder head which is not sealed.
3. Successively increase the leakage by introducing holes in the cowling or baffles, however, anincrease in the cylinder-head temperature must be accepted.

Methods 2 and 3 are not normally necessary in a well designed cooling system. It is more likely to be expected that the effect would make it necessary to cover the oil cooler at low ambient temperatures.

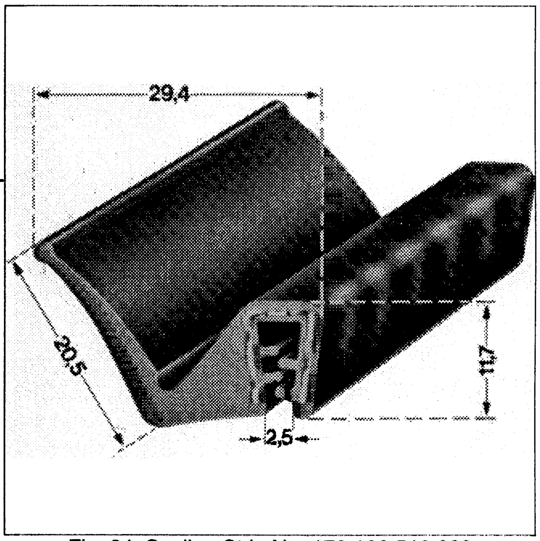

Fig. 24 Sealing Strip No. 170.163.510.000

High engine temperature after replacement of engine:

After replacement of an engine it is very likely that the engine temperature will be higher than previously. Possible causes are that the colling baffles and seals are no longer in the same position as before and it is also possible that the new engine produces a little more power.

The baffles expose the considerable production tolerances. For this reason new baffles must be chekked for correct seating on installation. If necessary, a little reworking is to be carried out.

Compliance:

If the temperatures increase, an inspection and repair of the cooling system is necessary as follows:

1. Check the temperature indication for correctness.
2. Retrofit an indicator for the cylinder-head temperature.
3. Carry out an inspection of the engine. Check the ignition timing and the carburetter setting. Check the induction system for leakage.
4. Inspect the condition of the cooling baffles. Repair cooling baffles which leak or are damaged.
5. Inspect the sealing between the engine cowling and the cooling baffles, repair if necessary. Check the effect of the sealing strip. When the cowling is installed, the edges of the seal must be curved towards the direction of flight. Replace any rubber parts which have become hard[1].

For appropriate sealing strips: Refer to the adjacent figures.

6. Inspect the sealing between the engine and the cooling baffles, repair if necessary[2]. If necessary, install the shell type baffles (refer to Fig. 21).

	Engine Model			
	L 2000 EA	L 2000 DA	L 2000 E0, EB	L 2400 EB
Front right	201.163.202.000	205.163.202.000	201.163.202.000	241.163.202.000
Front left	201.163.200.000	205.163.200.000	201.163.200.000	241.163.200.000
Rear right	201.163.203.000	205.163.203.000	201.163.203.000	241.163.203.000
Rear left	201.163.201.000	205.163.2001.00	201.163.201.000	241.163.201.000
Clamps 2x	201.163.206.000	205.163.206.000	201.163.206.000	241.163.206.000

7. Inspect the hoses to and from the cockpit heating and the carburetter pre-heating, repair if necessary. Carry out a functional check of the selector valve for the cockpit heating and the carburetter pre-heating. The hose for the outlet air must lead to the air outlet[3].

8. Inspect the edges at the air inlet, repair if damaged.

9. Inspect the condition of the openings at the air outlet. If necessary, repair the edges at the outlet and the diverting screen. Increase the cross-section to the maximum value given by the aircraft manufacturer.

10. Reduce the gap around the exhaust pipe to the minimum permissible dimension.

11. Increase the air speed during climb (reduced angle of climb)[4].

12. Reduce the boost pressure.

13. Modify the cooling system, observing the previously mentioned instructions.

Caution: **The modification of existing aircraft is subject to approval and must not be carried out without authorization. Please contact the aircraft manufacturer.**

Approval This technical bulletin is approved in accordance with the procedures of the LBA approved development organization I-EC 27

This document has been translated to the best of our knowledge. In case of doubt however only the german original shall be considered authorative.

1 Correct seating of the sealing rubbers can often be determined by the intensity of the ridges in the engine cowling. Alternatively, or perhaps even additionally, with the engine cowling installed, hold a lamp at the rear of the engine and look to see if there is any sign of light.

2 This area produces the greatest number of defects. Well known faults are; the sealing in the area of the propeller boss (often missing completely), in the area below the induction manifold (for twin carburetter models), the area where the intake pipes pass through the metal sheeting and all the points where the cables pass through (refer to Fig. 1).

3 The correct operation of the selector valve prevents continual intake of warm air (loss of performance) as well as a better cooling of the muffler (less radiant heat).

4 Except H 36 Dimona