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TIMBER INDUSTRY

DP/CMR/87/005

REPUBLIC OF CAMEROON

Technical report: Timber Construction *

Prepared for the Government of the Republic of Cameroon
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of C.R. Francis
Timber Engineer

Backstopping Officer: A.V. Bassili
Industrial Management and Rehabilitation Branch

United Nations Industrial Development Organization
Vienna

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* This document has not been edited.

V.89-56604

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SUPPLEMENTARY REPORT

1. Introduction

The bulk of the experts work and recommendations are covered in the accompanying Technical Report "ROOF TRUSSES". This was written specifically for Cameroon, but the expert considers that it could also be applicable to other West African Countries with similar timbers and architectural styles. That technical report was therefore confined to the subject matter and did not go into other matters which arose during the mission or to some particular local problems. It is considered that these matters should be restricted to Cameroon distribution, while the technical report, being of a general nature, could well be de-restricted immediately for distribution in neighbouring countries if desired.

2. Timber Frame Construction

The senior staff at CENADEFOR C.P.B. * Nkolbisson are familiar with prefabricated timber panel construction, and there are several factories in Cameroon which undertake the manufacture of prefabricated timber buildings. Discussions and examination of buildings erected by CENADEFOR staff showed that they have little to learn in prefabricated construction.

However, light timber frame construction, site cut, or factory pre-cut and site assembled was a new concept to them. Numerous discussions were held on this subject and by way of explanation and reference, sketches of typical details were prepared. These are reproduced as figures 1 and 2 of this report.

A major inhibiting factor to widespread introduction of timber frame construction in Cameroon is trade practice in sawmills. The closest dimension to scantling size in Cameroon is the "latte" of 8 cm x 4 cm sawn size. Where the highest quality of sawing is performed, the dimensional accuracy might just be adequate for construction purposes but generally planner gauging would be required. This would reduce the section to a dimension too small for studding and plates. These would have to be resawn 3 ex 30 cm to give an acceptable width. The 4 cm thickness is acceptable.

The drawings were prepared on the basis of nominal 5 cm thickness timber, but could in all cases be constructed in 4 cm timber of F8 or better, which in any case is the common quality in Cameroon. In the USA S4S softwood lumber is finished to 1 $\frac{5}{8}$" = 41.3 mm thick. The softwood grades actually used in the USA would correspond to timber of stress grades about F7 or F8.

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* "Centre de Promotion du Bois".

3. Weatherboards

Closely associated with timber frame construction is the use of accurately profiled weatherboards (Fr. "clins"). Profiles were prepared of rebated skew cut weatherboards which could be machined in the workshop at Nkolbisson (fig. 3). Two short samples were actually produced and were of satisfactory quality.

Designs were prepared for 15 cm x 3, 15 cm x 4 cm and 20 cm x 4 cm stock. The weatherboards which could be machined from the 3 cm stock are really too thin, and are certainly too thin to contain anti-capillary grooves in the head and the rebate. The weatherboards machined from 4 cm have sufficient thickness to contain these anti-capillary grooves as shown.

It should be noted that the rear face of these weatherboards is left in the band sawn condition and is not planed afterwards. This leaves maximum thickness. High quality sawing of this skew cut is therefore necessary.

The economics of these weatherboards may be approximately compared with the rough board siding currently constructed:

Current construction = 30 cm x 3 cm planks with
4 cm x 1 cm cover battens.

Cover: say 31 cm

Area of timber cross section $30 \times 3 = 90$
$4 \times 1 = 4$
94 cm2

Area per 1 m of wall height $= \frac{100}{31} \times 94$ cm2
$= 303$ cm2

Skew cut weatherboard, 2 ex 15 cm x 3 cm
Cover = 2 x 11 cm = 22 cm

Area per 1 m of wall height $\frac{100}{22} \times 15 \times 3$ cm2
$= 205$ cm2

Skew cut weatherboard, 2 ex 15 cm x 4 cm
Cover = 2 x 11 cm = 22 cm

Area per 1 m of wall height $= \frac{100}{22} \times 15 \times 4$ cm2
$= 273$ cm2

Skew cut weatherboard, 2 ex 20 cm x 4 cm
Cover = 2 x 16 cm = 32 cm

Area per 1 m of wall height $= \frac{100}{} \times 20 \times 4$
$= 250$ cm2

All the skew cut weatherboards are more efficient in terms of timber usage than the present construction. The ratios being:

Present construction	: 100%
2 weatherboards ex 15 x 4	: 90%
2 weatherboards ex 20 x 4	: 83%
2 weatherboards ex 15 x 3	: 68%

The most efficient, 2 ex 15 x 3 is very flimsy and is not recommended. However, the 2 ex 20 x 4 is substantial. It has not been ascertained whether the machining cost would bring the overall cost above the cost of present construction.

However, there is no comparison in terms of quality. The present construction is, and looks, rough and shoddy. Well machined weatherboards are weatherproof and are used on buildings of the highest quality.

To do justice to this quality, workmanship needs to be of a similar high standard. Weatherboard positions need to be carefully levelled and set out. Joints need to be carefully mitred. Nails should be diamond or jolt head galvanised finishing nails, punched home and the holes puttied. The heads and rebates of the boards should be prime-coat painted before erection, and ends cut on site should also be primed as erection proceeds.

If these good trade practices are followed, a top quality permanent job will result. With regular repainting, life expectancy of durable or treated timbers should exceed that of plaster on masonry.

4. Roof Truss Applications

During the expert's visit to Bamenda a meeting was held with the Chief Technical Adviser of FAO project DP/CMR/86/017 "Reduction of Post Harvest Food Losses". He had designed a masonry food store and wishes to erect a demonstration prototype. A Nail Plate connected truss was designed to suit his building and a quotation is being prepared for fabrication and delivery of the trusses. This truss is a typical "Industrial" type and is detailed in fig. 4 and 4 A. Note that heavier timbers are used than in the residential type trusses to suit the wide (3,2 m) spacing.

One of the senior staff at Nkolbisson is proposing to build a bungalow and asked for advice on the roof construction.

This house is "L" shaped and is to have a hipped roof. this is a quite typical example of a more complicated roof shape. The design (fig. 5) incorporates the following features.:

1. Common trusses along the ridge of the main wing.

2. Truncated trusses forming the hip ends on both main and small wings.

3. Common and truncated trusses of the main wing supported on a girder truss spanning across the small wing.

4 Jack rafters completing hip ends.

This configuration is frequent in countries with established roof truss industries, but is rather too complicated for a first job of a new factory. Some experience in truss fabrication should be gained before attempting this job. However, it is a good example of what can easily be done on more complicated roof shapes.

Some design features which have been incorporated and which may not be immediately apparent are:

1. The design as first proposed incorporated full hips. However, a semi gable was introduced at each end. This allows the use of two common trusses instead of truncated trusses. Common trusses are cheaper and easier to fabricate than truncated trusses. Also, the semi gable permits the installation of roof vents which cool the ceiling space and make day time conditions inside the house more comfortable.

2. A pitch of 20 degrees was selected. This allows a little extra depth in the end truncated trusses. With a pitch flatter than this the truncated trusses become very shallow and flexible and require heavier chords and more triangulation to maintain rigidity with consequent increase in cost.

3. With truncated truss support, the hip rafters do very little work. Consequently they can be the same depth as the jack rafters, not 1 1/2 times as deep, which is a common carpenter's rule of thumb. The top chord of the truncated trusses is dropped by this dimension to allow a birdsmouth in the hip rafter to seat directly on the top chord. The hip rafter is positioned laterally by the upstanding end of the sloping part of the truncated truss top chord.

4. The truncated trusses are positioned so that their inside face is on the true hip intersection line. This allows birdsmounthing of the jack rafters for easy seating and positioning of the truncated truss.

5. Nail Plate Manufacture

One manufacturer only was located who stated that he could make nail plates. However, he required a tooling fee of FCFA 500.000 and it was considered that his unit price of FCFA 6000 per meter of nominal 100 mm wide strip was excessive.

Accordingly a suitable punching machine was designed and steps are in train to obtain quotations for the manufacturer of this machine. The features included in the design, shown in fig. 6, are:

1. Pneumatic operation. This is perhaps rather inefficient in energy consumption compared with an inertia powered machine but it is simple and easily repaired.

2. Feeding and lateral positioning are by hand. This is slow and inaccurate compared with automatic feeding, but plate manufacture would still be a great deal faster than plate consumption in the forseeable future. Since coil stock is unlikely to be available, strips guillotined from 2.4 m sheets will be used and these are light and easily handled. Slight variations in hole positions can be tolerated - the designed centres are nominal in any case.

3. The requests for quotations have included ample spare parts requirements.

A reduced copy of the drawing is shown as figure 6. The original tracing is held by UNIDO in Vienna.

The design was done without the aid of mechanical reference catalogues. Therefore some dimensions are incomplete and others may not correspond with commercial dimensions of industrial components e.g. needle roller bearings etc.. To this extent the original drawing will require further detailing and amendment. Also, the author is not an expert on press tool technology and the whole design would benefit by expert review.

Because the author has only a nodding acquaintance with pneumatic circuits, no attempt was made to design the controls. A request has been made to a pneumatics supply firm to design and quote for supply on the following basis:

1. Workshop air available at 80 p.s.i. (5 - 6 bar).

2. The machine to operate a single stroke on one depression and release of a foot pedal control, regardless of duration of depression.

3. Punching work is only being performed during the first approximately 1/3 of the stroke. The rest of the stroke is swarf cleaning and punch withdrawal. Therefore the main air supply should be shut off at about this position leaving the rest of the cylinder stroke to be done by expansion of the contained air. This should result in a substantial reduction in air consumption. It should be easily accomplished by the toggle levers actuating a valve at their mid - travel position.

4. Although not detailed, the machine should have infeed and outfeed tables each about 2 m long x 250 mm wide covered with omni-directional ball conveyor surfaces. These tables could well be locally supplied timber, to be manufactured and fitted locally provided:

   (a) All bar roller conveyor components are supplied

   (b) A detailed drawing is supplied

   (c) If specific diameter holes are to be bored in the timber, appropriate diameter wood boring bits are included in the supply of the machine.

General: It is anticipated that the nail plate system of roof truss construction may be adopted in neighbouring countries. Therefore this specialized design could also have wider application than just Cameroon. Accordingly, the design considerations and constraints have been given in considerable detail.

A suggested inspection specification for use by PAC is attached as Annexe A.

6. Nkolbisson - New Workshop Building

A start has been made on a new building at Nkolbisson. Dimensions are shown in fig. 7. This building has been completed with floor and columns up to top beam height.

A design for completion of this building has been done. the major features are a timber top beam in suspended cantilever spans in 40 cm x 10 cm Iroko. An alternative would be continuous top beans in glulam. Exterior walls in light frame/weatherboard construction.

Because of the easy availability of large size clear hardwood there appears to be little point in specifying glulam if sawn sections can provide the necessary timber. This assumes that there are no absolute size (in this case length) or shape (eg. curve) requirements.

The section specified is a special, but judging by the sawmills seen in operation in Yaoundé, it could be sawn on the day of order.

The absolute provision for this type of construction, where the cantilever joints are placed at the contraflexure points of the equivalent continuous beam, are that:

1. The joints are positioned as detailed. (In this case it fortuitously happened that the theorical positions were round numbers).

2. The suspension stirrup is as detailed in fig. 8 which not only provides vertical support, but also provides longitudinal continuity.

3. There are several workshops in Yaoundé perfectly capable of fabricating the necessary stirrups.

4. The roof trusses themselves, if positioned as shown in the drawing, can be manufactured according to the details and propositions shown in UNIDO report DP/SER.A/353 " trussed rafter system" HW10. Consequently there is no necessity to provide a separate detail drawing, since dimensions, angles and cutting details are all contained in the order form/cutting sheet detailed in that report. Nkolbisson staff have been trained in the application of these cutting sheets and details.

it is considered helpful to their experience if they must work out these details themselves rather than have them handed over by a visiting expert.

7. Solar Drying Kiln

UNIDO is enthusiastic in promoting this minimal energy technology in tropical countries, and extensive discussions were held in Vienna with the author during project briefing.

The author was in Yaoundé only from late February to mid-April, but during that time remarked the general cloudiness and lack of bright sunshine. His local counterparts confirmed that this was general throughout the year, and compounded by obscurity caused by dust blowing off the Sahara desert. The author therefore urges caution before embarking on major expenditure on solar kilns without first checking available sunshine data in Yaoundé or other parts of Cameroon.

Since the observations were subjective and of such short duration, it is recommended that CENADEFOR should obtain sunshine data from the Cameroon Meteorological Service for evaluation by UNIDO as to whether the annual quantity of available solar energy at Yaoundé warrants the installation of solar drying facilities.

8. Pressure Treatment

The C.P.B. at Nkolbisson has a small pressure treatment plant. Details are:

Brand Marie Fredsverken Type A3-65-750

Serial N° 1720

Cylinder = 600 diameter x 7150 long. Working pressure = 16 Kg/cm2

Pump - 14 stage centrifugal 2900 rpm. Grundfoss

Vacuum system - solution driven venturi.

The plant has not worked since 1985 due to a faulty pump but otherwise appears to be in fair condition and probably only requires minor work to put it into working order. However, being originally designed for softwoods, and having a long horizontal storage cylinder, it lacks the facilities for final rate of flow determination which is vital for satisfactory pressure treatment of hardwoods. (It is only by accurate rate of flow observation that the true "refusal point" can be determined, and consequently the complete impregnation of the inner cell wall structure in hardwood species. It is this incomplete impregnation which is considered by experts to be a major contributing factor to the failure in service of a considerable proportion of C.C.A. impregnated hardwoods).

The plant also requires a roof over it, concrete pad, drip sump and transfer pump. Most of the materials and components are available locally, except the rate of flow meter. A suitable design of portal frame to cover the plant is n=shown in figure 9.

C.C.A. pressure treatment is well known in Cameroon, since large numbers of utility poles (mostly Eucalyptus saligna) are pressure treated at Bafussam and installed throughout the country. General observation will have demonstrated the efficacy of this process, and extension to building construction should be relatively easy because of the existence of widespread successful application of pressure treatment. The author recommends that UNIDO should include this item of plant with the woodworking machines to be repaired and should also supply a suitable rate of flowmeter for fitting at an estimated cost of US $ 150 (McMaster-Carr item Nr. 4112K3 12 US Gal per hour or similar).

ANNEXE A

Inspection of Nail Plate Punch Manufactured for UNIDO

1. The machine shall be inspected for general quality of workmanship, finish and precision of manufacture.

2. The machine shall be completely assembled on a bench and its operation demonstrated. The air supply should be adjusted to not more that 80 p.s.i. (3 - 5 bar). Not less than 200 rows of holes should be punched in nominal 1.2 mm thick grade 43 galvanised steel strip, to be supplied by the manufacturer.

3. At the end of this test no wear or damage should be evident on punches, dies or anywhere else on the machine.

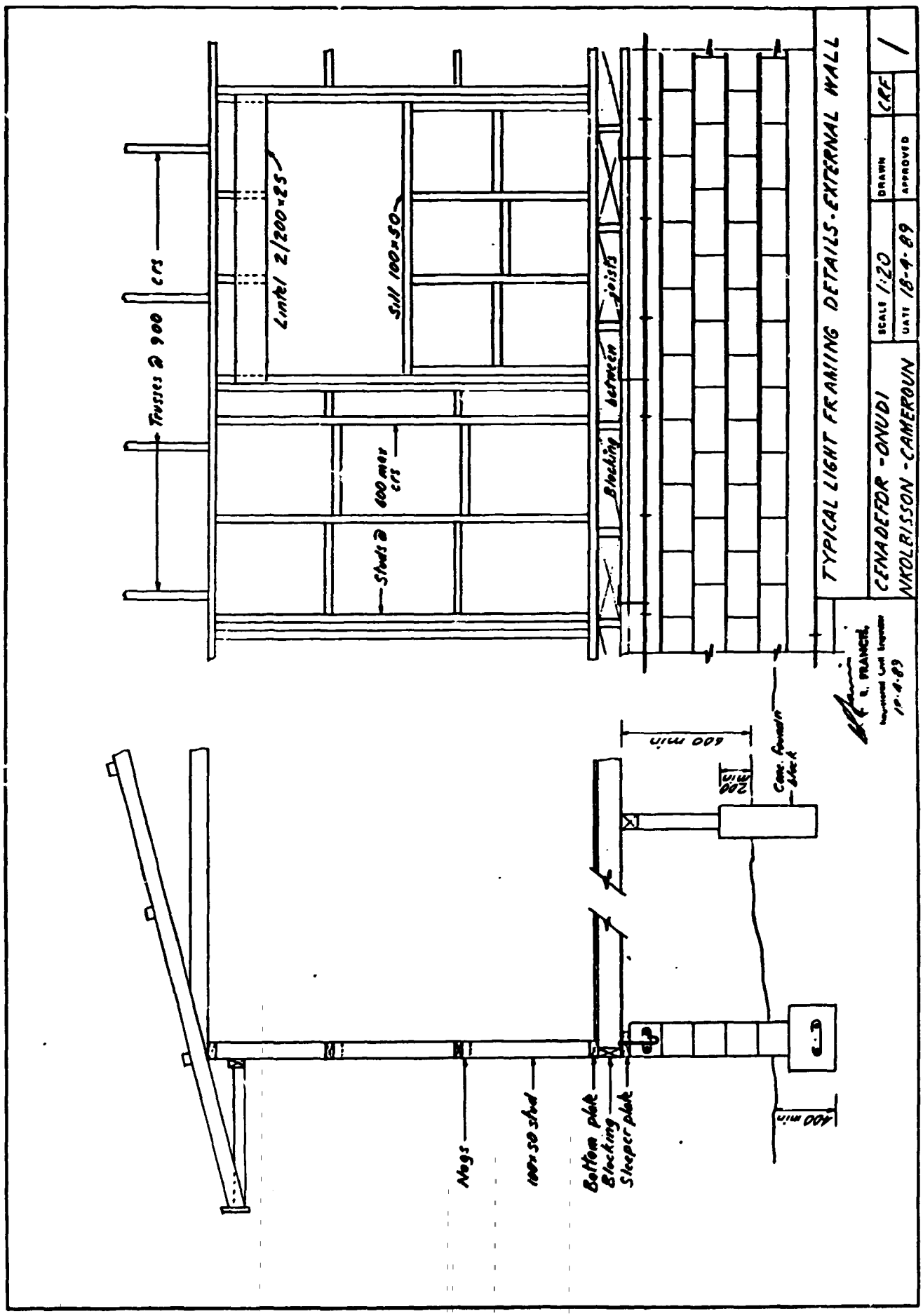
4. The hole pattern must be in accordance with the pattern supplied.

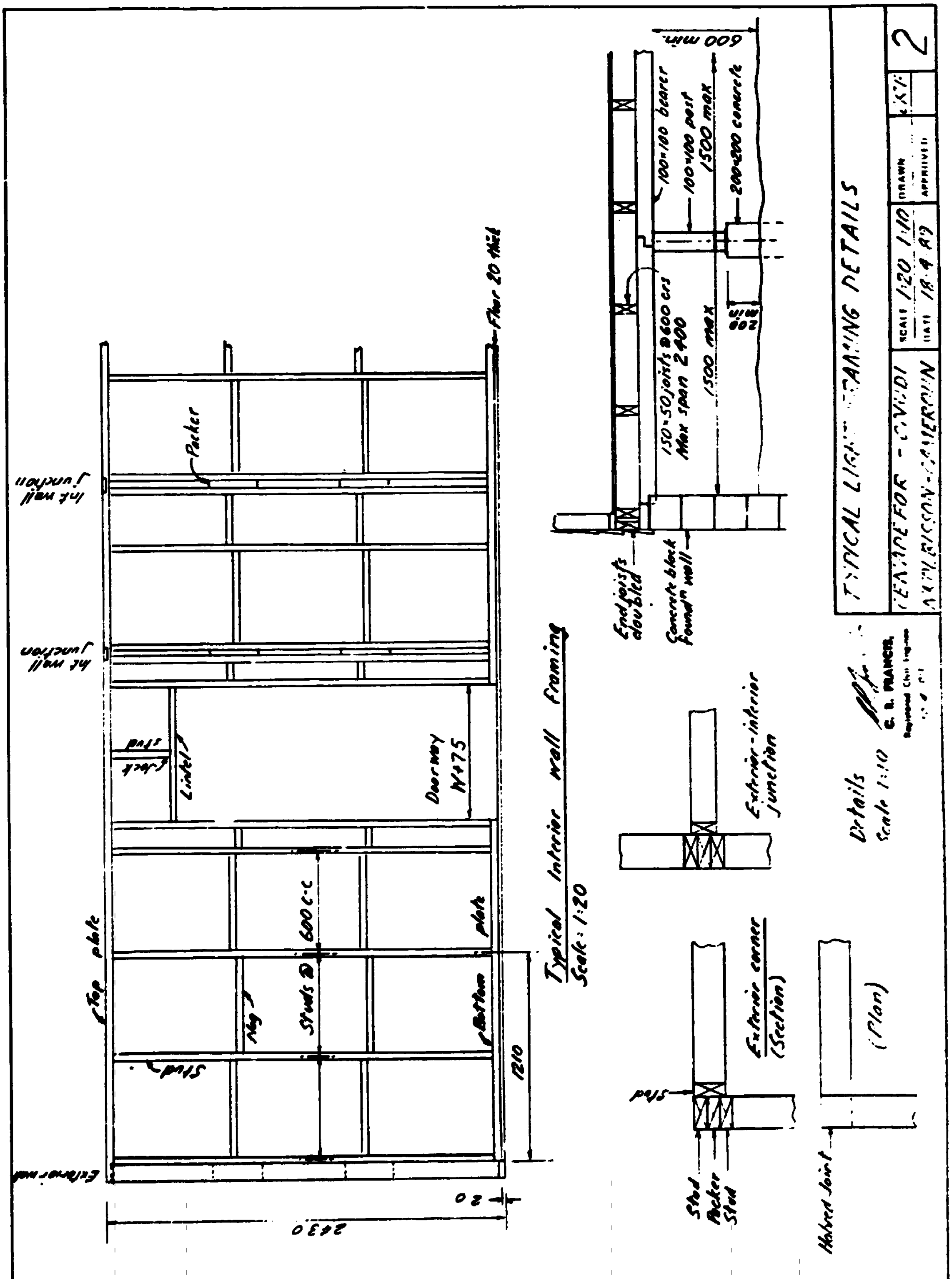
5. Random tests shall be made of the interchangeability of spare punches and dies (Note: this will require partial disassembly of the machine).

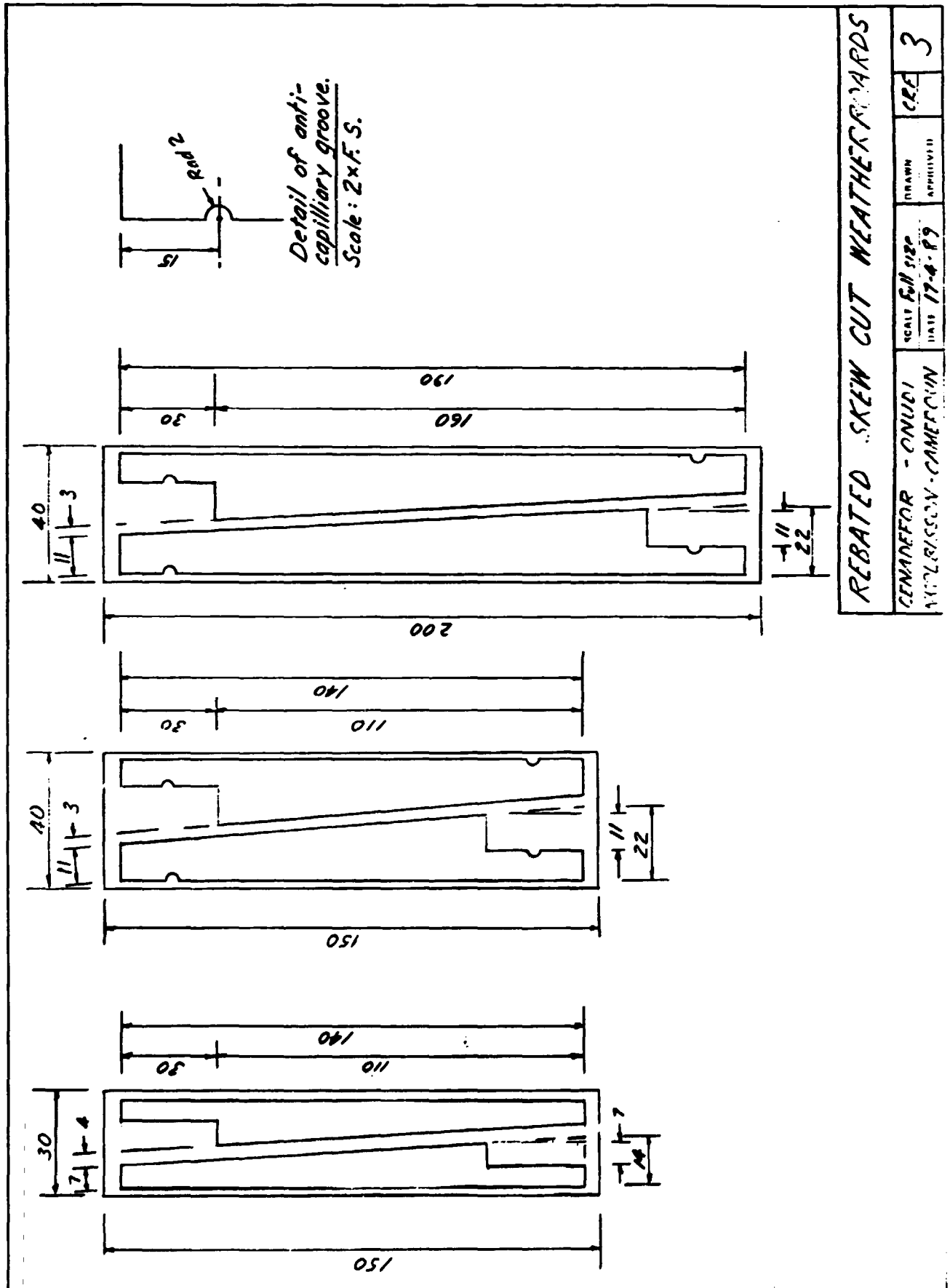
6. Two lengths each of 300 mm x 6 holes wide of punched strip shall be forewarded to UNIDO with the Inspecting Engineers' report.

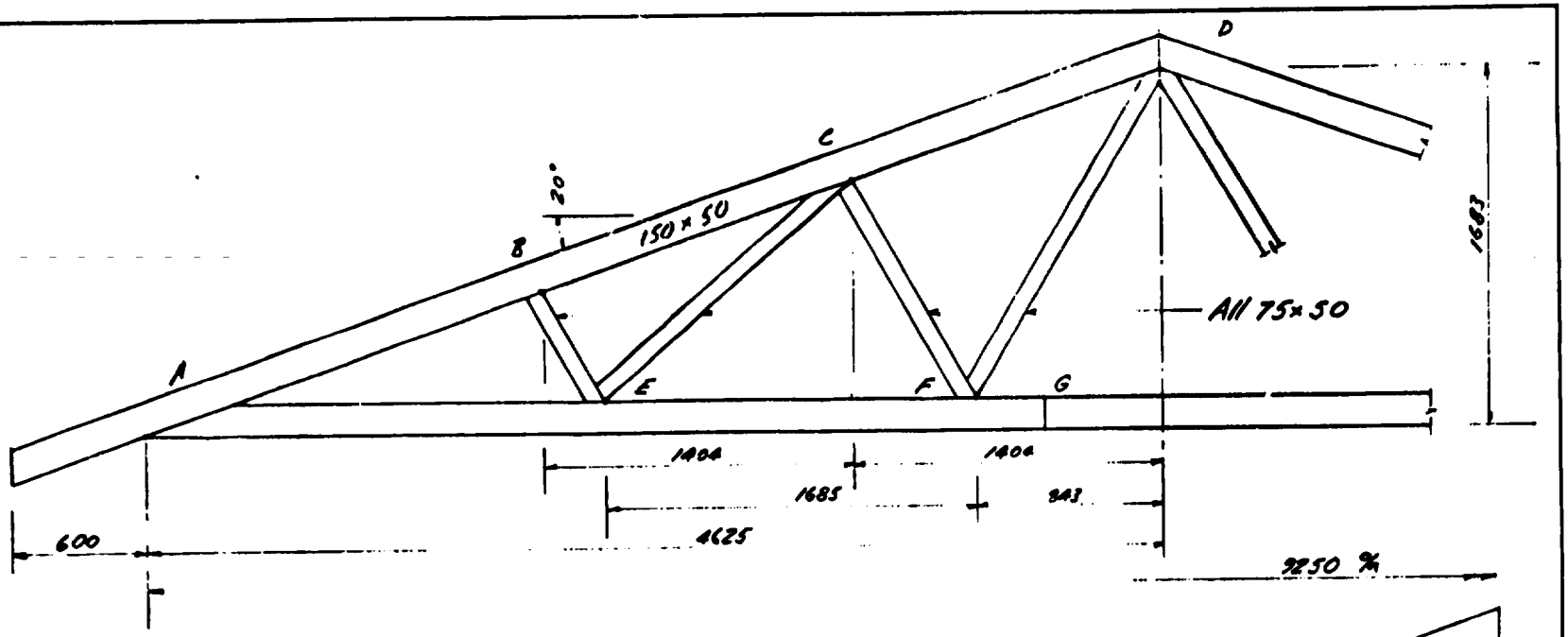
7. The Inspecting Engineer shall send two copies of his report to:

   The Chief P.A.C
   Ref DP/CMR/87/005
   UNIDO
   P.O. Box 300
   A - 1400 Vienna

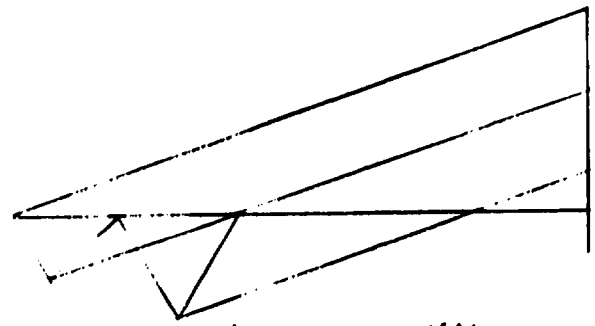

TYPICAL LIGHT FRAMING DETAILS-EXTERNAL WALL
CENADEFOR -ONUDI
NKOLBISSON -CAMEROUN
SCALE 1:20
DATE 18-4-89
DRAWN
APPROVED
CRF
1
Trusses @ 900 crs
Lintel 2/200x25
Sill 100x50
Studs @ 400 mm crs
Blocking
Battens
Joists
Nogs
100x50 stud
Bottom plate
Blocking
Sleeper plate
600 min
400 min
Conc. footing
Block


Typical Interior wall framing
Scale: 1:20
Top plate
Bottom plate
Stud
Nog
Studs @ 600 c-c
Packer
Int wall junction
External wall
Lintel
Jack stud
Floor 20 thick
2430
20
1210
600 min.
100×100 bearer
100×100 post
1500 max
200×200 concrete
150×50 joists @ 600 crs
Max span 2400
End joists doubled
Concrete block found'n wall
Exterior-interior junction
Exterior corner (Section)
(Plan)
Stud
Packer
Stud
Halved Joint
Details
Scale 1:10
G. R. FRANCIS
2


REBATED SKEW CUT WEATHERBOARDS
GENADEFOR - ONUDI
SCALE Full size
DRAWN
CEE 3
Rad 2
15
Detail of anti-capilliary groove.
Scale: 2×F.S.
190
160
30
40
3
11
22
200
140
110
30
40
3
11
22
150
140
110
30
30
4
7
14
150



Note: Timber F11-J3
Maximum truss spacing 3200

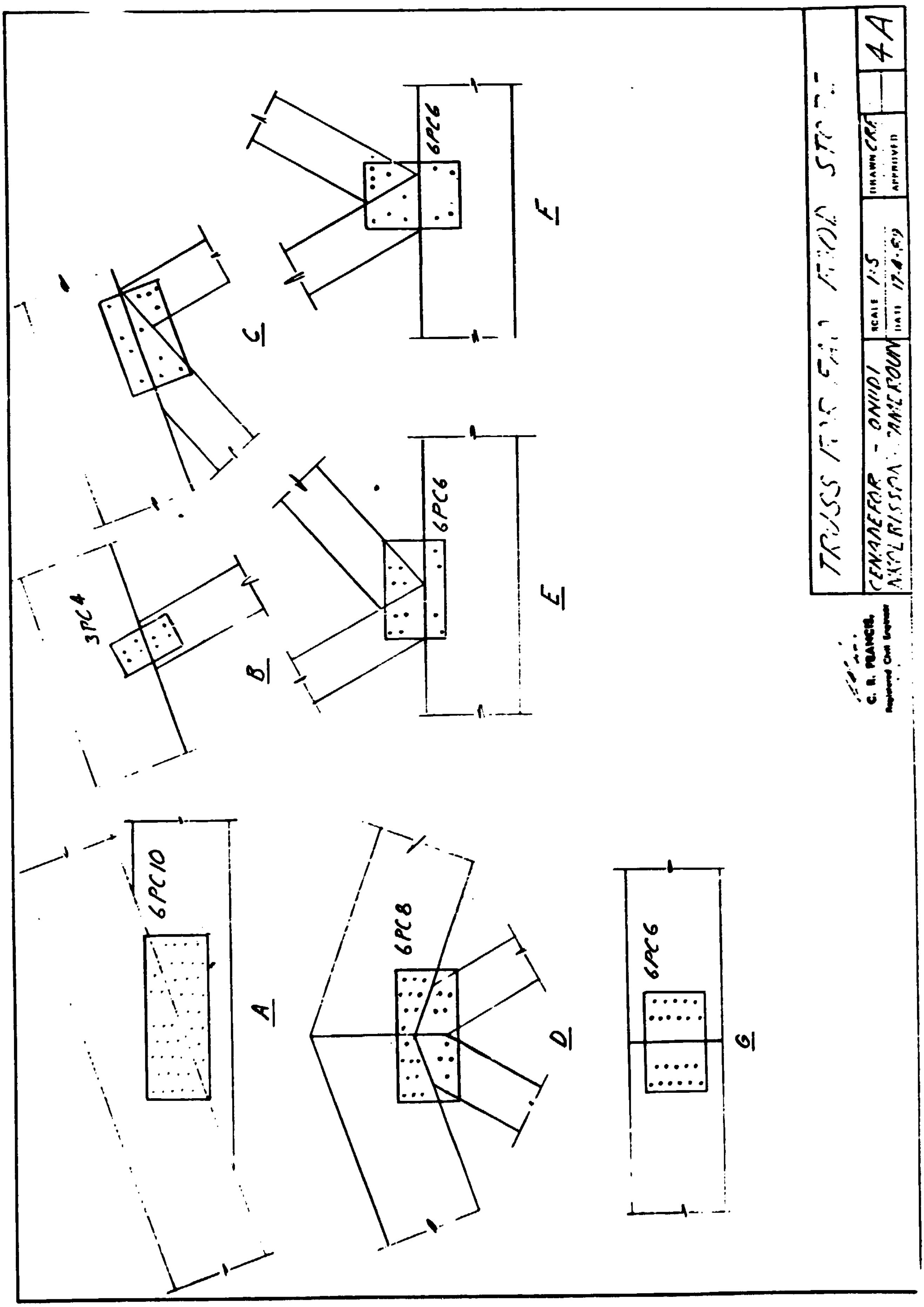


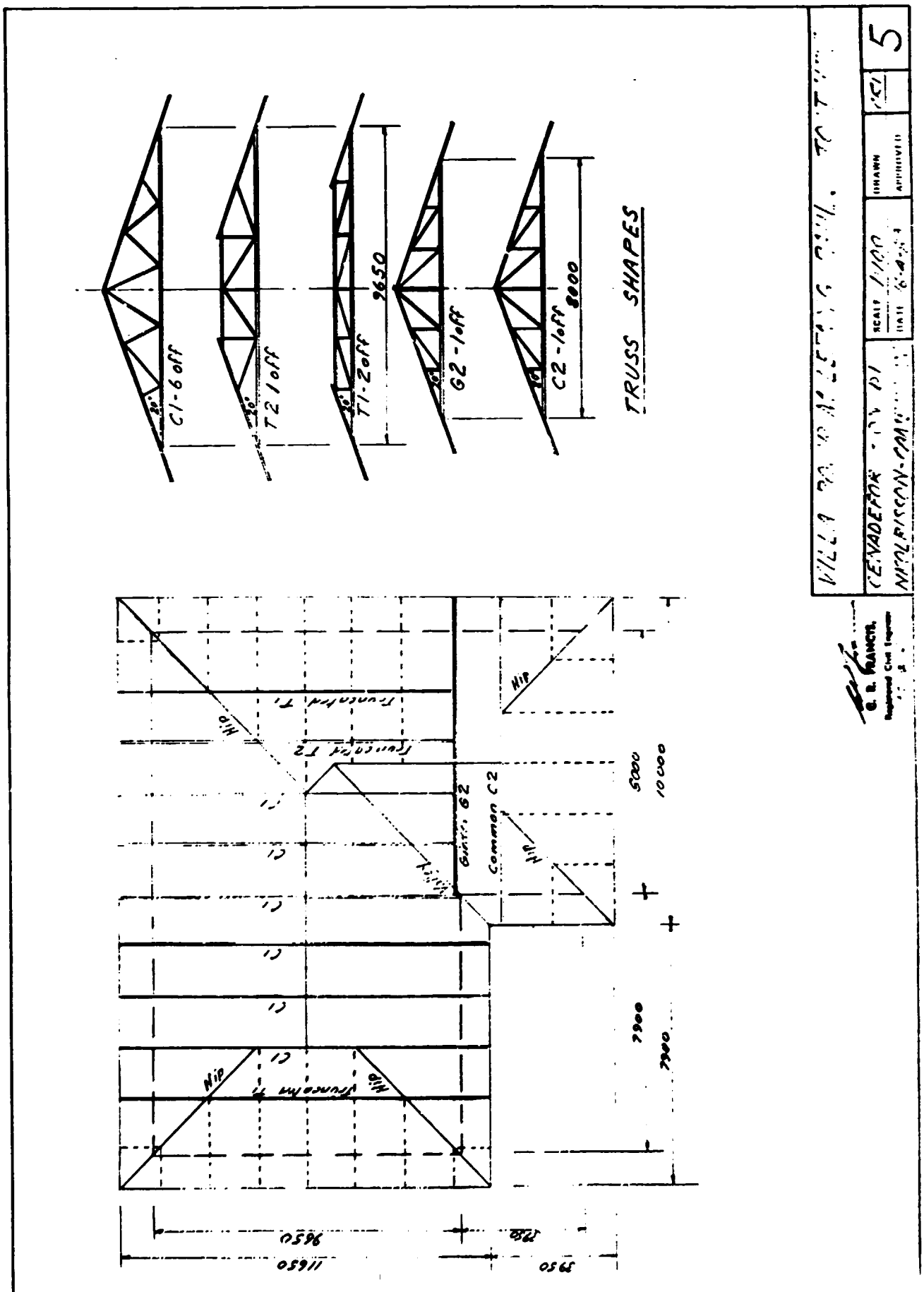
Force diagram. 10mm = 1kN

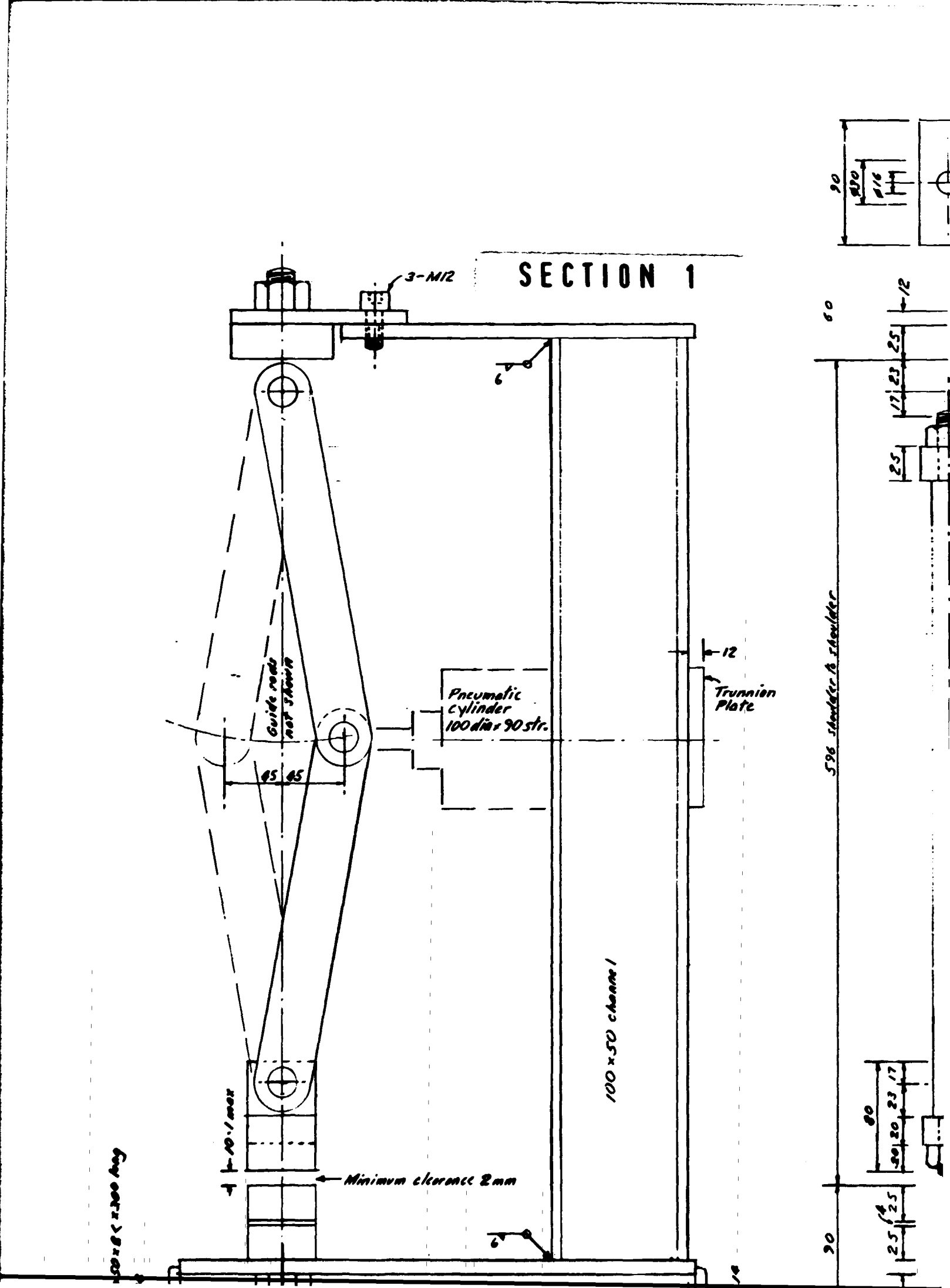
C. R. FRANCIS
Registered Civil Engineer

TRUSS FOR FAC FOOD STORE

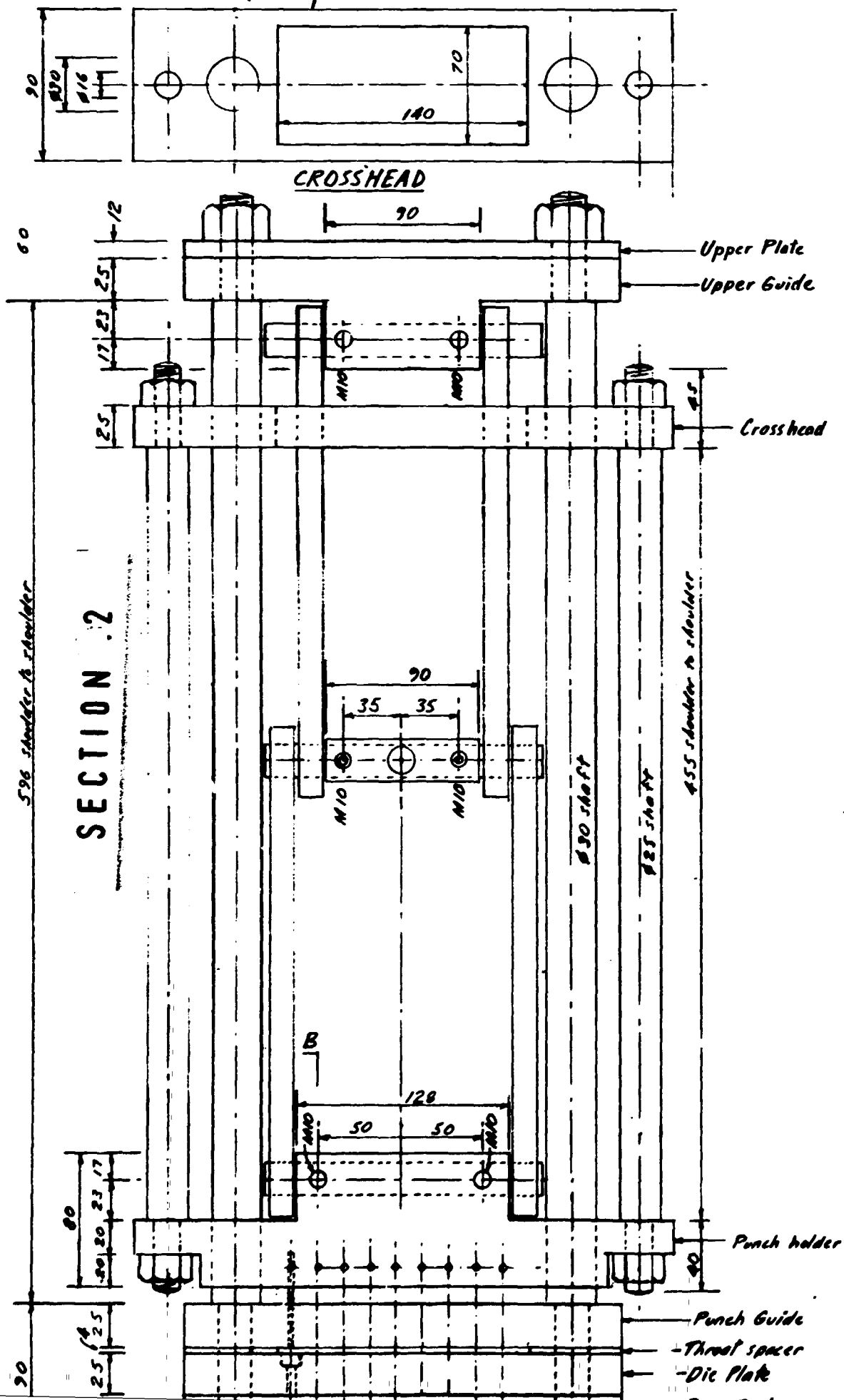
CENADEFOR - ONUDI NAPLES/SICILY CAMPANIA	SCALE 1:20	DRAWN	CRF	4
	DATE 17-4-89	APPROVED		


6PC10
A
6PC8
D
6PC6
G
3PC4
B
6PC6
E
C
6PC6
F
4A
SCALE 1:5
DRAWN CRA
APPROVED
C. R. FRANCIS,
Registered Civil Engineer

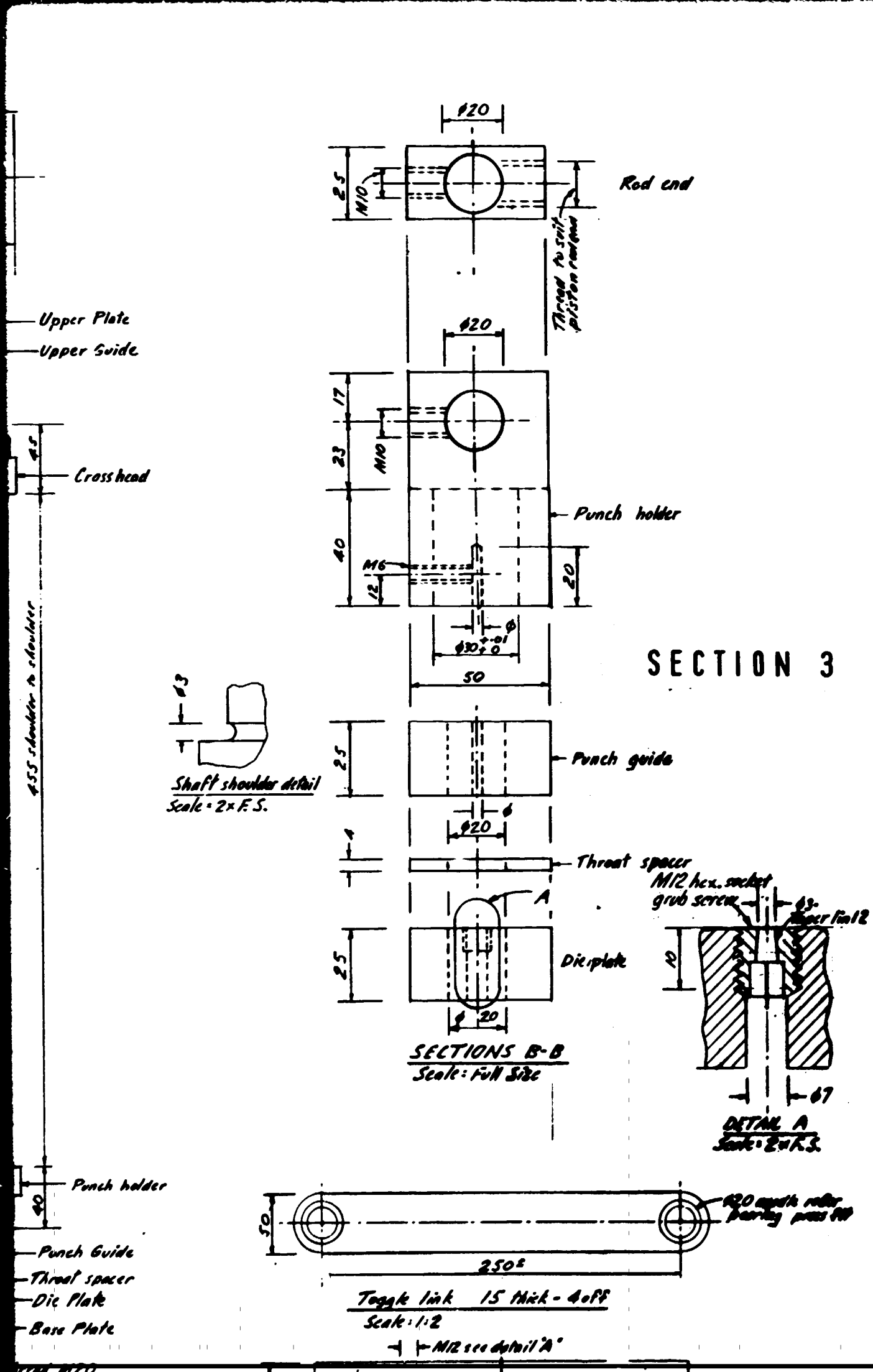

C1 - 6 off
T2 1off
T1 - 2off
3650
G2 - 1off
C2 - 1off
8000
TRUSS SHAPES
Hip
Common T1
Common T2
Common G2
Common C2
Common C1
5000
10000
2500
2500
11650
9650
2000
3950


SECTION 1
3-M12
6
Guide rods not shown
65
65
Pneumatic cylinder 100 dia x 90 str.
12
Trunnion Plate
100 x 50 channel
Minimum clearance 2mm
6
596 shoulder to shoulder
60
12
25
23
17
25
80
20
30
25
14
25

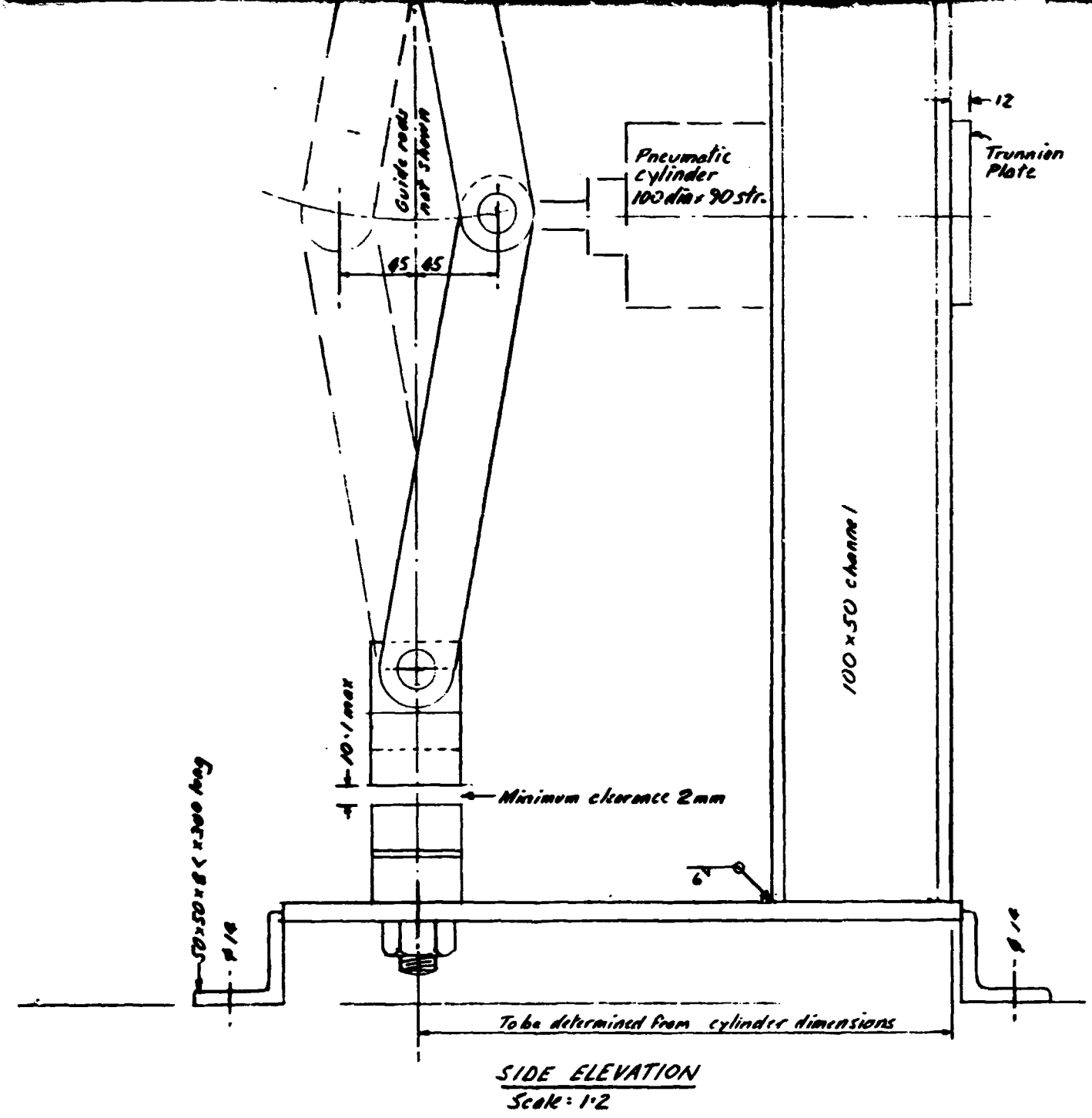
18/-19/20



Shaft shoulder detail
Scale = 2× F.S.

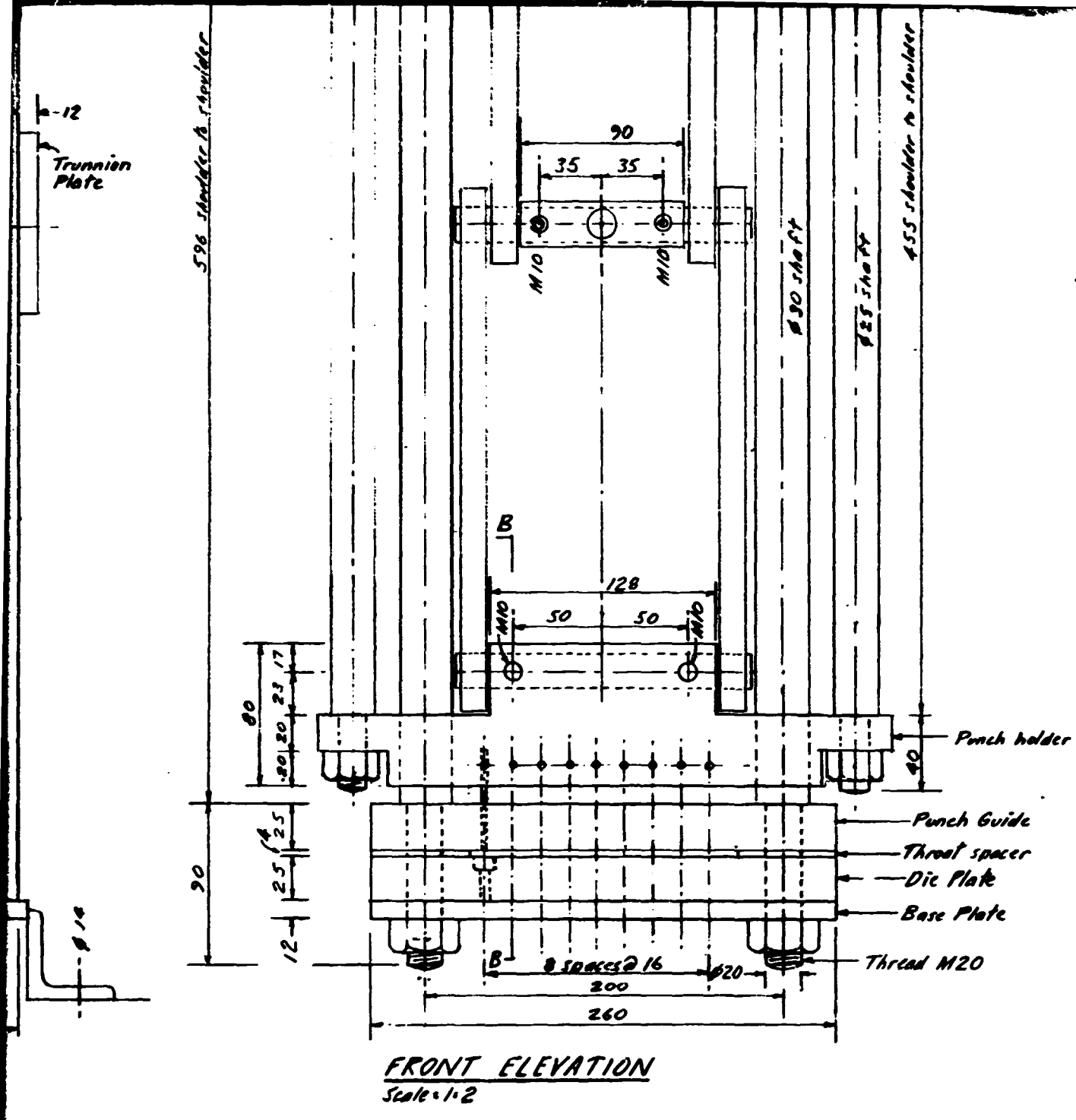

Upper Plate
Upper Guide
Crosshead
Punch holder
Punch Guide
Throat spacer
Die Plate
Bore Plate
Rod end
Punch holder
Punch guide
Throat spacer
Die plate
Shaft shoulder detail
Scale = 2× F.S.
SECTIONS B-B
Scale: Full Size
M12 hex. socket grub screw
DETAIL A
Scale: 2× F.S.
Toggle link 15 Mild - 4 off
Scale: 1:2
M12 see detail 'A'

SECTION 3

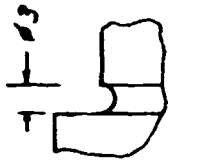


SIDE ELEVATION
Scale: 1:2

SECTION 4

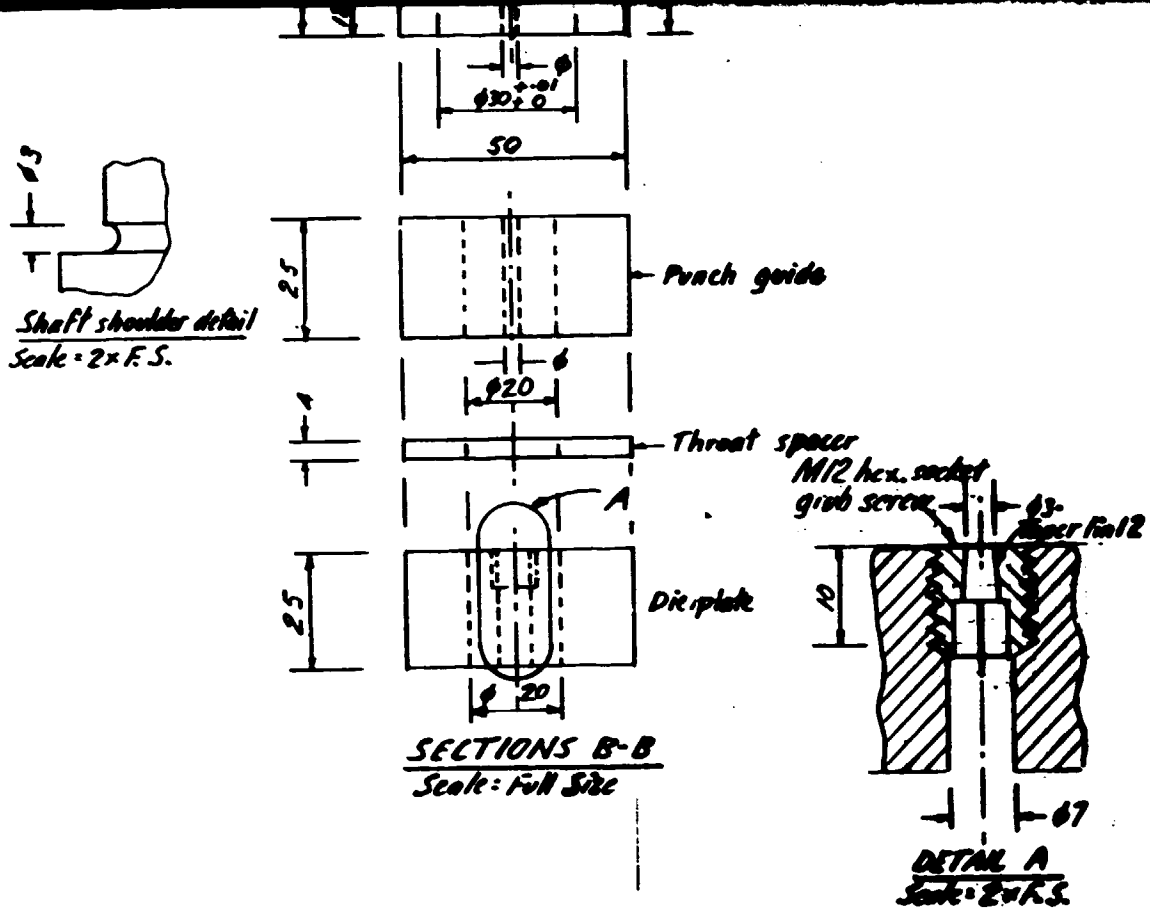


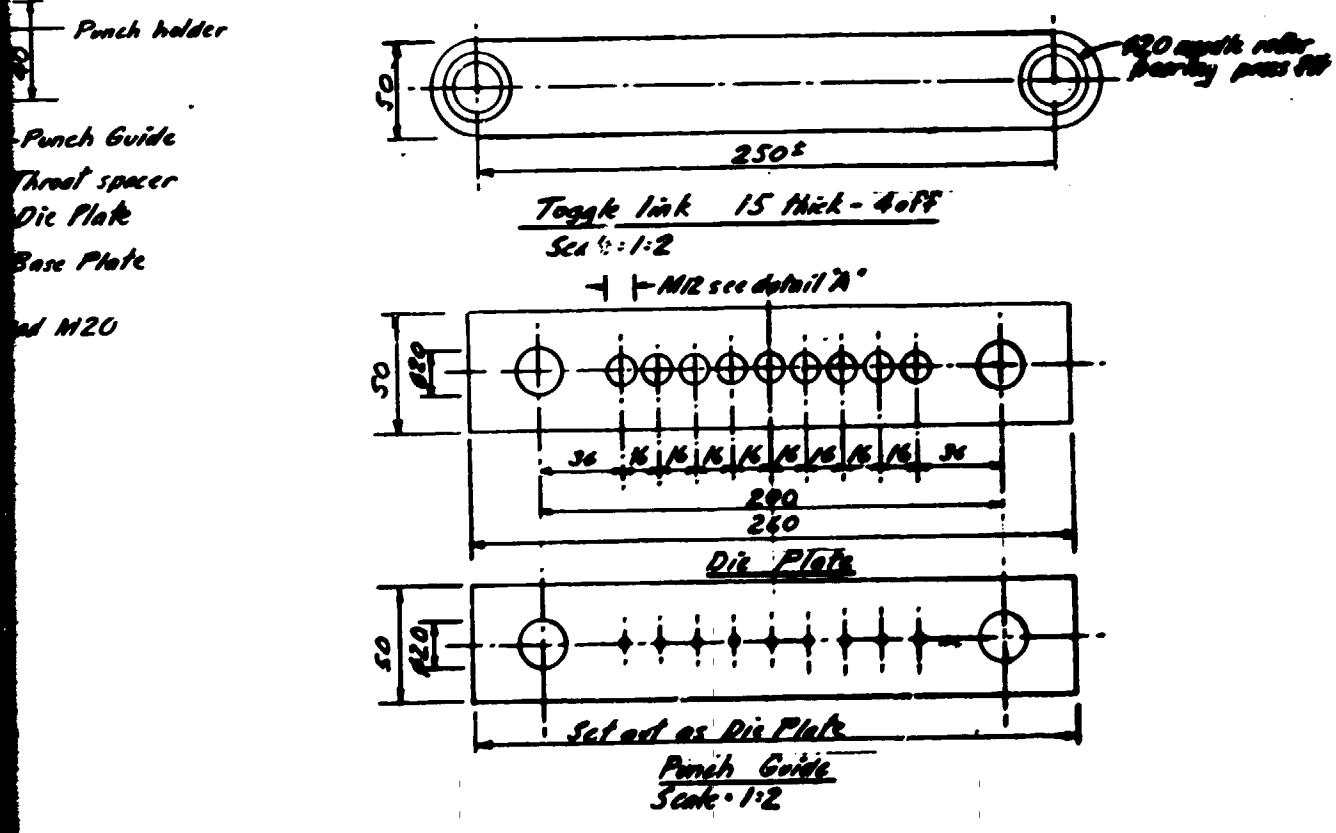
FRONT ELEVATION
Scale = 1:2



Shaft shoulder d
Scale = 2× F.S.

SECTION 5

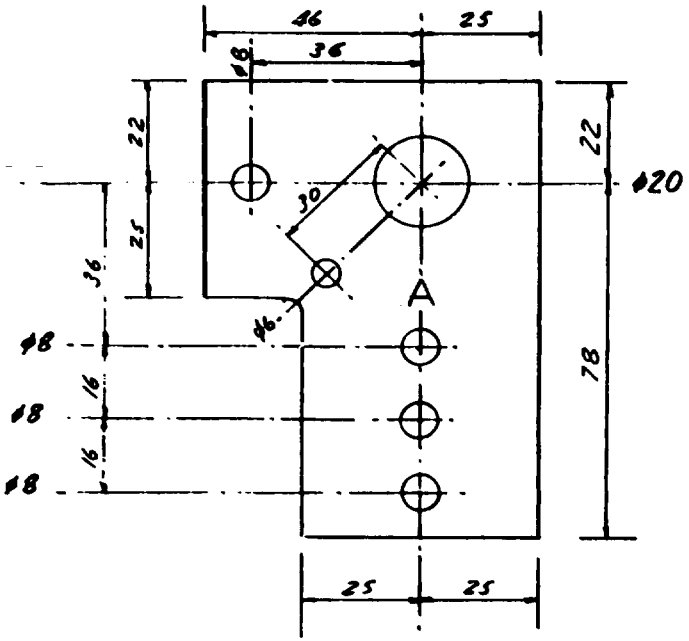




NAIL PLATE PUNCH				
CENADEFOR - ONUDI NKOLBISSON - CAMEROUN	SCALE: As shown DATE: 20-4-89	DRN	CRF	6

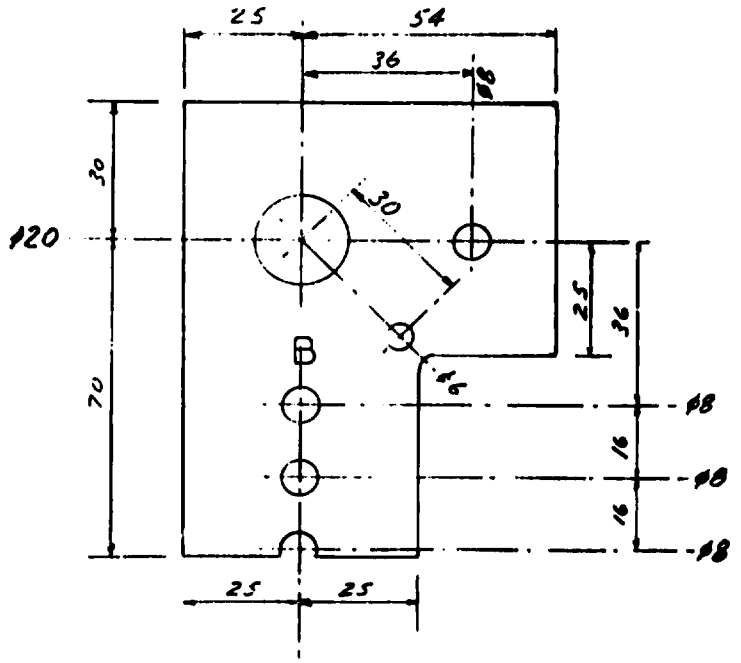
C. L. FRANCIS
Registered Civil Engineer
20-4-89

SECTION 6



SPACER A

Material 4mm mildsteel.
Both faces ground flat.

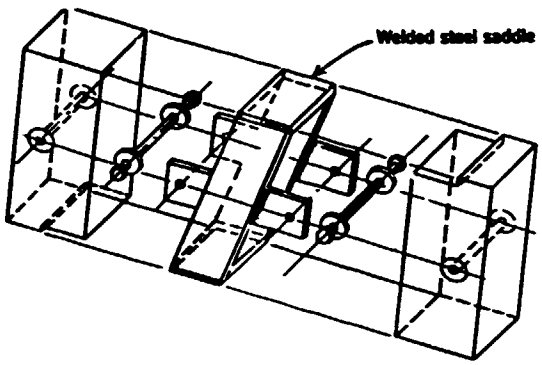


SPACER B

C. R. FRANCIS
Registered Civil Engineer
27-4-89

NAIL PLATE PUNCH - SPACERS

SCALE Full Size	DRAWN	CRF	6A
DATE 27-4-89	APPROVED		



SADDLE TYPE WITH TENSION TIE—EXPLODED VIEW. For moderate and heavy loads. Ends of members are cut square.

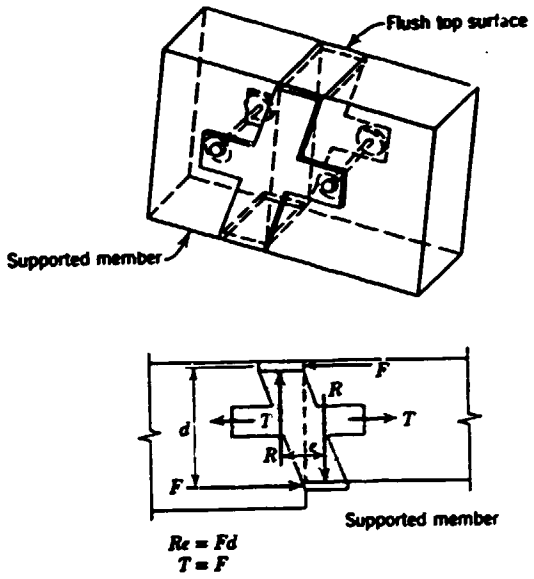
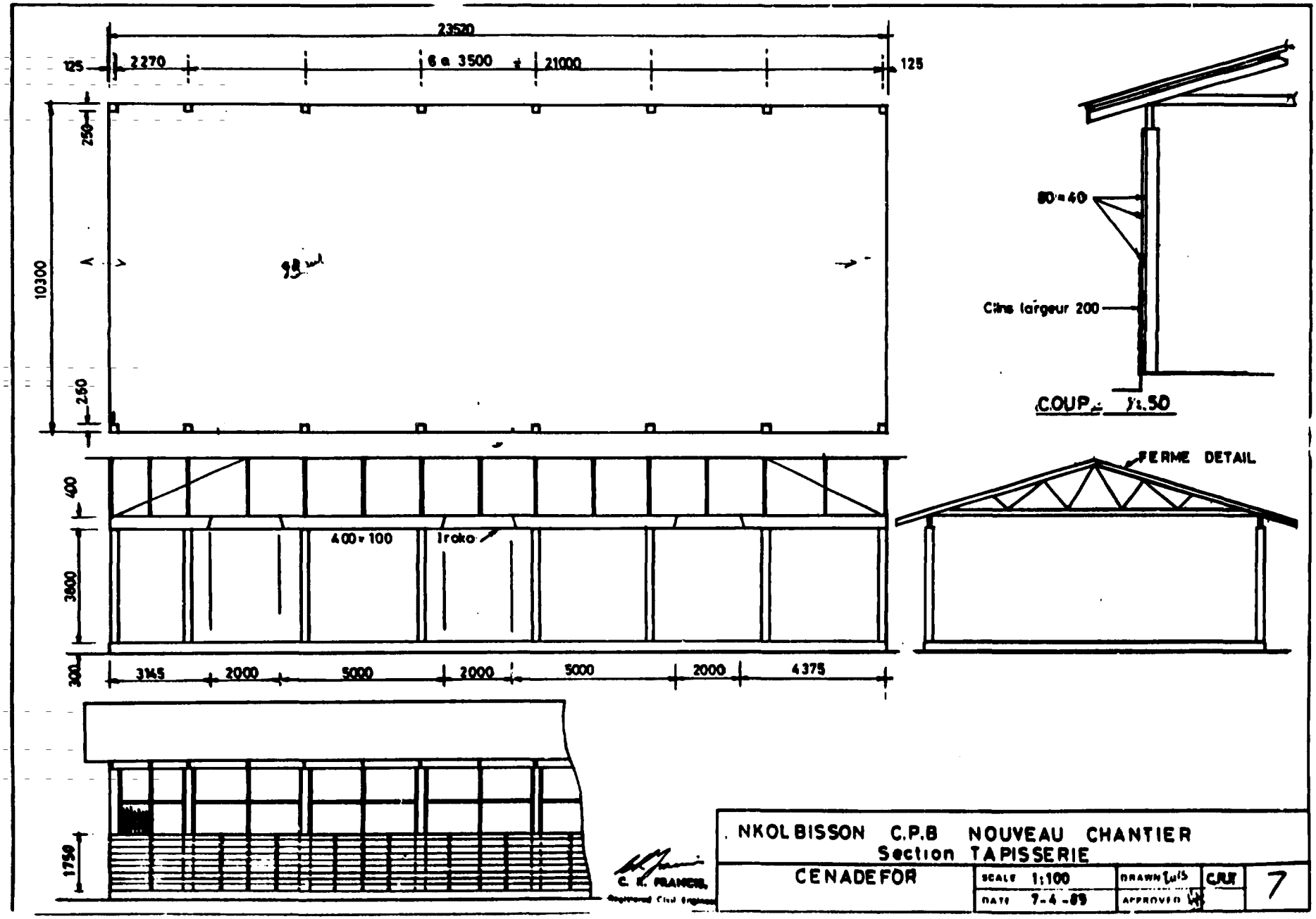


Figure 8. SADDLE TYPE WITH TENSION TIE—ASSEMBLY AND FREE BODY DIAGRAM. In the saddle-type cantilever beam connection, the vertical reaction of the supported member is carried by the saddle side plates and transferred in bearing perpendicular to grain to both the supported and the supporting members by the saddle bearing plates. The rotation of the saddle due to the eccentric loading is resisted by the bearing of the edge of the saddle bearing plate against the end grain of both the supported and the supporting members. To obtain this end grain bearing on the edge of the bearing plate it is necessary to let the plate into the top face of the supporting member and also into the bottom face of the supported member only when both beams are of the same depth. If the supported member is of lesser depth, this end dap on the lower face is not required to obtain the end grain bearing. The tension side plates are used to resist the separation force developed between the beams by the rotation couple of the end grain bearing on the bearing plates, and also to serve as a tension tie where an axial tension tie between the beams is required.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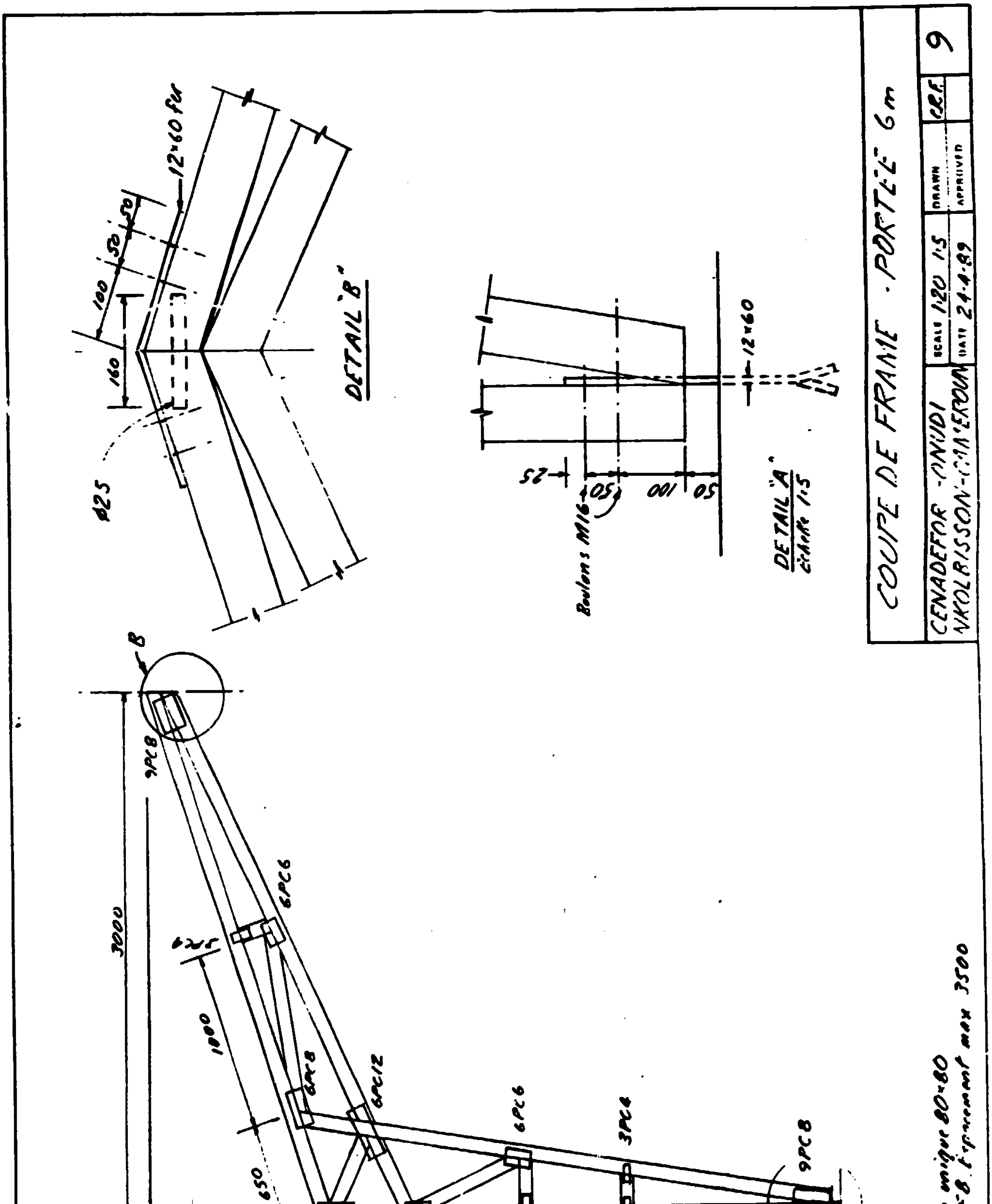
2270
6 a 3500 = 21000
125
250
10300
250
98 m²
80 x 40
Cins largeur 200
COUPE 1:1.50
FERME DETAIL
400
3800
300
400 x 100
Iroko
3145
2000
5000
2000
5000
2000
4375
1750
C. E. FRANCIS
Registered Civil Engineer
NKOL BISSON C.P.B NOUVEAU CHANTIER
Section TAPISSERIE
CENADEFOR
SCALE 1:100
DRAWN Luis
CJU
DATE 7-4-89
APPROVED
7


COUPE DE FRAME · PORTEE 6m
CENADEFOR - ANUDI
NKOLBISSON - CAMEROUN
SCALE 1:20 1:5
DATE 24.4.89
DRAWN
APPROVED
REF.
9
DETAIL 'B'
DETAIL 'A'
échelle 1:5
Boulons M16
Note: Section unique 80x80
Bois F.B. Espacement max 3500