TRAFFIC ORGANISATION IN PAKISTAN

By

M. SADIQ SWATI

September, 1975.

M.C.P. (Transportation Planning),

M.S. (Traffic Engineering),

Deputy Chief (T & C),

Planning Division, Islamabad

TRAFFIC ORGANISATION IN PAKISTAN

By

M. SADIQ SWATI

The problem of safety on highways in Pakistan is very acute. According to the latest statistics available motor vehicle accidents killed 1411 people in Pakistan in 1969. Another 4248 were seriously injured. Pedestrains with 2028 casulties were the greatest sufferers. The total number of accidents during that year were 4609, averaging about 13 accidents per day. This does not include a vast number of accidents which took place on the highways resulting in varying degrees of personal injuries and property losses, but were never reported. On a comparable scale, the casualty rate in West Pakistan is 9 times higher than the United States.

The rate of accidents in Pakistan over the years has steadily increased. All available evidence indicates that the accident rate in the future is bound to increase sharply. As a confirmation of it, the latest statistics available for Punjab indicate that since 1973 a total of 3763 person have lost their lives & another 7841 were injured in road accidents. The property damage during the period is estimated at Rs. 500 million.

In this country the time has long passed when it became abundantly clear that the traffic situation was deteriorating rapidly. Even though the problem is enormous, it is not impossible to solve. As a matter of fact, it is the indifference and pathetic attitude of all those concerned rather than the physical size of the problem which is causing deep concern in the planning circles in this country. The problem, no mattar how big, can be tackled provided those directy concerned with it are aware of its existence and are competent and determined to eradicate it.

State of the Art.

After decades of concerted research in the United States and other western countries, it has been established that the key to the traffic problems lies in a simple principle known as Three E's namely Engineering, Education and Enforcement.

Engineering.

By engineering is meant physical facilities adequate enough to handle the traffic demand. Very broadly it includes roads with adequate width to accommodate the traffic; standard traffic control devices, namely signs, signals and marking to guide the motorist along the route with speed and safety ; and removal of conflict points by providing grade separation structures.

It is obvious that the road facilities existing in this country are outmoded. Inadequate sight-distances, narrow widths, high grades, absence of access control and grade separation structures are the factors contributing to high tolls on our roads.

The problem of safety is further complicated by the absence of facilities to segregate fast and slow moving traffic. The speed differential created by the presence of animal drawn vehicles in the traffic stream is undoubtedly one of the most dangerous situations faced by the drivers on our highways.

Another important factor contributing to higher accident rate is the shortage of transport. This is demonstrated by the large number of people involved in traffic accidents while travelling by public transport. The buses are usually crowded. The majority of the buses, being privately owned, engage in dragracing for the sake of maximum profit, thus endangering the lives of the passengers.

Education.

It is of utmost importance that those who are privileged to drive a vehicle should thoroughly know the rules of the road. They should be well aware of their rights and limitations to avoid creating a hazardous situation on the roads, endangering their own as well as other people's lives.

As far as education is concerned, it wonid be safe to assume, without the fear of contradiction, that the majority of the drivers are ignorant of modern traffic safety rules. Their knowledge of traffic safety laws is limited to elementary hand signals used by traffic constables at street intersections.

In a period of more than 4 years, 99.9 % of the locally licensed drivers interviewed by the author had no concept of such basic thing as Right-of-Way. 99% admitted that they derived their knowledge directly from the person who taught them how to drive a vehicle which primarily consisted of lesson in stearing, stopping and starting the vehicle. Nobody remembered seeing the Highway code.

The Traffic Police Foot Constables, and even some of the officers were found to be totally ignorant of the Traffic Safety Rules.

Traffic Enforcement.

Enforcement holds the pivital position in the whole gamut of Traffic Planning. Without proper and effective enforcement even the best and most modern highway facilities would be helpless to cope with the traffic problems.

A modern traffic police officer has varied responsibilities. He has to be adopt in the art of providing first-aid to the injured in an accident ; should be able to investigate and analyse an accident methodically and systematically ; and should be skilful mechanic to provide necessary aid to stranded drivers. He has to be firm, courteous and pleasant. Above all, he should command respect from the road users, which entirely depends on how well versed he is with his job.

Unfortunately traffic police in this country are in every respect one of the most ill-equipped enforcement agency in the world. Neither are they imparted sufficient training in the art of traffic control nor do they have adequate powers to make speedy enforcement. Even nominal training in the art of traffic control which traffic foot-constable used to reveive in the past, is at present frequently dispensed with. The majority of the traffic constables are unaware of the traffic laws and regulations. As a result traffic offences occur under their very-noses without their being aware of it. The pathetic attitude of the public towards today's traffic constable stems from the fact that the poor fellow is not properly groomed for his job and in many cases he is unsure of himself. The result of such past policies is self evident.

Previously a traffic foot constable was authorized to chalan the traffic offender but under Traffic Ordinance 1965 these powers have been withdrawn. Now the traffic foot-constables are mainly engaged in watching traffic, at intersections, go by. The motorists consider him as spectators and treat him with contempt. As a result he is liable to be intimidated by uppish drivers, who are well aware of his lack of authority, familarity with rules and regulation and general helplessness on his part to cope with the situation.

Another serious disadvantage suffered by the traffic constable is that he is not properly equiped to do the job. In majority of the cases he is immobile and can not persue and apprehend the offender who decides not to stop.

Fundamental Problem.

Analysing the three E's name'y Engineering, Education and Enforcement, in the context of conditions prevailing in the country, and to determine the root cause of the accidents, traffic chaos and other related problems, it is obvious that the engineering facilites though not par excellence, are adequate for the existing traffic density on various routes and cannot be held responsible for the majority of the accidents. This is further borne out by the fact that even on the routes such as Karachi-Hyderabad super highway, the accident rate has not decreased. Serious engineering deficiencies however exist in terms of signs and signal to guide the motorists with safety, but again very few drivers pay any heed to them even where these do exist. Hence lack of proper signs and signals canot be blamed for a great majority of accidents either.

This leads us to the other two factors, namely Education and Enforcement. Since road users, enforcement staff and general public alike are ignorant of the traffic safety rules, therefore, complete confusion and chaos is the natural consequence. Imagine the outcome of a game where players and the rafree both do not know or observe the rules. It is therefore, obvious that to improve the road safety our best chance lies in alleviating the diffi ulties in the two areas namely Education and Enforcement. However this does not in any way imply that road improvement are not reguired for safer and comfortable operation.

Proposed Measures.

The author is well-aware of the fact that building of physical facilities, driver education and creation of an effective enfrcement agency shall require considerable capital which is beyond the resources available at present, How ver. a scheme of things can be evolved in which at least a beginning can be made to put the traffic organization on a sound basis.

The proposed concept is neither a novelty nor is its validity limited to any geographical area of the world. tt has been evolved over the years and has stood the test of time.

Some of the measures that need to be implemented without any further delay are as follows :-

1. **Driver Education:**

Driver education in this country is one of the most neglected fields. No

systematic programme for driver education exists today. As yet, there is no realization of the fact that in order to cope with today's complex traffic problems, a driver has to h.ve much more than simple ability to drive a vehicle. The traffic scene on our streets today makes a very dismal pictu e and so many unnecessary accidents occur and innumberable narrow escapes take place every hour primarily because of ignorance of traffic safety laws and regulations on the part of the majority of the drivers. Similarly a lot of traffic safety rules are violated daily by a large number of road users un-knowingly and by misinterpretation of the rules.

One of the critical areas of highway safety is constant and continued driver education. The fast and rapid rate of technological developments in the field of highway transportation brings numerous new problems in their wake. Also, some of the problems are so complex that it is difficult for an average driver to comprehend them on his own. Even in the countries with the highest literacy level, this point is brought out d.ily and great emphasis are placed on driver education on continuing basis. Sporadic traffic safety drives do not fulfill the need.

There are three fundamental problems of driver education namely :-

(*a*) Education of the drivers already possessing valid driving licenses.

(*b*) Education of the driver to be licensed in future.

(*c*) Traffic safety education of the general public.

The most pressing problems, as far this country is concerned. today are the a & c. The following measures are proposed to alleviate the situation :-

(*a*) **Education of the already licensed drivers:**

The following measures have to be adopted to achieve the goal :-

(*i*) The first thing that has to be done is to update the 'Highway Code, published by Ministry of Communications in June, 1965. The code has become out moded and does not cover the entire range of Highway Safety regulations. The code should also be translated in Urdu. This should be done by experts in the field of traffic engineering.

(*ii*) The cover for the Highway Code should be designed in such a way that every licensed driver should have his personalized copy.

(*iii*) The Highway Code should then be handed over to a reputable publishing firm for printing and sale through their normal channels at Rs. 5/- per copy.

(*iv*) The money thus earned (sale price - printing and sale/service charges) should be placed at the disposal of the Traffic authoities for installing needed traffic signs, signals and other safety measures.

(*v*) An executive order should be issued, requiring every licensed driver to own a personal copy of the code. The Post Office Department should be directed not to renew the license of any driver not possessing personal copy.

(*vi*) The most important of Highway Safety Rules should be prepared in a 10" × 16" poster form and displayed in two prominent place in each public transport. The poster should be aimed at the travelling public, informing them of their rights and obligations. This would help policing of the rash and negligent drivers by the travelling public and would discourage the flagrant violation of the rules by the public carriers which is a frequent occurance today.

(B) **Education of the future driver.**

Perhaps the most effective way of driver education is to teach high school students various safety measures and **inculcate** in them the spirit to faithfully follow those rules. This method has proved to be a most valuable tool in the hands of transportation safety planners and traffic engineers. Also properly equipped driving schools should be opened all over the country and every future professional driver (chaufer) should be required to undergo training from one of these driving schools as a pre-requisite for issuing a driving licence.

(c) **Traffic Safety Education of the Public.**

The general public must be made aware of the rules of the roads so that they should know their rights and limitation and avoid creating hazardous situations inadvertantly. The following measures should be adopted :-

(*i*) The daily newspapers, Urdu as well as English, should be persuaded to publish one Traffic Safety rule from the Highway Code each day as a public service and without charge.

(*ii*) T. V. should project Traffic Safety slogans such as "Drive Carefully". "Watch out for the other Guy", "Drive Defensively", "Heed Safety Rules" and "Observe driving courtesy" as public service ads.

(*iii*) The programme announcers and disk jockeys of Radio Pakistan should be asked to drop safety hints in between the programmes.

(*iv*) Traffic Safety documentaries should be telecast weekly from T. V. Station and also shown in the cinema houses.

The proposal beside involing no extra financial burden shall also inculcate the spirit of self policing in the road users once they are aware of their right and obligations This is essential since it is not possible for the traffice police to monitor the movement of each vehicle. Also in case of mishap. every driver would know who was at fault and not decide the issue with their fists as is being done at present.

2. ENFORCEMENT

To correct the situation the following measures should be adopted :-

(*i*) The Traffic duties should be entrusted to only these foot constables with education at least upto Matriculation. The task of traffic operation and control is too complex for an uneducated or Semi-literate person to comprehend. There are a number of foot constable in the regular Police Force with the requisite qualification whose services can be secured by transfer. Those without the desired qualification, who have entered the traffic police organization on various grounds, be sent to the regular Police Force.

(*ii*) The powers of the foot constables to issue tickets for traffic violations should be restored forthwith.

(*iii*) Each traffic constable, seargent, etc. should be supplied with his personal copy of the Highway Code.

(*iv*) Every foot constable on roving duty should be provided with a motor cycle for speedy and prompt apprehention of the traffic offenders.

(*v*) Every traffic cop should be properly trained for the job and the training period should be minimum of six months.

(*vi*) Traffic Police should de-emphasise the checking of papers etc. and concentrate on moving violations such as failure to yeild. R.O..W, dangerous and reckless driving etc.

3. LICENSING PROCEDURES :

The existing licensing procedures are very archiac and outmoded. At the top of this, the task of issuing of the licenses and administring the driving tests are frequently entrusted to the people who are themselves not able to drive. I do not want to go into the details of malpractices in issuing driving licenses and conditions prevailing in the Traffic Police departments, but I do not believe there could be any two opinions on the issue.

To check the growing menance of semi skilled drivers on our procedure and bring standards to an acceptable level.

The following suggestions are offered :-

(*i*) Before a permanent driving license could be issued the applicant should be given a test comprising of 100 short answer type questions covering the entire range of safe driving practices and rules and regulations as given in Highway Code. The pass level should be 95%.

(*ii*) Those qualifying the written test should be given a driving test by somebody who is a competent driver.

(*iii*) Apart from written and road test. a parallel parking test should also be given. This requirement is of c itical importance if we have to get rid of artificial congestion caused by improper parking at various public places.

4. STANDARD PENALTIES FOR TRAFFIC VIOLATIONS

Another very serious problem with the existing system is the lack of streamlined procedure to adjudicate the traffic violations. The process is archaic and cumbersome. It does not recognize the fact that the majority of the violation are not criminal acts and hence do not need to follow criminal procedure of justice. 90% of the violations are minor infractions of the law. All the developed countries of the world recognize the difference and have devised standard penalties for most of the traff c violations. The fine for these infractions can be paid witnout appearing before a court. The court appearance is necessary only for major offences such as invovlement in an accident, leaving the scene of an accident, and for those who want to plead "Not Guilty", and habitual offenders.

Relaxing the reguirement of court appearance for minor traffic violations would ensure prompt and proper disposal of the serious cases more ju diciously.

A list of common traffic violations and their standard panalties is given below :

S. No.	Violation	Penalty
	Moving Violation	
1.	Speed v olation less then 20 mph above the speed limits	Rs. 25 00
2.	Improper turn (turning from wrong lane)	Rs. 15.00
3.	Improper turn (without proper signal)	Rs. 10 00
4.	Improper U-turn	Rs. 15 00
5.	Prohibited turn	Rs. 20.00
6.	Disobeying Stop sign	Rs. 25 00
7.	Disobeying Red Signal	Rs. 40.00
8.	Disobeying Yield sign	Rs. 20.00
9.	**Improper overtaking.**	
	(*a*) At intersection	Rs. 25.00
	(*b*) At curve	Rs. 50 00
	(*c*) At hi l.	Rs 40 00
	(*d*) At "No passing" zone	Rs. 50 00
	(*e*) Cutt ng in after overtaking	Rs. 25 00
	(*f*) Passing on the left (excep when vehicle in front is making right turn).	Rs. 50 00
10.	Improper lane usage (straddling).	Rs. 25 00
11	Failure to yield the Rig t-of-Way	Rs. 50 00
12.	Following too closely	Rs. 25.00
13.	Reckless driving	Rs 50.00
14.	Careless driving	Rs. 30.00
15.	Tooting horn silense Zone	Rs. 5 00
	Parking Violations :	
1.	More than one foot from the curb	Rs. 10 00
2.	Parking on a sidewalk	Rs 20 00
3.	Less than one foot from another car	Rs 0 00
4.	Parking on a crosswalk	Rs. 20.00

S. No.	Violation	Penalty
5.	Less than 10 ft. from fire hydrant	Rs. 10.00
6.	Less than 30 ft. from a Stop sign	Rs. 15.00
7.	Less than 25 ft. from intersection	Rs. 20.00
8.	Parking in a No-Parking Zone	Rs. 30.00
9.	Overtime parking	
	a. At the meter	Rs. 5.00
	b. Restricted parking area	Rs. 10.00

The court appearance should be required only in the following cases :-

1. More than two moving violations in twelve months period.
2. Drunken driving.
3. Accident involvement.
4. Leaving the scene of accident.
5. Pleading not guilty.
6. Driving with revoked licence.
7. Speeding more than 20 mph over speed limits.
8. Ignoring the traffic officer's signal to stop.

The traffic violation ticket should be issued in triplicate. One copy should be given to the offender, second copy should be sent to the fine collection agency and third copy retained for record.

Since the fine collecting agency is usually the same where the road user pays his license renewal fee and road tax, they should be instructed not to renew the licence & registration or accept token tax if there is outstanding due against him.

Also every serious violation of law should be recorded on the license of the offender and the license of the habitual offenders should be revoked.

5. Updating Traffic Rules And Regulation :

As has been mentioned earlier that rapid technological development are taking place in the art of traffic control and operation. Vehicle dynamics are changing, social and cultural patterns of vehicular travel are changing and new discoveries are taking place in all traffic related fields which have to be made use of. The laws and regulations govering the traffic have to be updated on a continuing basis. The following are immediately required.

(a) Updating Highway Code :

The existing traffic rules were framed in 1939. Over the years they have been modified and amended (the latest revision in 1965) but stiil they do not cover the full spectrum of transportation problems. The art of transportation planning and traffic control has come a long way since 1939. The modern day transportation and traffic problems are too complex and intricate to be solved by amendment to outmoded and archaic methods of 1939.

The existing rules are limited only to the basics and do not cover the entire range of Traffic Safety Regulation. Consequently they do not provide adequate protection to the drivers under all conditions. It is therefore essential that these laws should be immediately updated by an expert in the field of traffic engineering.

(b) Manual of Uniform Traffic Control Devices :

At present, no such manual exists to govern the installing of traffic control devices. Consequently, these devices are erected in a very haphazard way, without regard to the need. The erection/installation of these devices is governed by individual whims. As a result they often create more problems than they solve. To overcome this difficulty, it is suggested that a manual should be prepared to establish minimum and maximum warrants for such traffic control devices as signs (regulatory, warning, guidance, etc.), signals, makings, channelization (exclusive turning lanes, islands, etc.) and other highway signs essential for guiding the mortorists with speed and safety under all conditions.

6. Vehicle Registration And TAX Collection System :

The existing arrangements of collection of road taxes, licence fees etc. has proved to be a failure and must be scrapped. There is no coordination between registration and tax collection agencies. No reliable and uptodate data are available regarding road statistics, since 1969, the time the job was entrursted to the Post Offices. Evasion of road taxes is wide spread. Also the existing registration laws do not make any provision for scrapping the vehicles once registered, even if the vehicles once registered, is junked. As a result the number of vehicles actually on road and number of vehicles registered are not the same, which creates confusion.

The following measures are proposed :—

(*i*) The task of collecting road taxes, licence fees etc. should be handed over to a bank with computer facilities.

(*ii*) The bank should be required to submit quarterly return regarding number of vehicles paying taxes.

(*iii*) To eliminate the evasion of tax, a computer card should be prepared for each vehilce in the country. The bank should keep tabs on each vehicle whether or not paying taxes and reason thereof. If the vehicle is scrapped the information should be duly recorded with the help of the computer. Similar tabs can be kept on traffic offenders who have not paid their fines or have been convicted of serious traffic offences.

7. Accident Reporting And Accident Record :

The accident reporting and record keeping leaves much to be desired. The accident reporting form used at present does not give all the information regarding the accident which is so vital for the purpose of proper analysis of the causes of the accidents and the remedial measures needed to alleviate the problem. Also, no systematic record of the accidents is kept.

In order to enable the engineer to determine what improvements should be made to alleviate the accident problem at any given location, it is essential that he be furnished with a complete record of accident experience at that location. The record should be precise, unambiguous, and encompassing all aspects of the problem.

Accident is defined as an error in driver-vehicle-roadway system and it must be recognized that different types of accidents are caused due to different factors. It is usually possible to identify the cause of accidents at any given location by the predominent type of accidents occuring at that location, namely, rear-end ; side-swipes ; head-on ; night-time ; bad-weather, etc. For each of these types of accidents, separate remedial measures are required. For instance, predominance of rear-end accidents will indicate slippery pavement whereby the drivers have difficulty stopping in the time. Side-swipe accidents will indicate ambiguous traffic control devices, causing confusion among the drivers regarding right-of-way Head-on collisions signify lack of adequate sight distances at the location. Predominance of night-time accidents at the location will indicate serious problems with night time visibility. Bad-weather accidents can result due to a road pavement which becomes dangerously slippery when wet or it may be due to inadequate signs for inclement weather. Similarly, there are numerous other types of accidents which occur due to a variety of reasons. The job of the accidents analyst

therefore is to relate the accidents experience at any location to one or more causes. The state of the art permit such treatments The tools normally employed are, Accident Spote maps, Condition Diagrams and Collision Diagrams etc.

In view of the above, it is imperative that an accidents report form must be devised which will give all the necessary and relavant information in clear and precise terms. Also, the record of the accidents should be kept properly.

8. Reducing The Licencing Of Horse-Drawn Carriages :

Perhaps the greatest safety problem facing the developing countries today is the lack of segregation of slow and fast moving traffic. It has been established that the speed differential resulting from the presence of slower moving traffic in a traffic stream has the greatest potential for hazard. It is in view of this recognition, that in developed countries of the West, it is now customary to post minimum speed limits on all important roads. It is as much illegal to drive below the posted minimum speed limit as it is to exceed the maximum posted limit.

The flow characteristics of the two means of locomotion, namely horse-drawn carriages and automobiles, are so different that it is not possible to combine them with harmony. The only satisfactory solution available at present is to segregate the two modes of travel. Unfortunately, our financial resources do not allow building of separate facilities for slow moving vehicles. Consequently, the only alternative availables is to gradually eliminate the horse-drawn carriages from our arterial and other important roads.

10% of the registered horse-drawn carriages should be mandatorily eliminated every year. Thus it will take 35 years to completely eliminate the last of the horse-drawn carriages but in seven short years the number of horse driven carriages will be reduced to 50% of the existing number.

9. Organizational Reforms :

To implement the proposed measures it is suggested that a traffic organization at local (municipal), regional (district), and provincial levels should be created in each province.

(*i*) Municipal Traffic Engineer :

At the local level each municipal committee of greater than 100,000 population in the country should be asked to hire a qualified traffic engineer or arrange to train one of their engineers for supervising modern traffic control and operation within the urban area. The local governments should be required to regulate

traffic flow, parking etc. The municipal government should be empowered to frame legislation to back the Zoning regulations establishing no-parking zones, one-way streets, loading and unloading zones and closure of certain streets to automobilies in general or for certain types of vehicles. The city and municipal government should be empowered to impose and realize the fines for various traffic violations committed within the city limits.

(*ii*) District Traffic Engineer :

At the district level, a qualified traffic engineer should be posted in the office of S.S.P. and entrusted with the job of planning and installing traffic control devices on the roads outside the jurisdiction of municipal corporations/ committees and investigation of accidents and their analysis. He should work closely with the District Traffic administration.

(*iii*) Provincial Organization :

The provincial level agency should be entrusted with the job of policy making. Its responsibilities shoud include drafting suitable legislation for effective traffic police training programmes for the entire province ; modernizing and simplifying the traffic code, licensing regulations, traffic fine collection methods and organizing Traffic Safety education for the general public through the help of the media, (radio television and newspapers) etc.

Conclusion :

It is felt that the problem of traffic safety in the past has not received the kind of attention deserved. The majority of the past efforts in this regard were not only inedquate, but they were also misdirected. No proper framework was created to cope with the problem on a systematic basis. Also, the methods used were archaic, whimsical and short sighted.

It seems that the problem of traffic safety on our roads and highways has already reached crises proportions. Any further delay in initiating the programmes based on modern scientific principles, will have disastrous consequences. The time is running out rapidly.

It is therefore, proposed that prompt measures should be taken to avert the danger before it gets out of hand. The proposed measures if adopted can help organize the traffic in this country on scientific basis and keep alleviate the problem of Safety on our streets and highway at a very little cost.

ALIGNMENT AND SHAPE OF A SPUR HEAD

By

S. M. AYOOB
Secretary,
Irrigation & Power Department,
Punjab, Lahore.

CH. MUHAMMAD ALI
Principal Research Officer,
Irrigation Research Institute,
Lahore.

CHAPTER I

OBJECTIVES OF RIVER TRAINING

A controlled river is a great life giving, asset to the area through which it flows as long as it is utilised usefully for the region, and not allowed to destory it due to its ever shifting sinuous course or its dangerous flood heights.

In other advanced countries the rivers are usually trained for attaining proper depths of flow for navigation, to improve the cross section of flow for passing the high and super floods (to reduce flood height) and for efficient transport of sediment load, to stabilise the river banks, to stop recession of the river banks for the protection to flood bunds and towns threatened by caving banks and to reclaim land.

Mississippi river in United States of America is the fourth largest drainage basin in the world exceeded in size by the water sheds of the Amazon, Cango and and Nile Rivers. Its total length from source to mouth is 4149 miles. Its maximum discharge on record is 26,62,000 cusecs and it drains 41% of the United States. The inland water-ways on this river and its tributaries is 5000 miles. The river all along its length is trained to a stabilised course by levees, bank protection and groynes (solid and permeable). The cut-off (*Fig. 1*) programme in the lower Mississippi river of the 930 decreased the length of the river by 35%. Over 110 miles of dikes comprising 73 dike systems have been built to date. The Mississippi river, meander belt was 15-20 miles wide prior to any attempt to control it. Now it is less than 2 miles wide and has thus confined the meandering to a very narrow belt.

No extensive river training works have been carried out in West Pakistan except on short reaches of the rivers for the following specific purposes :—

(*a*) For directing and guiding the flow through a bridge and over a barrage, and the main purpose is to constrict the wide and indeterminate river to a reasonably economical waterway requiring least maintenance cost.

The typical example is the training works upstream of Taunsa Barrage for leading the river flows to the barrage to impart uniformity and

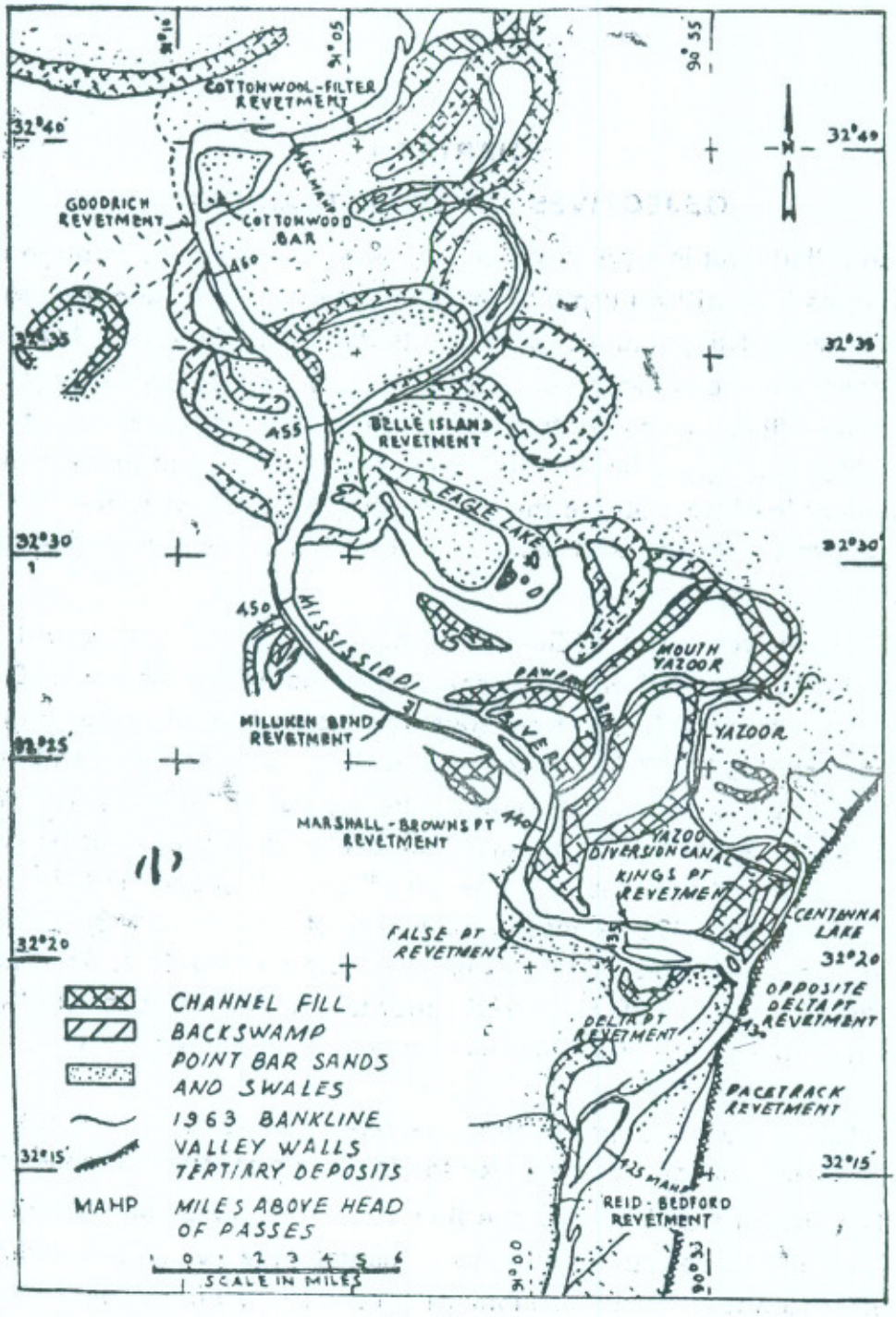
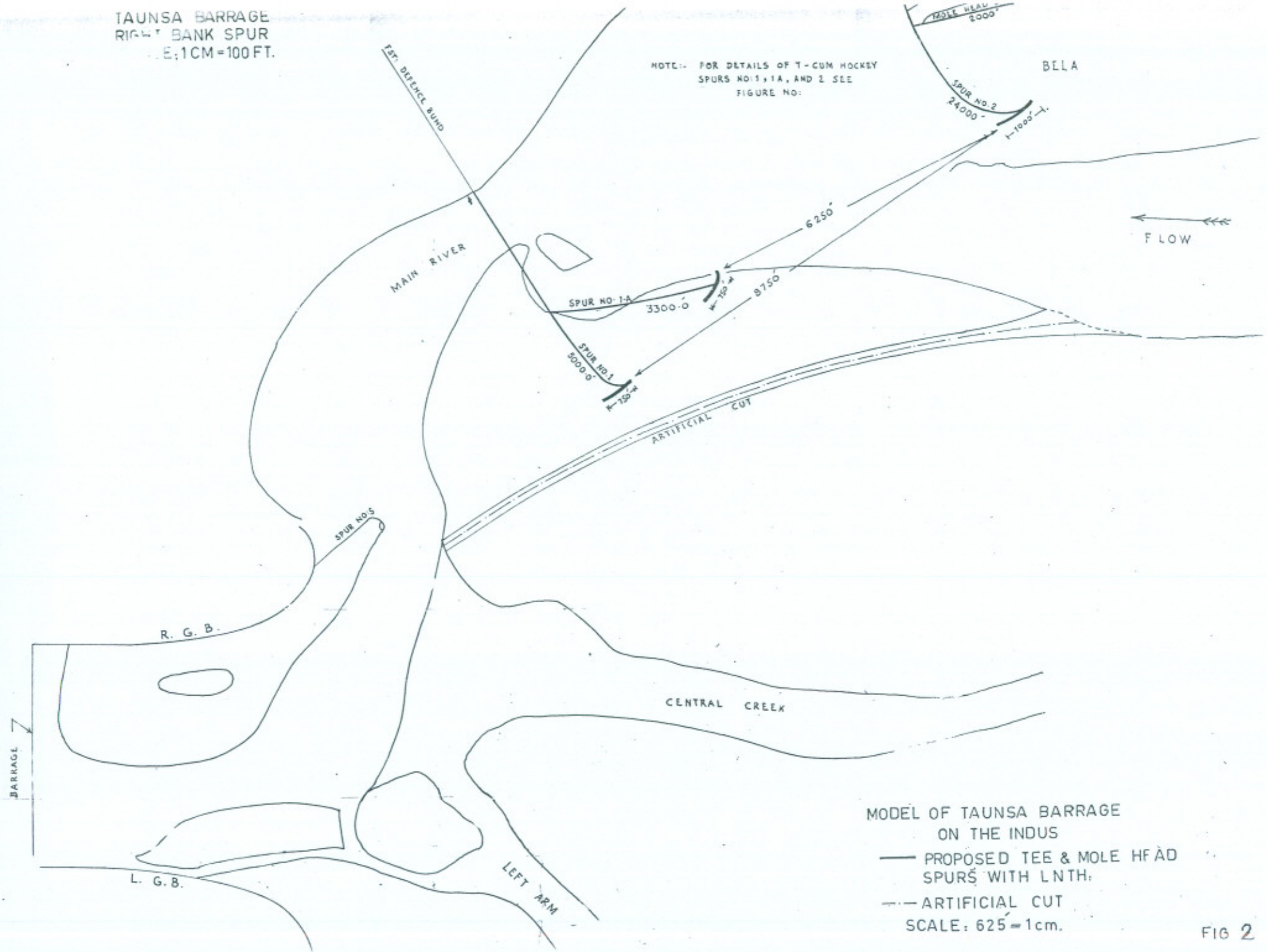


Fig. 1.

Major floodplain deposits in the meander belt of the Mississippi River, after Waterways Experiment Station Potamology Investigation Report No. 12-15 (1965). (Vicinity of Goodrich to Reid-Bedford Revetments).



MODEL OF TAUNSA BARRAGE
ON THE INDUS

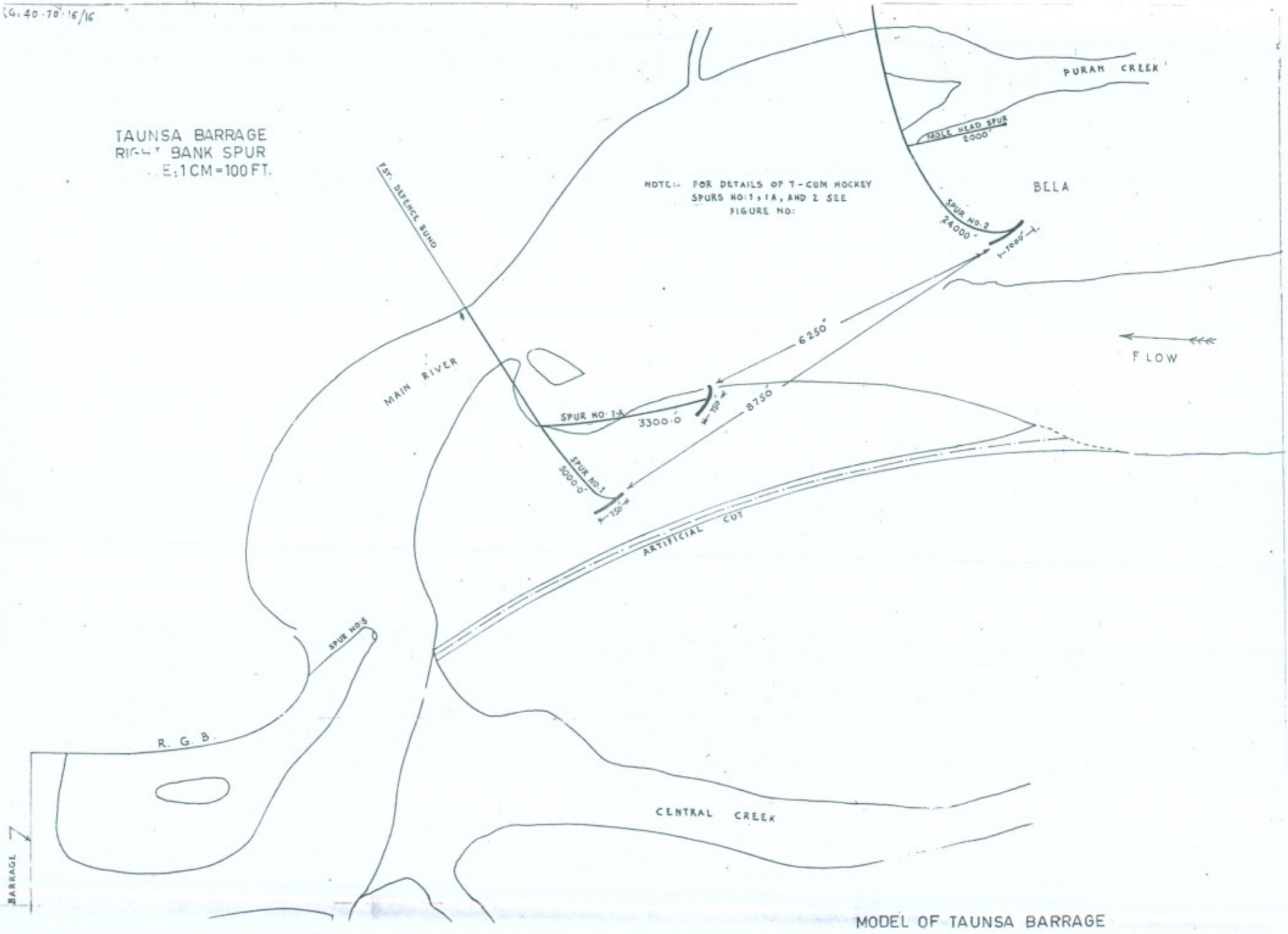
— PROPOSED TEE & MOLE HEAD SPURS WITH LNTH:

—·— ARTIFICIAL CUT

SCALE: 625' = 1 cm.

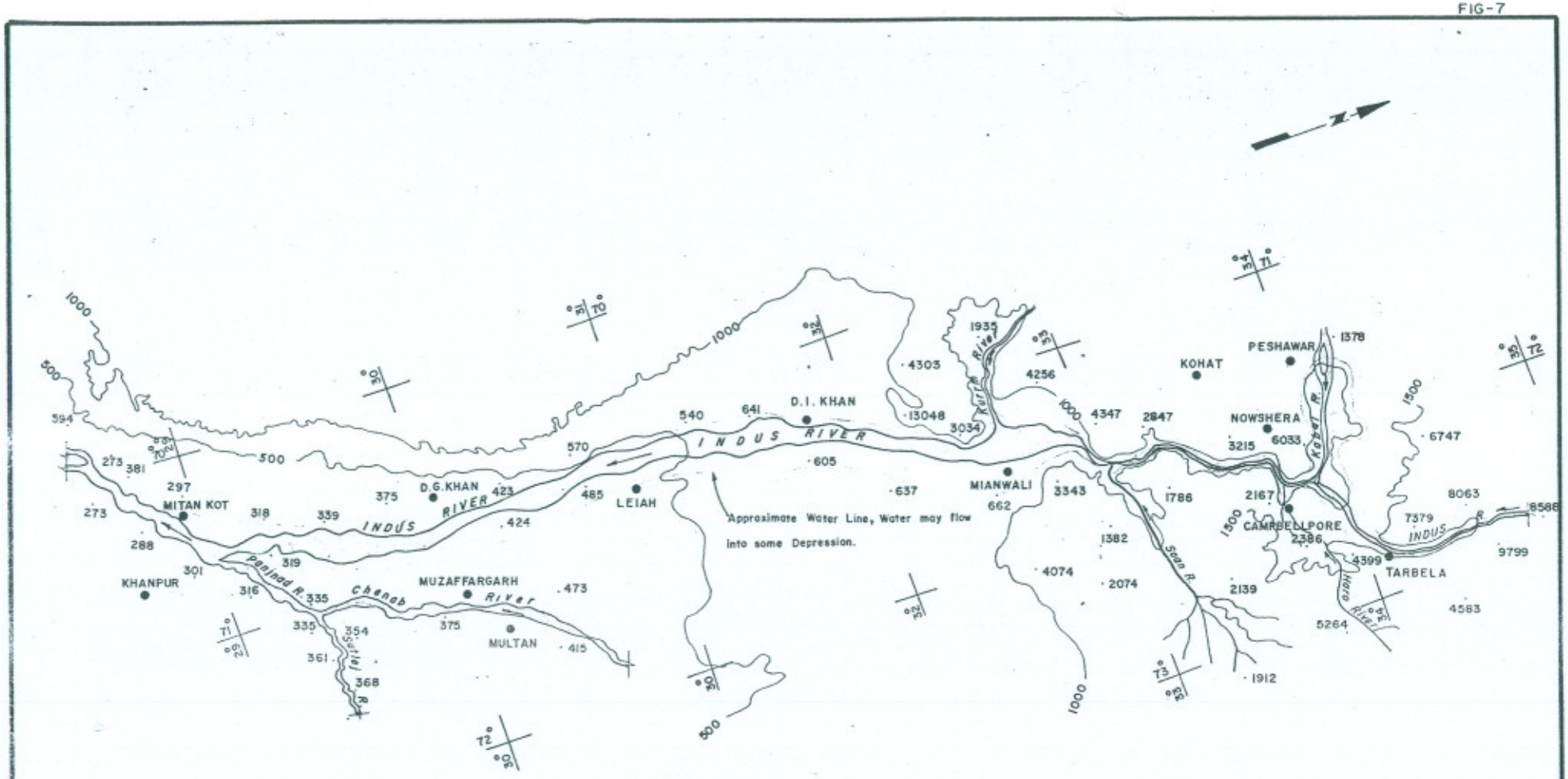
FIG 2

G:40-70-16/16



MODEL OF TAUNSA BARRAGE

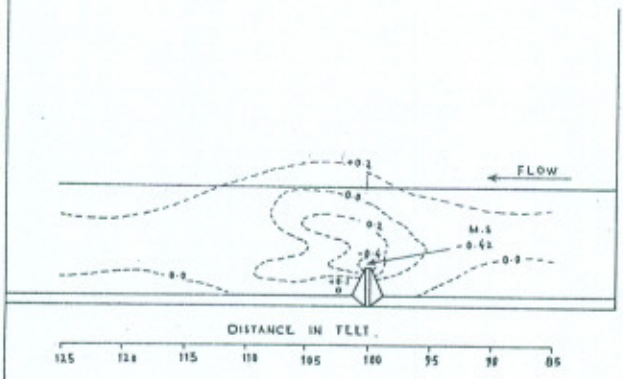
FIG-7


N
INDUS RIVER
D.I. KHAN
D.G.KHAN
MITAN KOT
LEIAH
MIANWALI
KOHAT
PESHAWAR
NOWSHERA
CAMPBELLPORE
TARBELA
KHANPUR
MUZAFFARGARH
MULTAN
Chenab River
Panjnad R.
Sutlej R.
Kurram River
Kabul R.
Haro River
Soan R.
Approximate Water Line, Water may flow into some Depression.
SCALE IN MILE
PAKISTAN WAPDA
DIRECTORATE OF P & I
TARBELA DAM-FAILURE FLOOD MAP OF PROBABLE FLOODED AREA
Drawn Sarwar Submitted
Traced Habib ur Rehman Recommended
Checked Approved
LAHORE Date: Dwg:

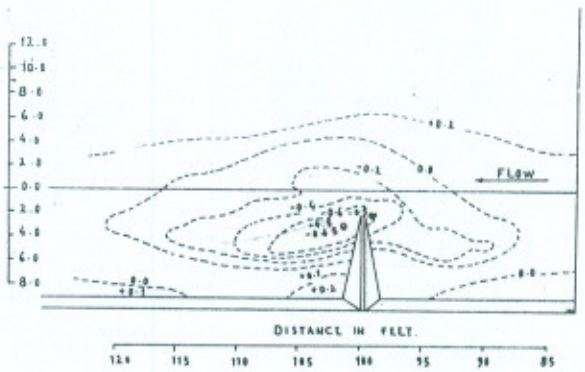
DRG: 2.6.72. 29/8

BASIC STUDY ON THE DESIGN OF SLOPING SPUR

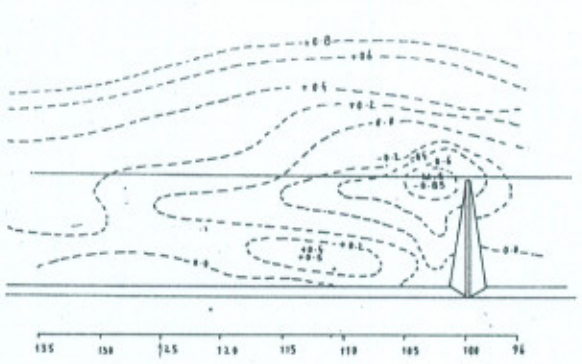
BED CONFIGURATIONS ALONG SPURS WITH DIFFERENT TOP SLOPES AT THE END OF TEST RUN



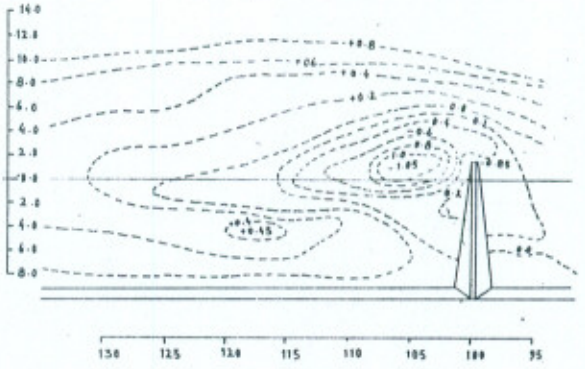
SPUR TOP SLOPE 1:2



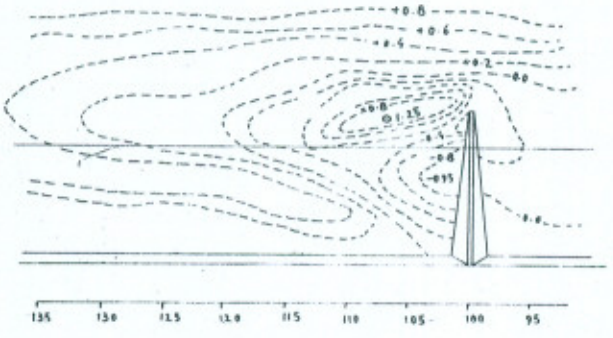
SPUR TOP SLOPE 1:4



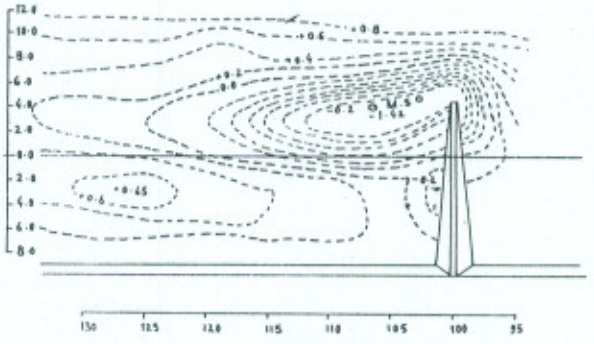
SPUR TOP SLOPE 1:6



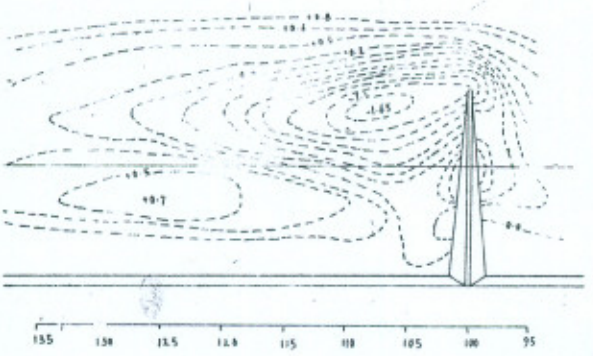
SPUR TOP SLOPE 1:7

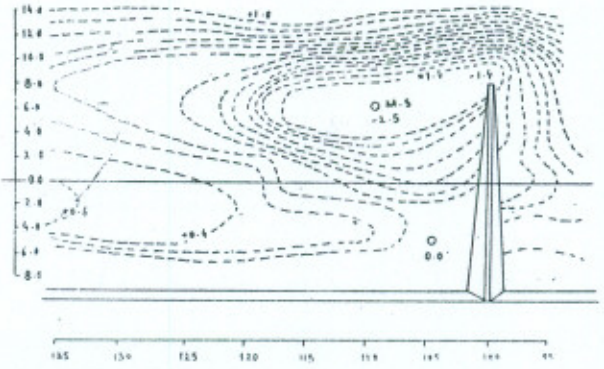


SPUR TOP SLOPE 1:8



SPUR TOP SLOPE 1:9



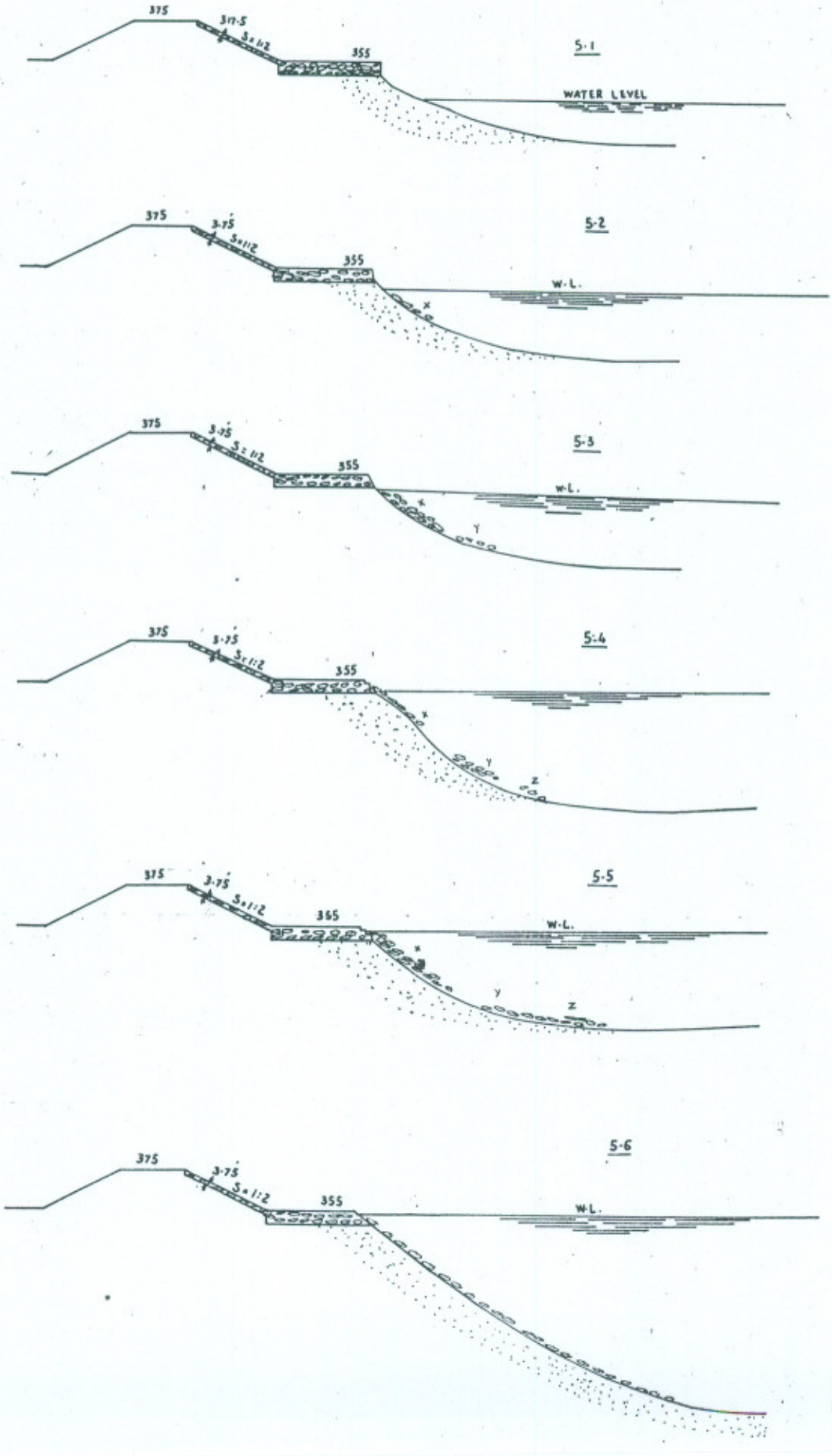


MODEL OF BASIC STUDY ON SHAPE OF SPUR HEAD

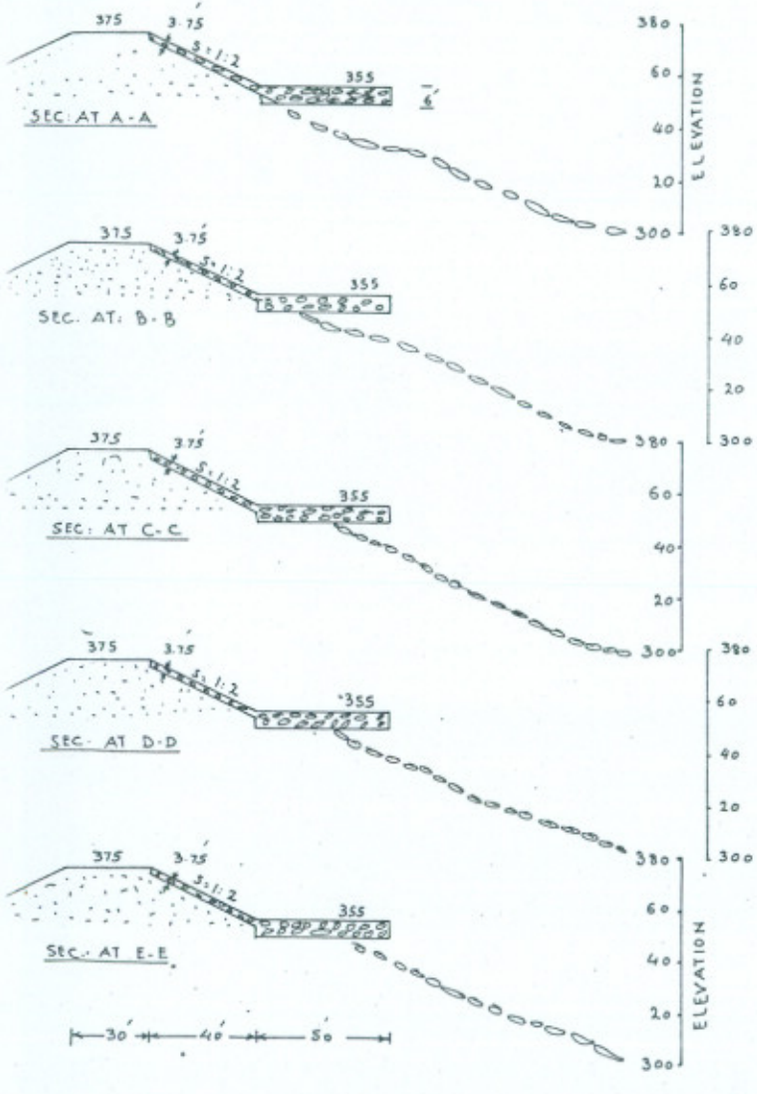
SCALE = 1/60

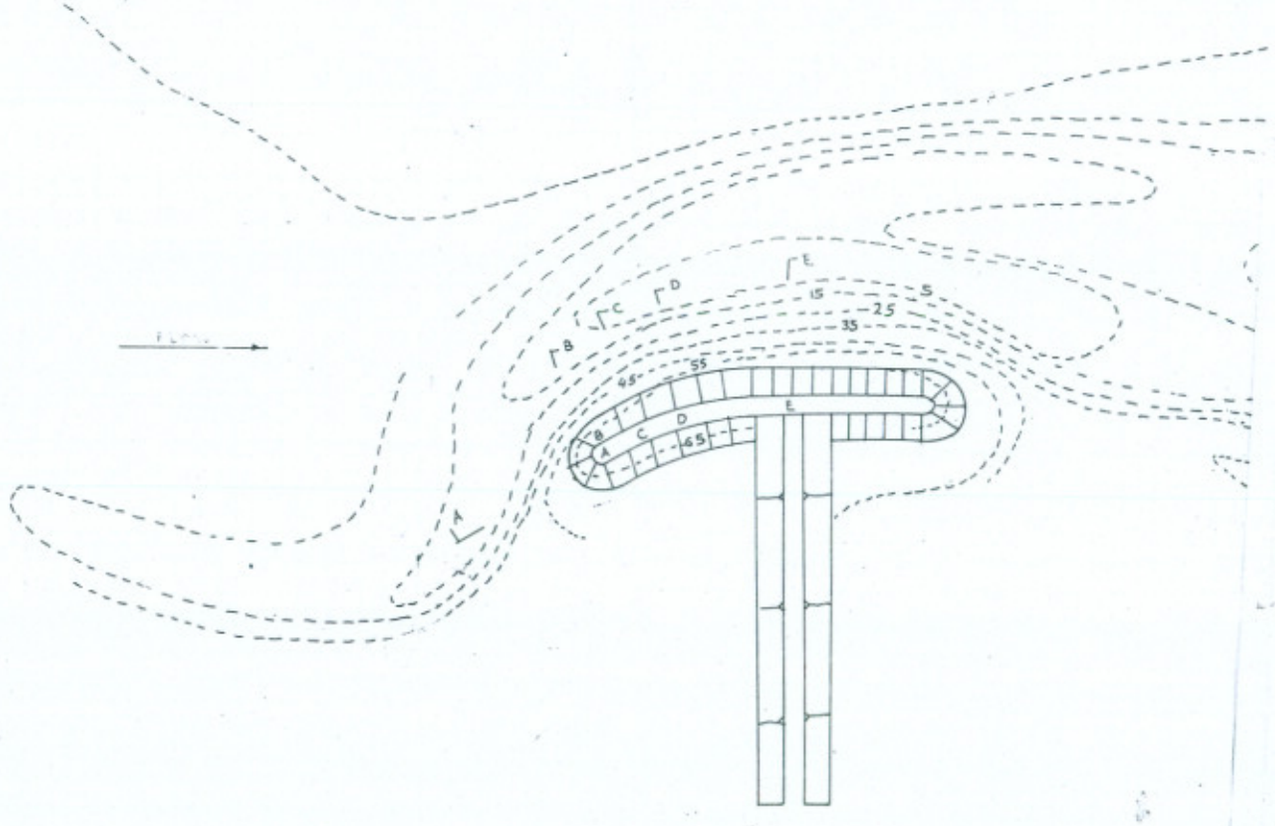
MECHANISM OF APRON LAUNCHING

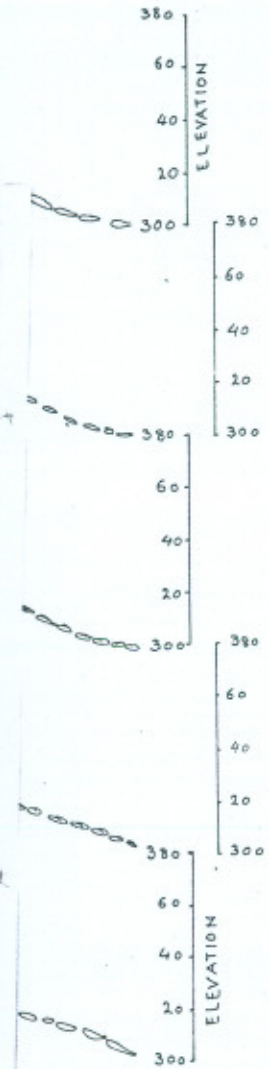
WITH TANGENTIAL RIVER APPROACH

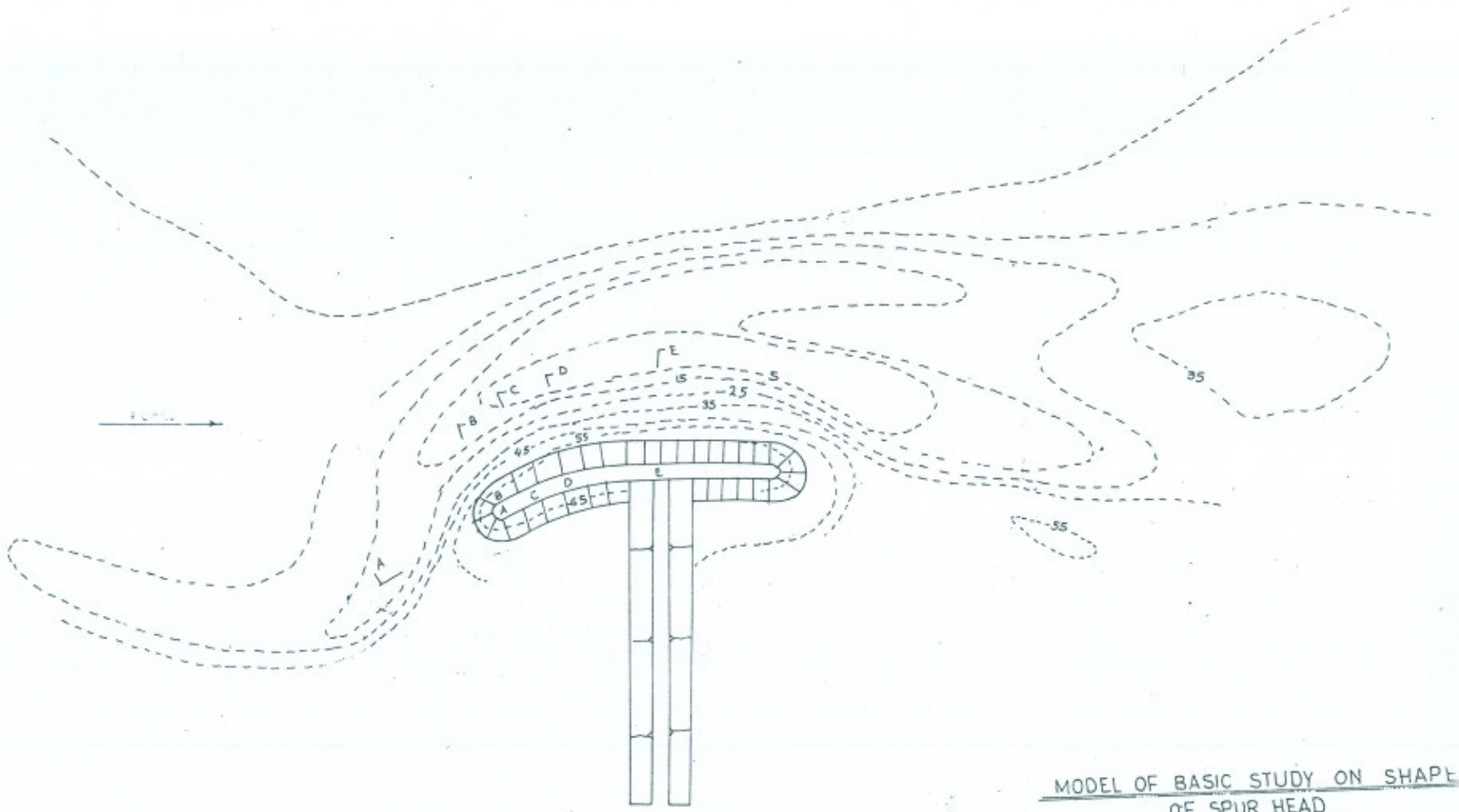


AFTER THE TEST









MODEL OF BASIC STUDY ON SHAPE OF SPUR HEAD

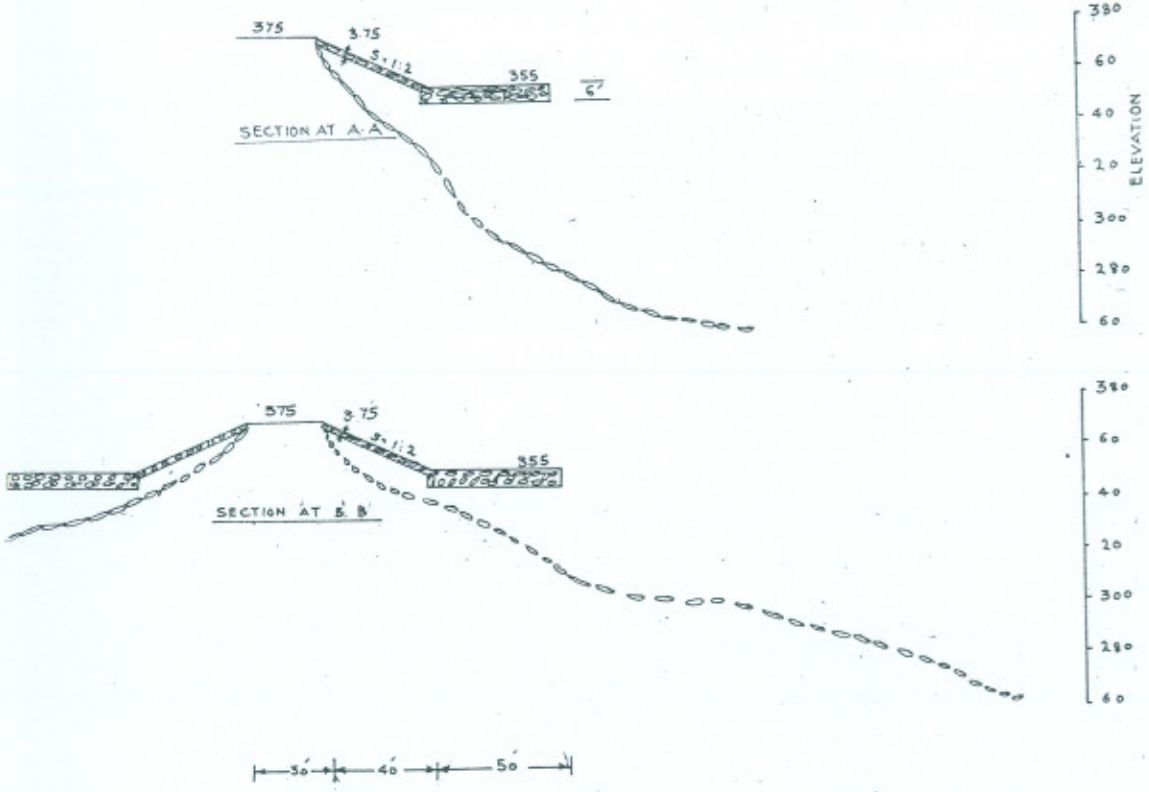
SCALE = 1/40

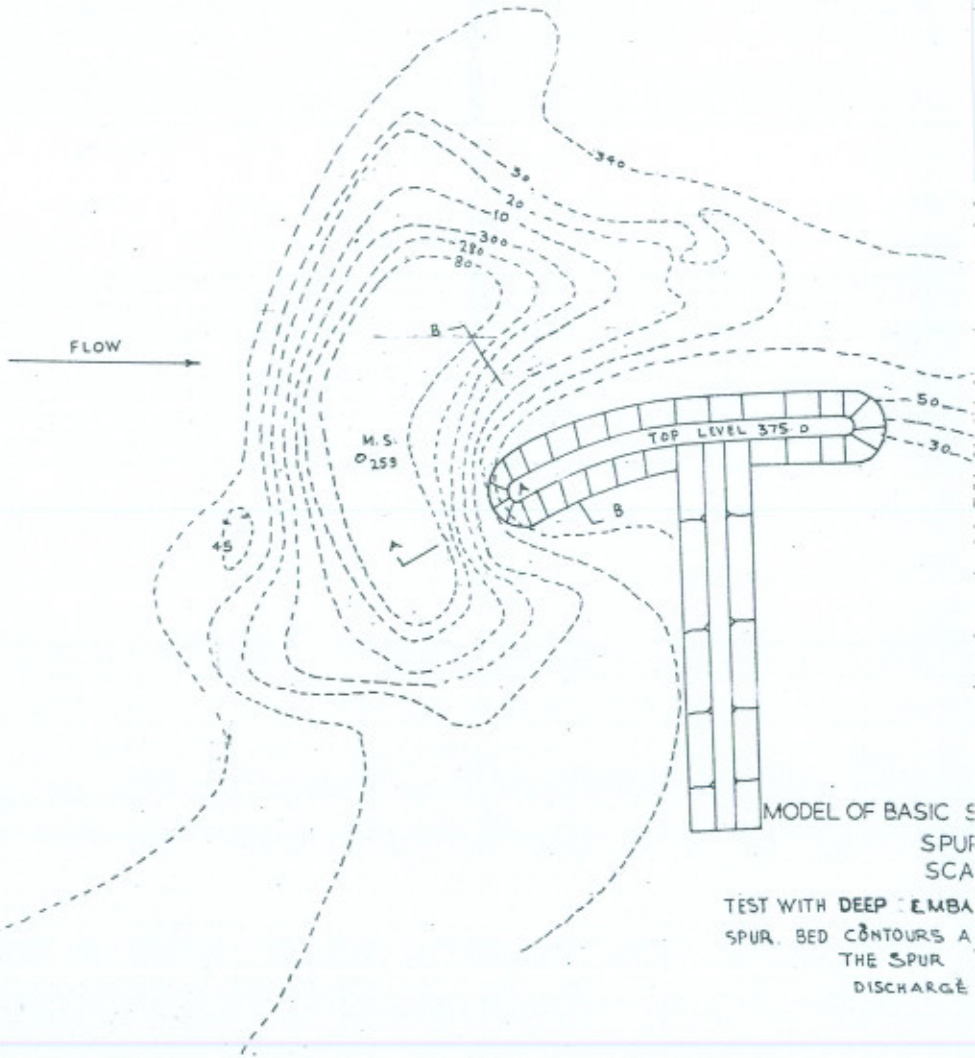
TEST WITH TANGENTIAL APPROACH TO T. HEAD SPUR

BED CONTOURS AND CROSS SECTIONS AT THE SPUR HEAD AFTER TESTS RUN

DISCHARGE: 200,000 CUSECS.

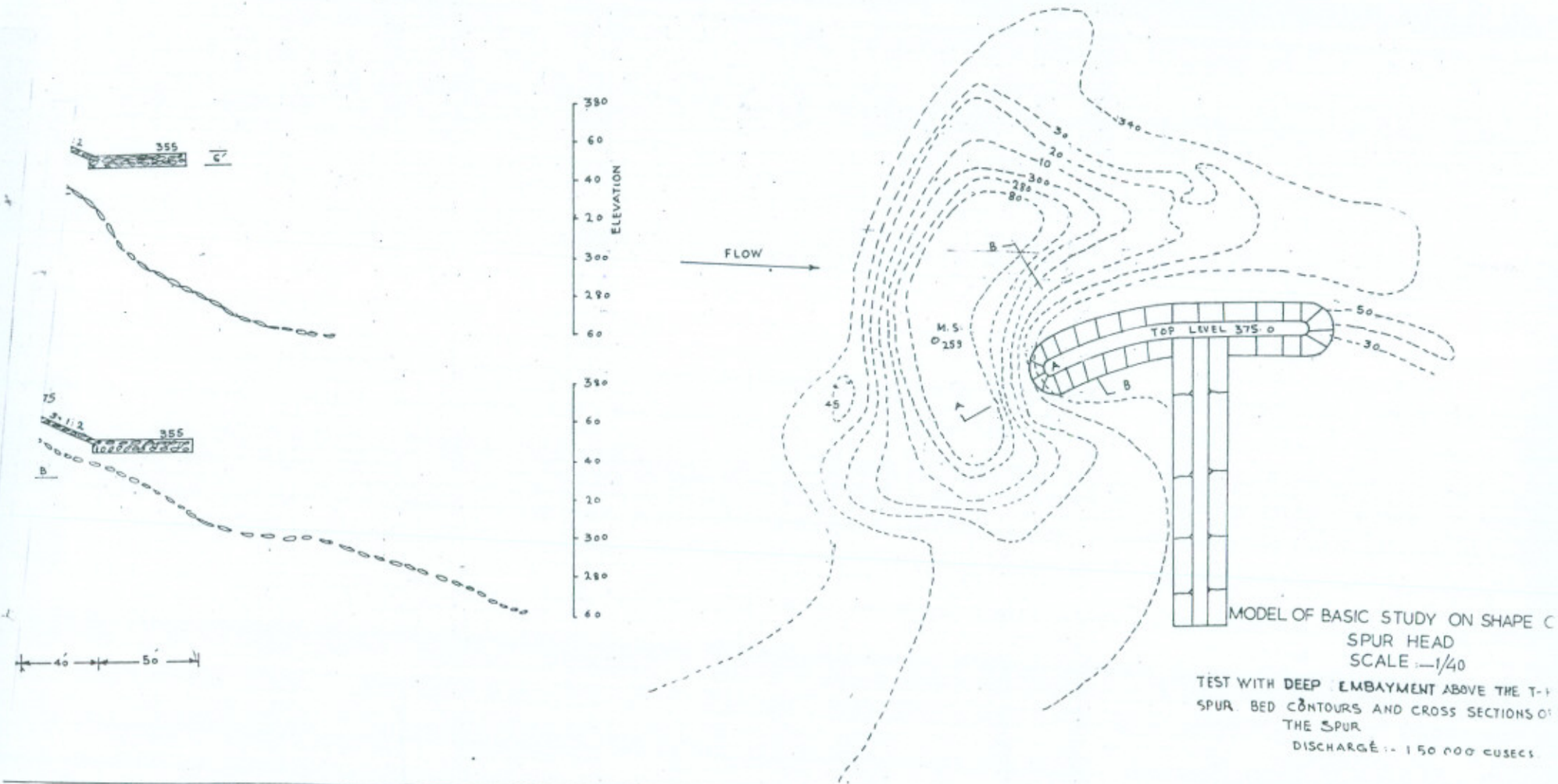
FIG. 21





MODEL OF BASIC S
SPUR
SCA

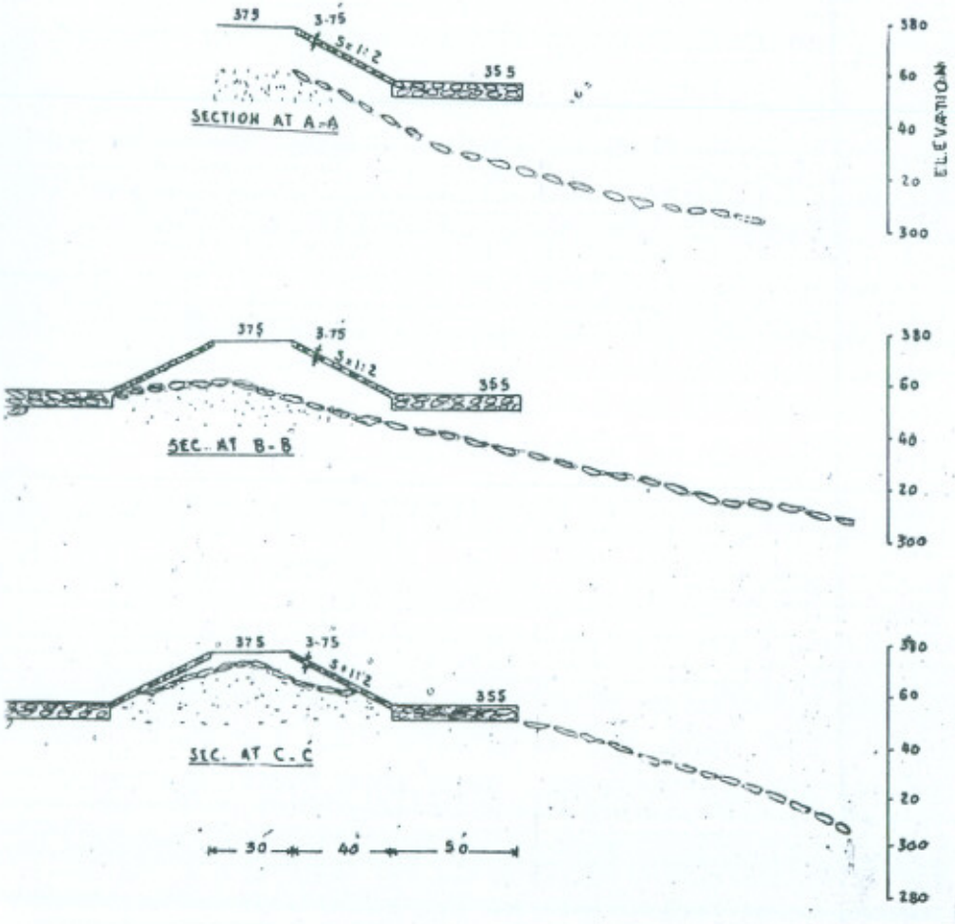
TEST WITH DEEP EMBA
SPUR. BED CONTOURS A
THE SPUR
DISCHARGE

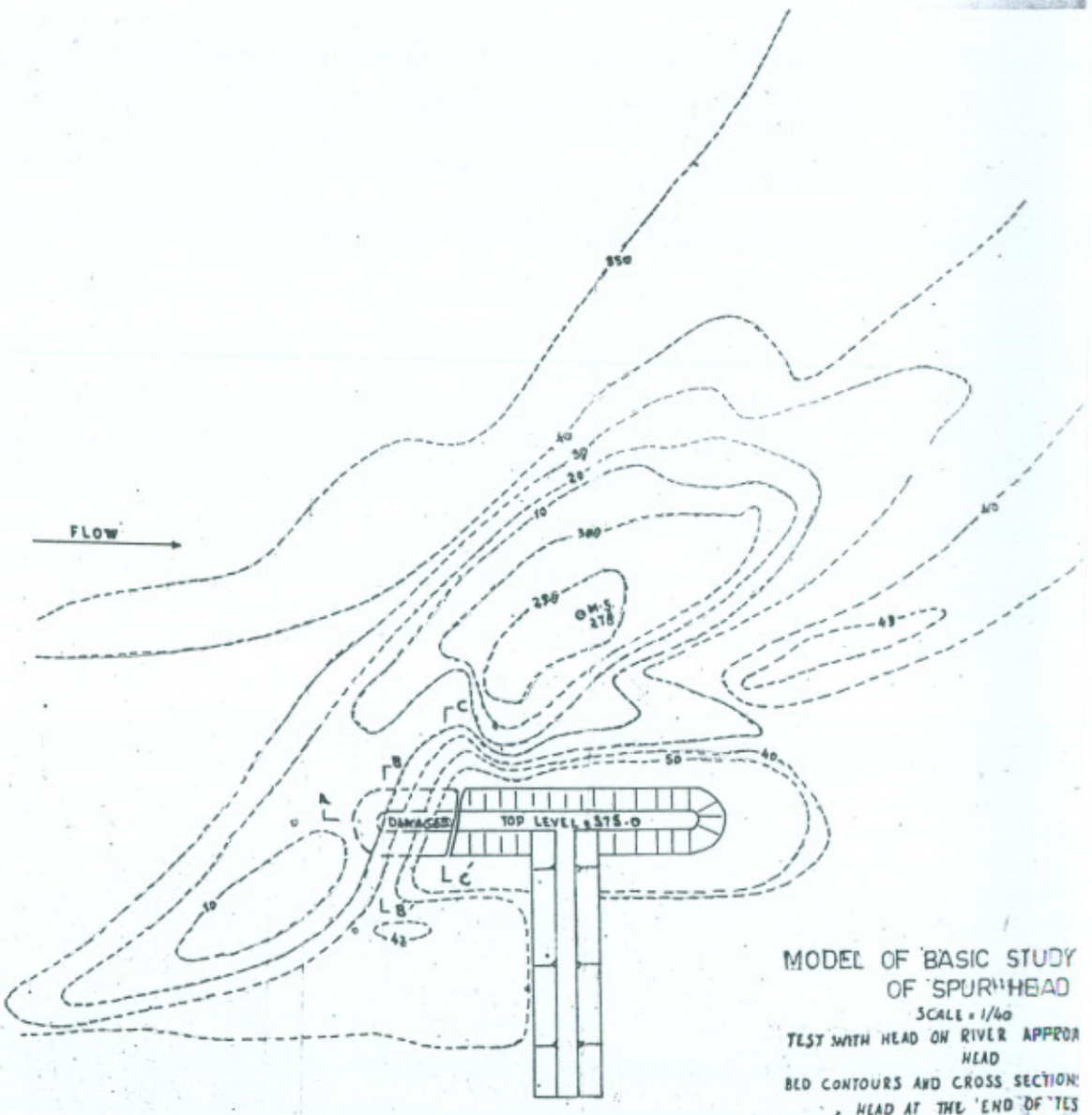


MODEL OF BASIC STUDY ON SHAPE C
SPUR HEAD
SCALE :—1/40

TEST WITH DEEP EMBAYMENT ABOVE THE T-
SPUR. BED CONTOURS AND CROSS SECTIONS O
THE SPUR
DISCHARGE :- 150 000 CUSECS

FIG. 2



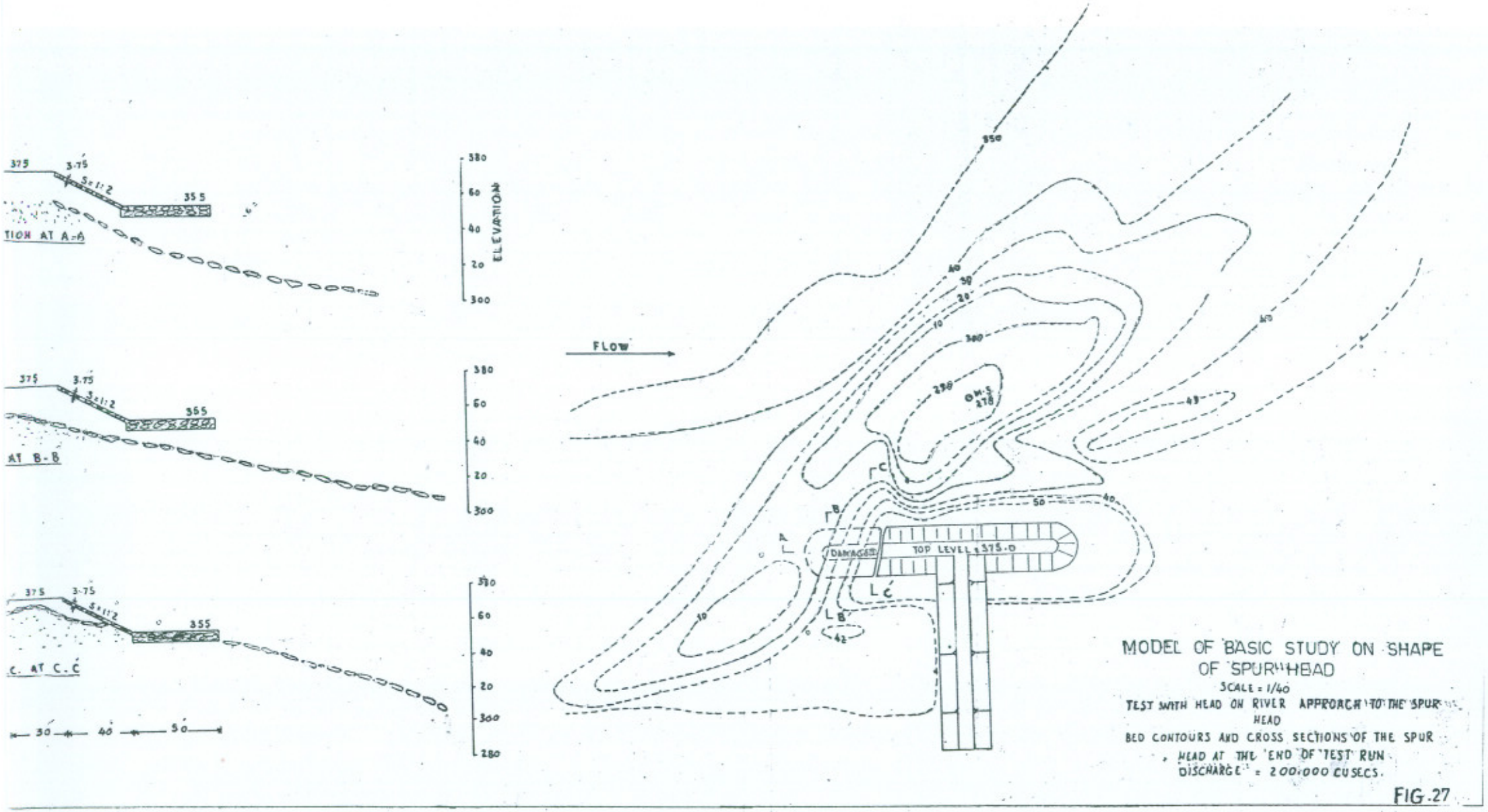


MODEL OF BASIC STUDY
OF SPUR WITH HEAD

SCALE = 1/40

TEST WITH HEAD ON RIVER APPROA
HEAD

BED CONTOURS AND CROSS SECTION
, HEAD AT THE END OF TES
DISCHARGE = 200.000 C



MODEL OF BASIC STUDY ON SHAPE OF SPUR HEAD

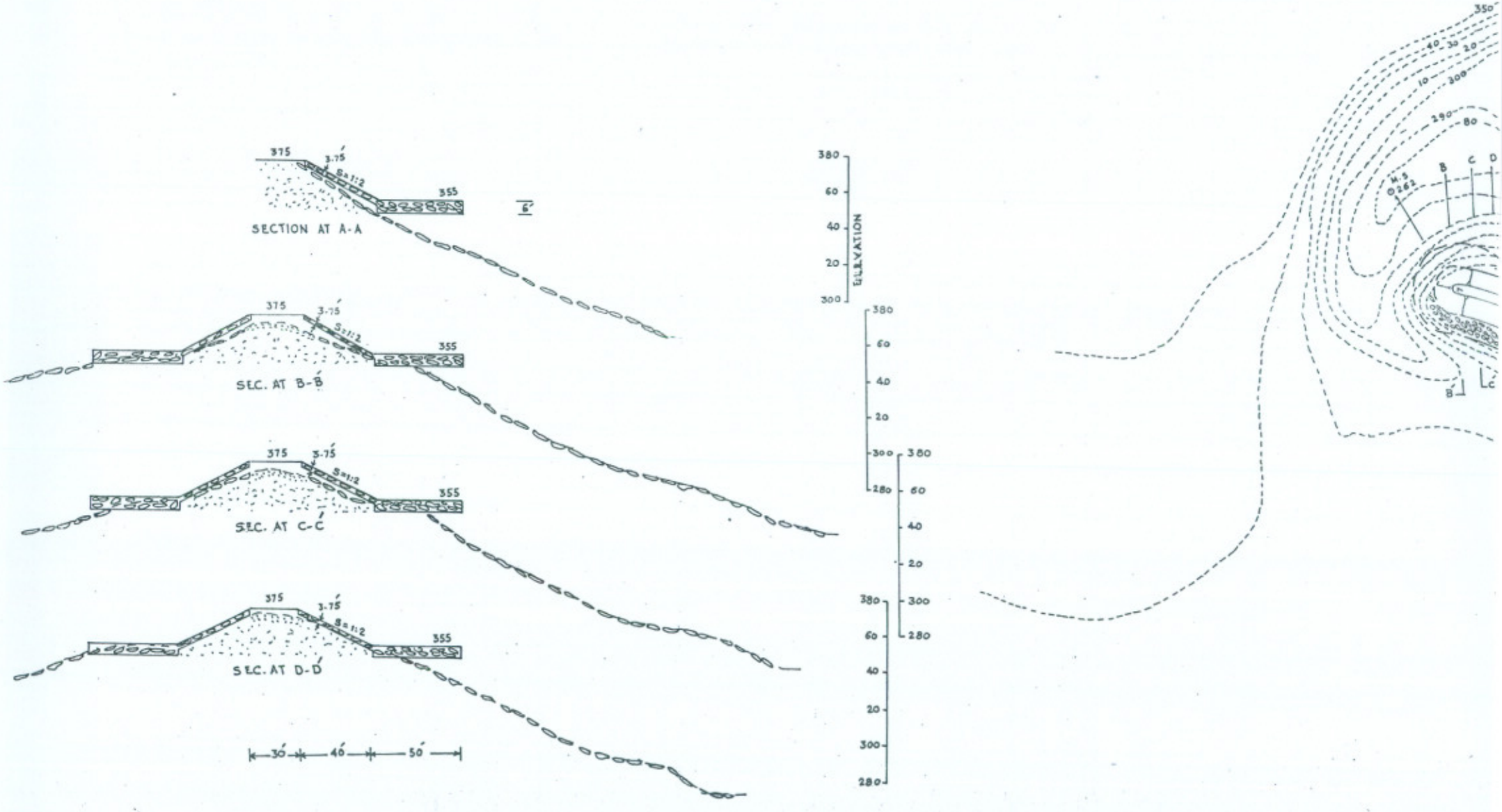
SCALE = 1/40

TEST WITH HEAD ON RIVER APPROACH TO THE SPUR HEAD

BED CONTOURS AND CROSS SECTIONS OF THE SPUR HEAD AT THE END OF TEST RUN

DISCHARGE = 200,000 CUSECS.

FIG.27


375
3.75
S=1:2
355
SECTION AT A-A
SEC. AT B-B
SEC. AT C-C
SEC. AT D-D
30'
40'
50'
ELEVATION
380
60
40
20
300
280
350
290
80
B
C
D

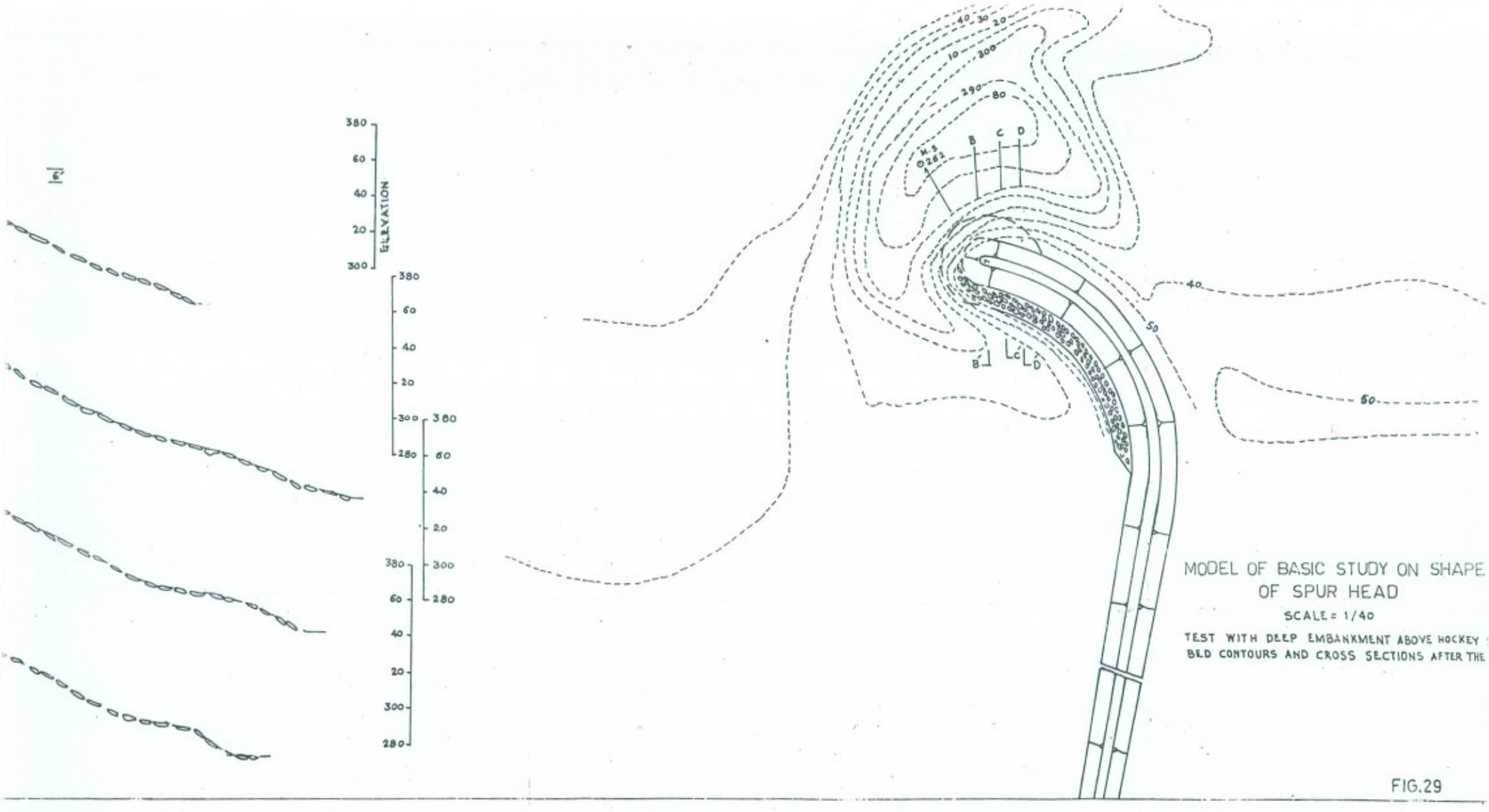
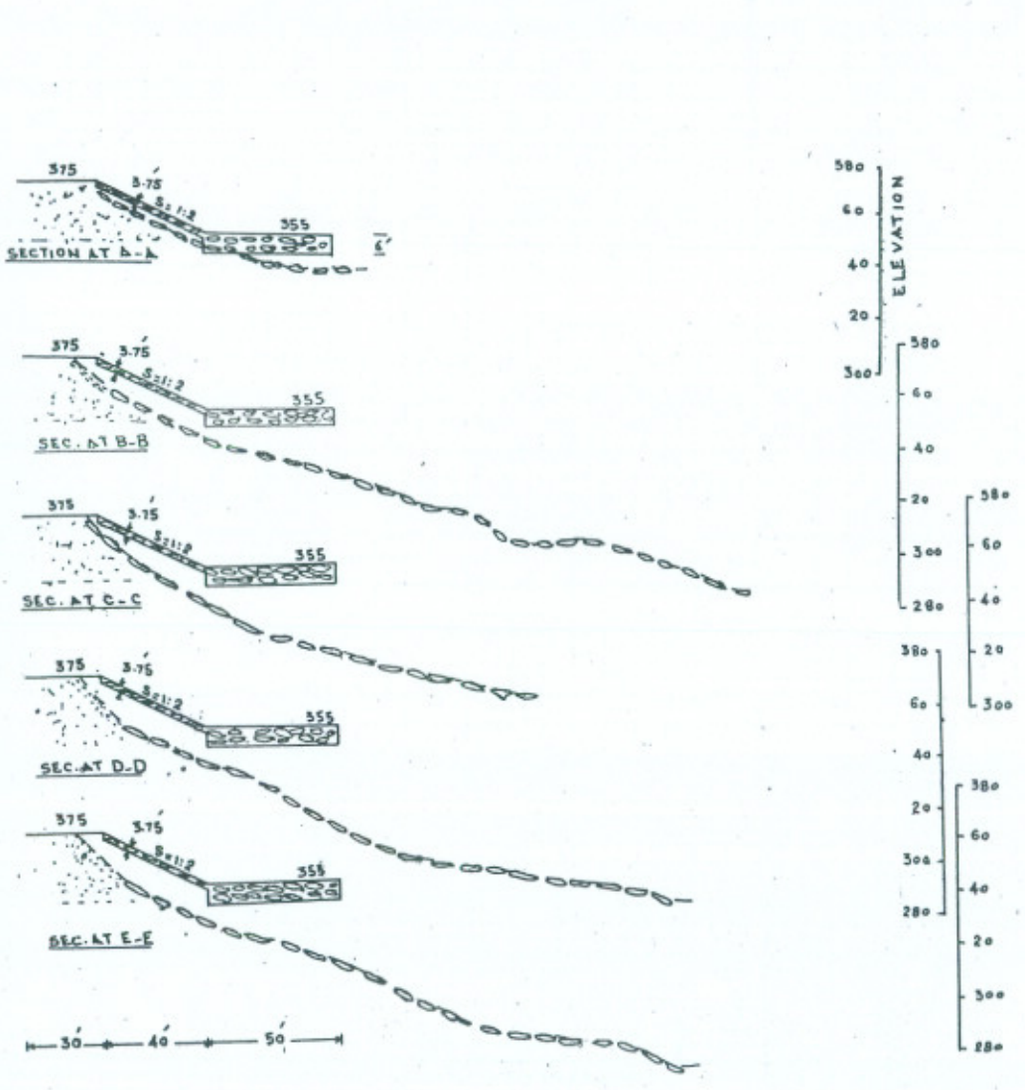

ELEVATION
380
60
40
20
300
280
B
C
D
40
50
60
MODEL OF BASIC STUDY ON SHAPE OF SPUR HEAD
SCALE = 1/40
TEST WITH DEEP EMBANKMENT ABOVE HOCKEY
BED CONTOURS AND CROSS SECTIONS AFTER THE

FIG.29



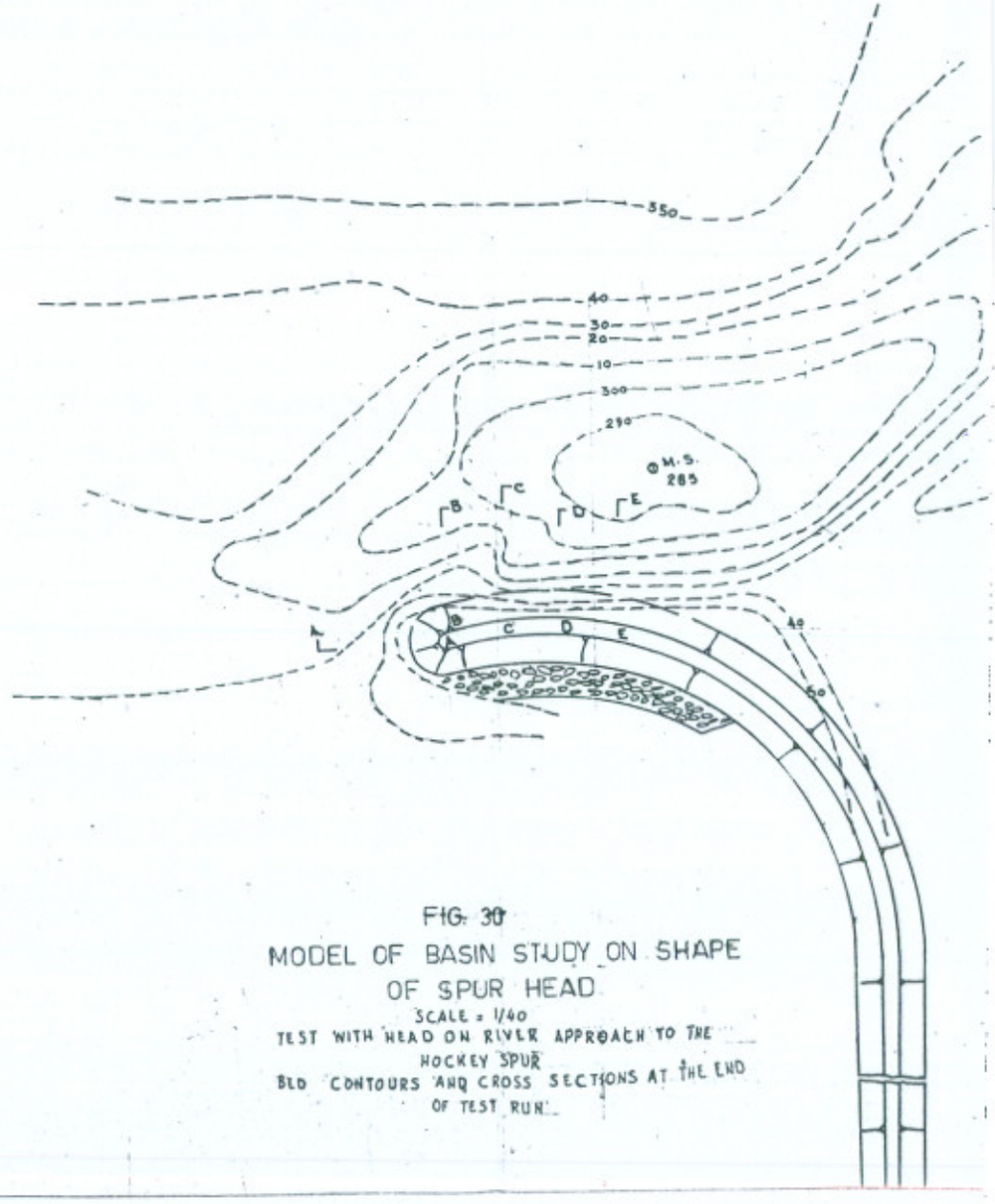


FIG. 30

MODEL OF BASIN STUDY ON SHAPE OF SPUR HEAD

SCALE = 1/40

TEST WITH HEAD ON RIVER APPROACH TO THE HOCKEY SPUR

BLD CONTOURS AND CROSS SECTIONS AT THE END OF TEST RUN.

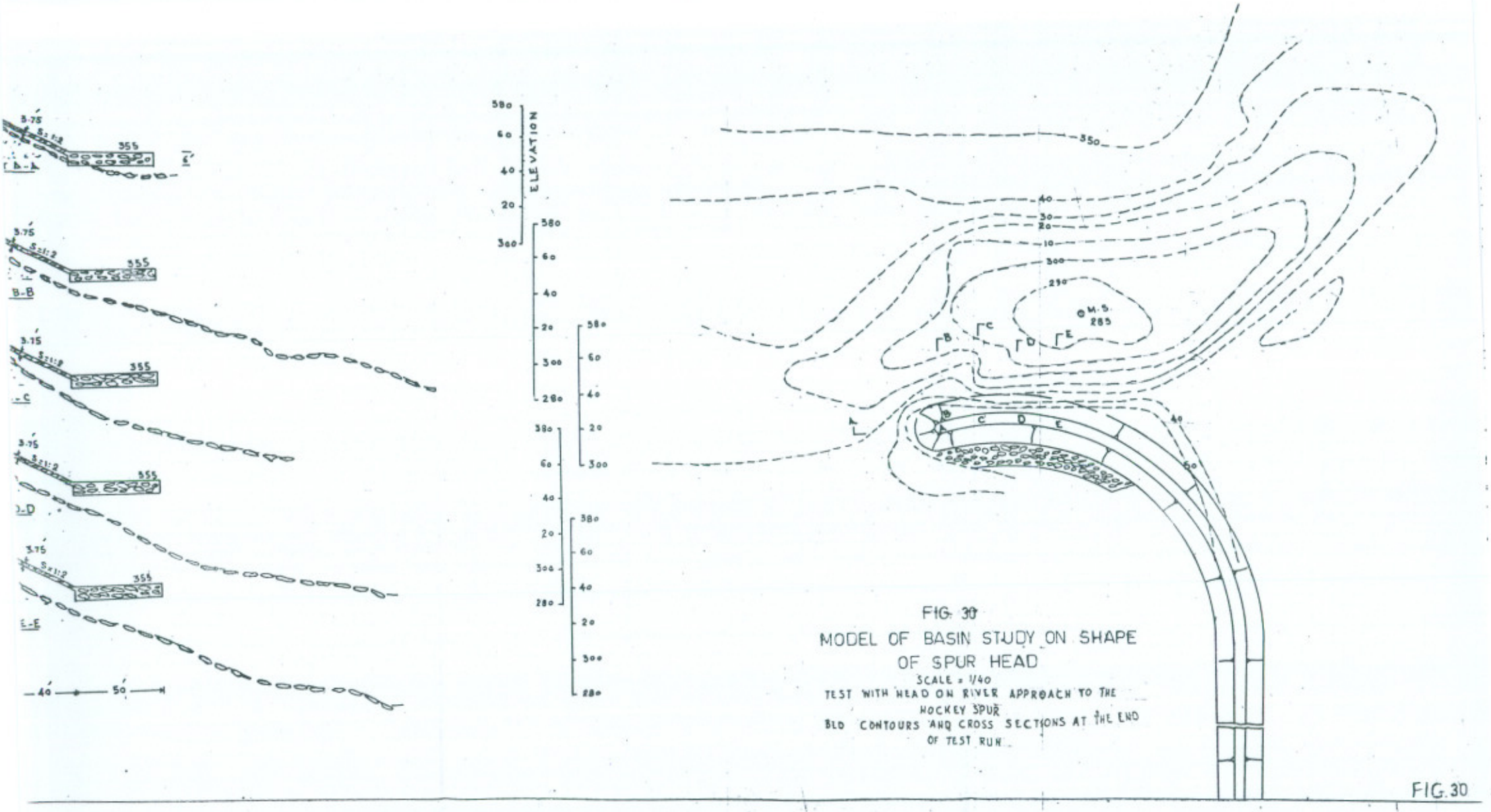


FIG. 30

MODEL OF BASIN STUDY ON SHAPE OF SPUR HEAD

SCALE = 1/40

TEST WITH HEAD ON RIVER APPROACH TO THE HOCKEY SPUR

BLD CONTOURS AND CROSS SECTIONS AT THE END OF TEST RUN.

FIG. 30

PROTECTION OF MOHAD-JO-DERO

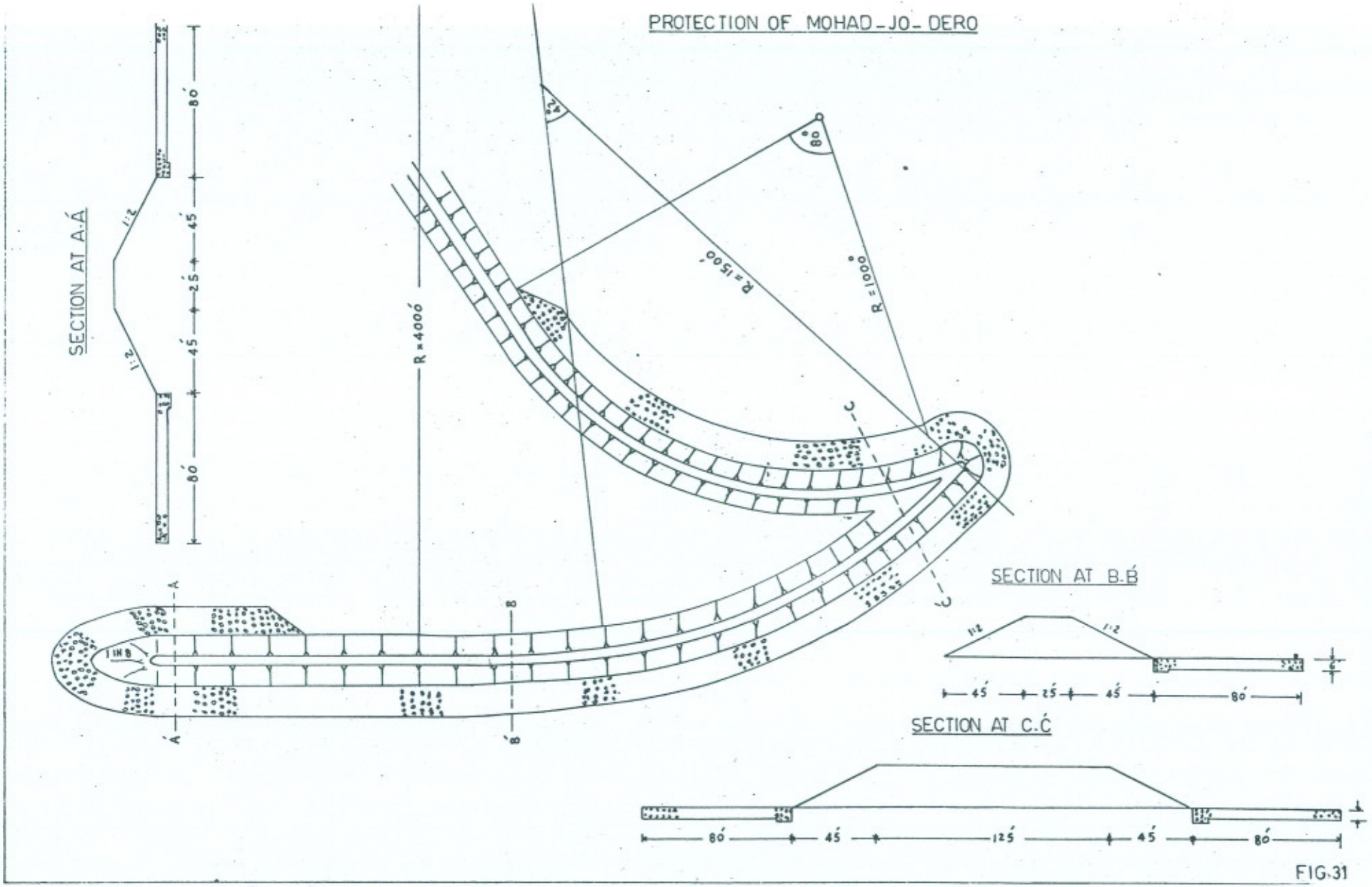
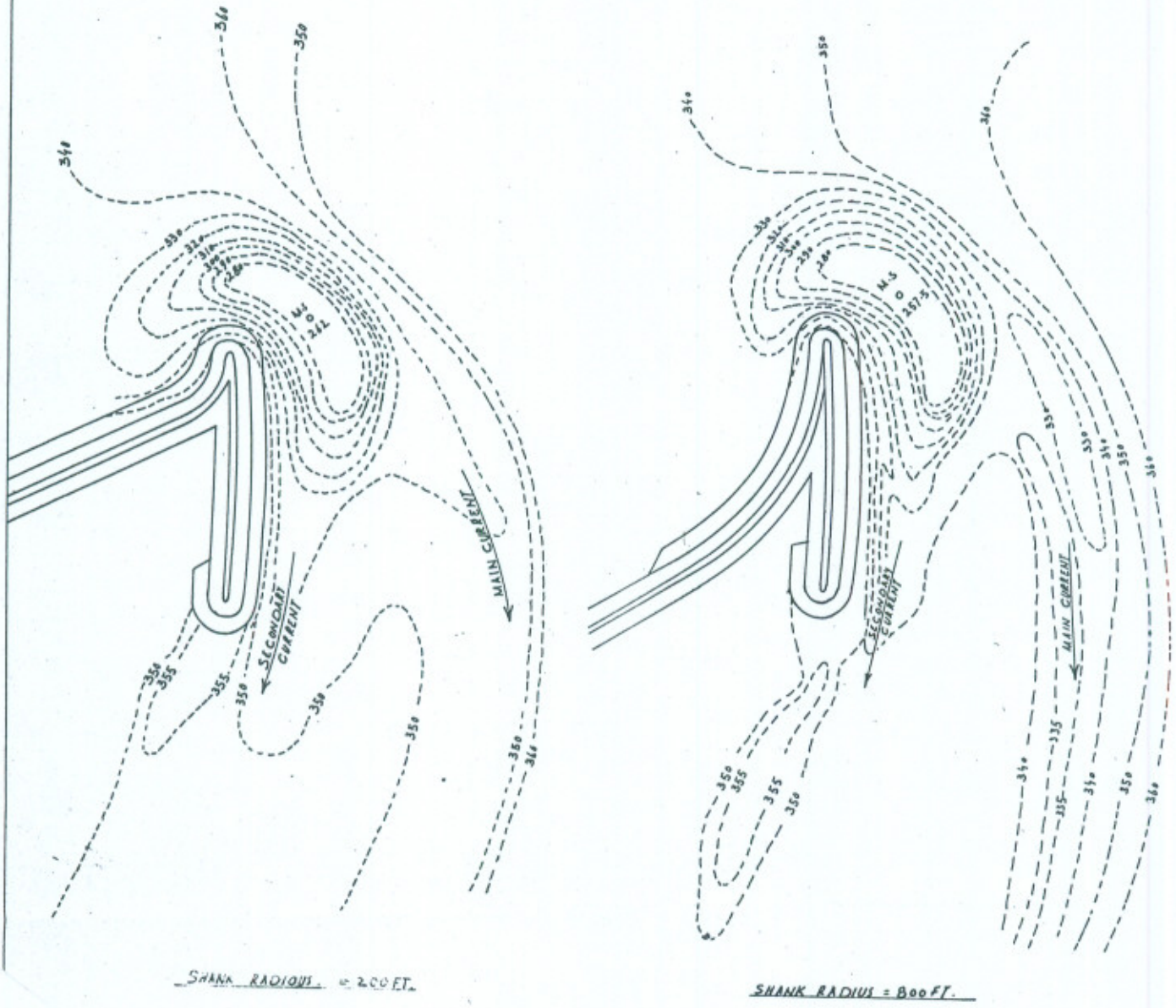


FIG.31

MODEL OF
BASIC STUDY ON J SPUR
SCALE : 1CM = 4

BED CONTOURS AFTER THE TEST WITH RADIUS
OF SHANK 200 & 800 FT.



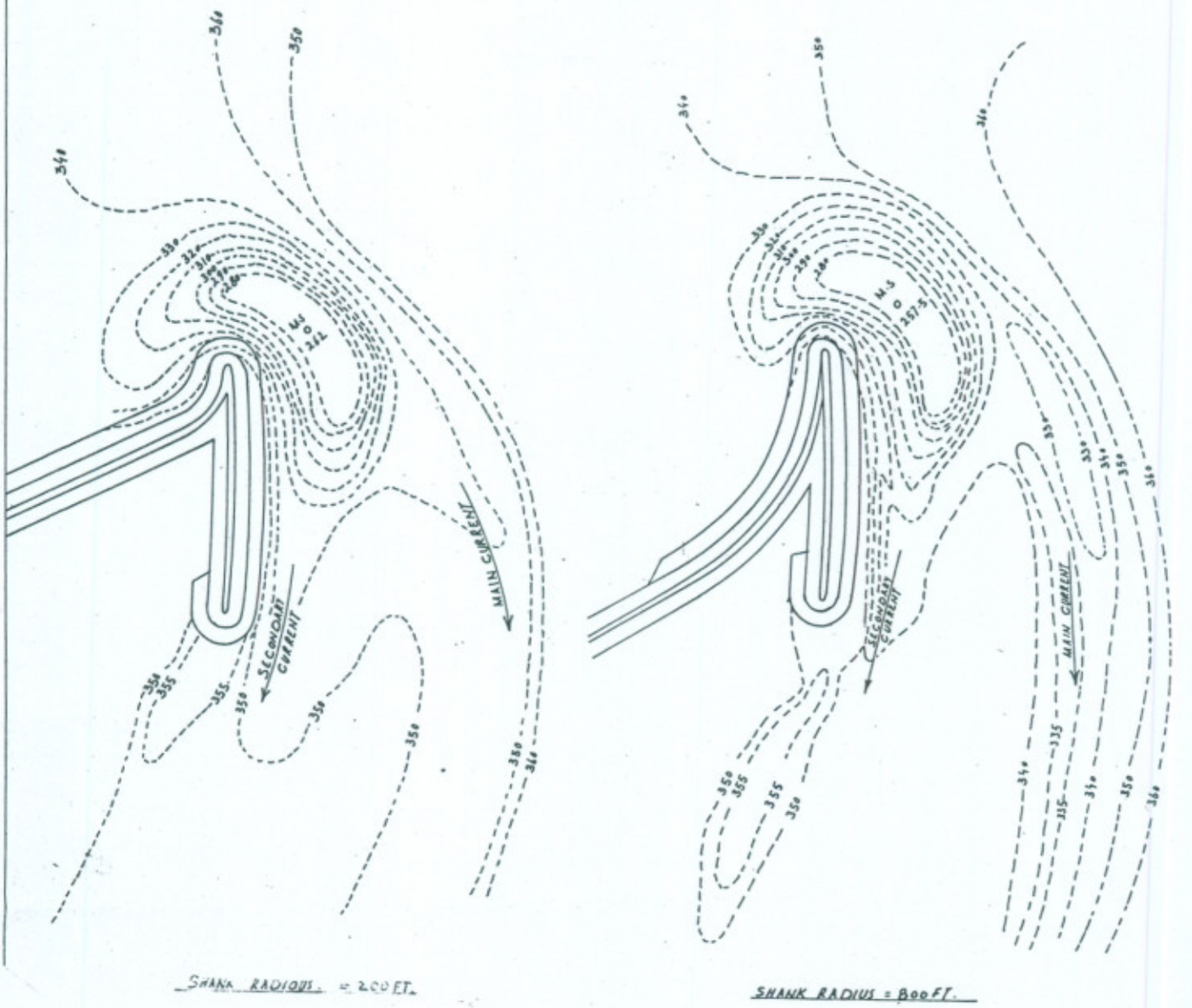
SHANK RADIUS = 200 FT.

SHANK RADIUS = 800 FT.

FIG.32

MODEL OF
BASIC STUDY ON J SPUR
SCALE : 1CM = 4

BED CONTOURS AFTER THE TEST WITH RADIUS OF SHANK 200 & 800 FT.



SHANK RADIUS = 200 FT.

SHANK RADIUS = 800 FT.

FIG. 32

evenness of flow over the barrage in floods and to attain acceptable approach to the two head sluices of off-taking canals on the two flanks of the river for exclusion of slit. *Fig.* 2

(*b*) To protect an area noted for its highly productive agricultural economy.

Examples :

Protection of right bank area along Indus from Chashma to D.I.Khan by a system of 22 No. T spurs. River training in Dir and Swat valleys against Panjkore and Swat rivers.

(*c*) To protect canal system against parallel or direct attack of river.

Examples :

Protection of B.R.B.D. (R.D. 225-283) upstream of Ravi syphon and Burala branch 318-322 against Ravi river, protection of Rangpur Canal R.D. 320-322 against Chenab, K.W. Feeder (R.D. 3 to 24) against Indus river.

(*d*) To protect a town embankment against direct attack of a river.

Examples :

Protection of Shahdara town, Sharaqpur town Syedwala town against Ravi, Taunsa town against Sanghar Nullah, D.I.Khan, Ghazi Ghat and Hala towns against Indus, Jhelum town against river Jhelum.

(*e*) To protect Sui Gas Pipe Line crossing.

Examples :

Crossing of Sui Gas Pipe Line at Ravi and Sutlej.

(*f*) To protect flood embankments. The Indus is doubly embanked (against floods) almost continuously from below Kashmore to near Nawabshah covering a length of 217.5 miles and is further diked on left to the sea, the land along right bank in this reach is high. The length of the existing embankments along rivers within Punjab including the marginal bunds of various head works is of the order of 1300 miles. When stakes involved are heavy and embankments are threatened by river the training of river is a must.

Examples :

Protection of left marginal bund upstream of Marala by a series of spurs against Jammu Tawi, protection of R.M.B. and L.M.B. of Qadirabad Barrage against Chenab and Protection of Hajipur Bund (mile 13/4 to 17/5) against Indus.

CHAPTER-II

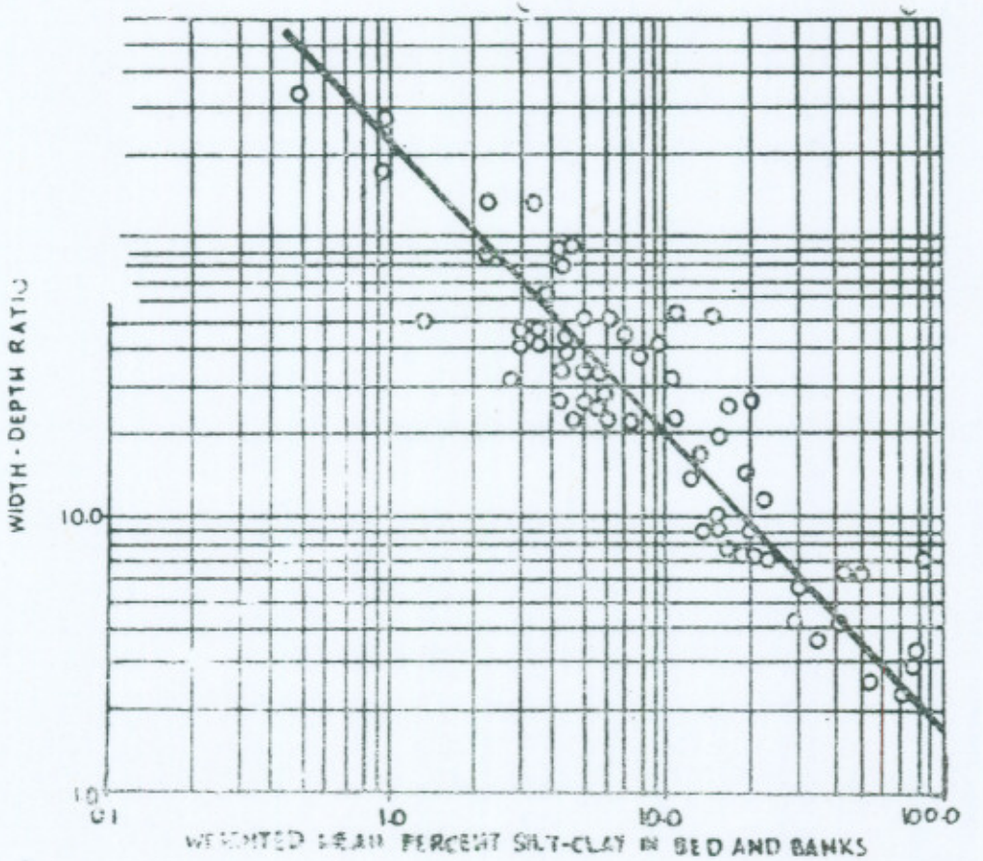
BENDS IN ALLUVIAL CHANNEL

Due to non-uniform variations in discharge, the quantity and character of sediment load, turbulence and local interference, the flow currents in river (involving a complex system of cross and spiral currents, converging and diverging flows and eddies of various strengths and directions) inter act with erodable bed and bank material and change the geometry of section of the channels and their courses. The characteristics of the valleys and river flood plains which normally confine the flow at flood stage, play an important role in channel geometry. Also, the outflow seepage forces at the rising stages of river and the inflow seepage forces at the falling stages of river through the interface between water and the bed and banks of a channel in permeable alluvium have a significant effect in resistance to flow. If there is outflow in rising stages, the seepage force acts in the direction of gravity and increases the effective weight of sand and thus the stability of the bed material and vice versa if there is inflow during falling stages.

The flood embankments on the flanks of river (which are constructed for perventing velley inundation in floods) besides increasing the rate of travel of flood wave, peak of flood wave, and the water level, increase the slope and the scouring action through leveed sections and decrease the slope and scouring action above the leveed portion.

River scour potential varies with stages of river, degree of convergence of currents, percentage concentration per foot run, strength of eddies, fluctuations in water level and the wave action.

The other factors contributing for river bank in-stability are impingement of thalweg on bank lines, formation and movement of sand bars, variability of the composition of the banks (See fig1) and the presence of old river channels. As pointed out by Sir Francis Spring, the series of meanderings in the shape of 'S' curves was due to the search for a gradient at which the velocity of flow was recoordinated to what the material of its bed and banks could best withstand. Each loop advanced gradually down country in a direction parallel to the generel axis of the Khadir (River Belt). Horse-shoe curves tended to occur where the slope of the country through which the river flowed was flat, the material composing the neck was hard as compared to the soil at the arc and where the level of ground



Note : From Schumm, S.A. 1960. The Shape of Alluvial Channels in Relation to Sediment : Uses, Prof. Paper 382-B

POTAMOLOGY STUDIES
GEOMETRIC STABILITY ANALYSIS

Fig. 3. Mississippi River, Width-depth ratio vs. percent silt-clay in perimeter of channel.

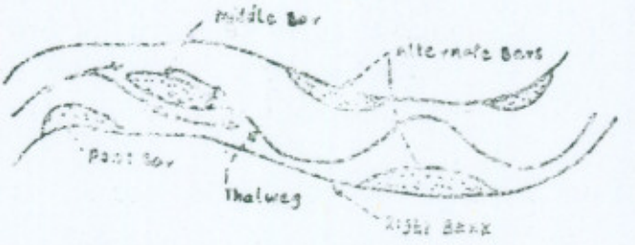
at the neck was high so that little water passed over the neck even in floods. Cut-off was likely to occur in floods if a secondary channel or depression across the neck was available to pass discharge with scouring velocity for a sufficient time to develop the secondary channel into the main channel.

Channels in erosion—resistant materials are invariably narrow and deep while those in erosive material are wide and shallow Fig. No.3. Thus the artificial stabilization of banks permits the general narrowing, deepening of the channel boosting up of velocities in the channel which can accommodate higher flows with minimum increase in stage.

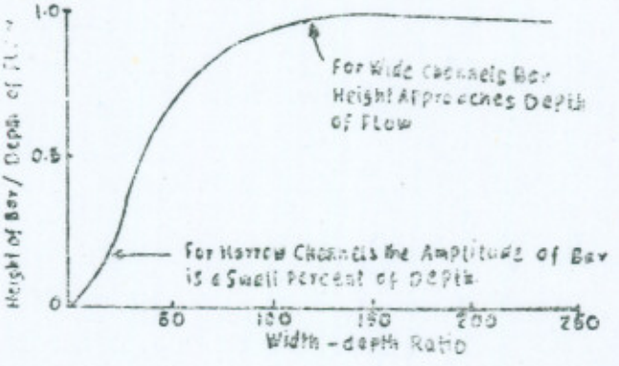
The accepted forms of bed roughness of sand bed rivers are ripples, dunes in lower regime and a transition region, plane or a flat bed, standing waves and antidunes in the upper regime. It is common to find more than one type of roughness in the same cross section depending on the velocity distribution. As river stage rises much of the river bed roughness may shift from lower regime to higher regime and in so doing the Mannings, in value drops from ·025- 013 to .014 -·018 thus permitting the river to handle large incresaes in discharge with corresponding lesser increase in stage. The stage at Hardings Bridge on the Ganges river in East Pakistan (Now Bangla Desh) rose only 5 feet to accomodate enhancement in discharge from 1,300,000 cusecs to 2585,000 cusecs.

Large sand bars particularly in rivers with large width—depth ratios are also common in sand bed channels which significantly increase the form roughness of the channel. The point bars form on the inside of the channel bend, the alternate bars in the straight reaches and the middle bars (shoals or even belas) in the wide, shallow, unstable reaches Fig. No.4 (a). The height of bars is a function of width—depth ratio Fig No.4 (b). The sand bars are a function of stage, width-depth ratios, bed and bank material and hydraulic variables including velocity V, shear distribution, stream power (Tractive force x velocity) and the velocity distribution and the sediment transport.

Rivers may be broadly classified as braided, meandering and straight. In braided rviers there are two, or more poorly defined and unstable channels that cross one another and change their courses. with river stage and time in an upredictable manner. The sub-channels and sand bars also rapidly change position. Such rivers have relatiyely steep slopes and carry large concentrations of sediment.



Point, middle and alternate bars



Relation of bar amplitude-depth ratio to the width depth ratio.

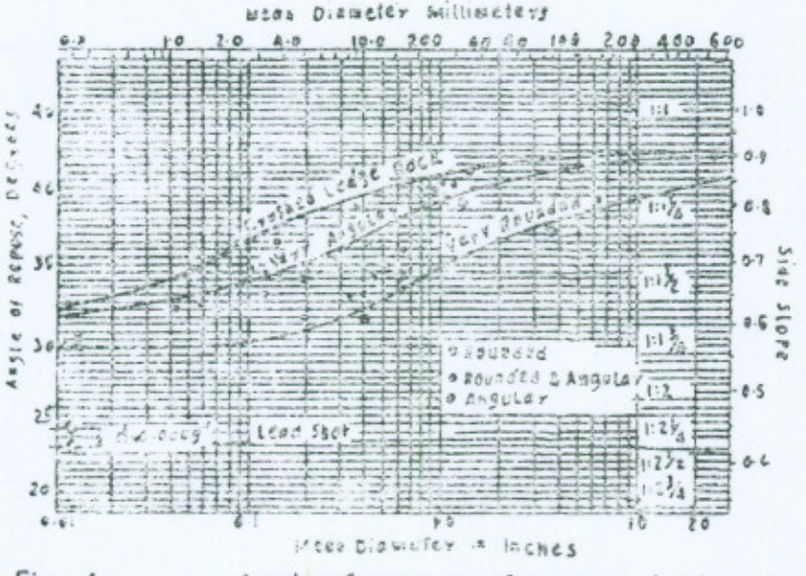


Fig. 4. Angle of response for non-cohesive material, after Lane (1955).

A meandering river consists of a series of more or less regular S curves chained up together. The individual bends of S curves are connected together by crossings. In bends the channel cross section are more triangular being deep adjacent to the outside bank and shallow near the inner bank. The centrifugal force in bend causes a transverse water surface slope and consequently helicoidal flow in the bend. The conditions of transverse equilibrium and resultant transverse flow with reference to elemental fluid volume in cylinderical co-ordinates within a river bend are as shown in Fig. No. 5.

The elemental fluid volume $= \delta r \times r\delta\theta \times \delta z$

The elemental fluid area in the direction of cross flow $= r\delta\theta \times \delta z$

Total force towards centre of bend

$$= \left[\left(P + \frac{\delta P}{\delta r} \frac{\delta r}{2}\right) - \left(P - \frac{\delta P}{\delta r} \times \frac{\delta r}{2}\right) \right] r \times \delta\theta \times \delta z$$

Total force away from the centre of bend

= mass × centrifugal acceleration

$$= (\rho \delta r \times r\delta\theta \times \delta z) \frac{V^2}{r} \text{ or } \delta\rho = \rho \frac{V^2}{r} \times \delta r \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (a)$$

where V = tangential velocity .....

The total super elevation between outer and inner bank

$$z = \frac{1}{\rho g} \int_{\rho_i}^{\rho_0} d\rho \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (b)$$

$$= \frac{1}{g} \int_{r_i}^{r_0} \frac{V^2}{r} dv \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (c)$$

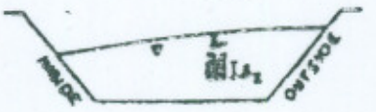
where ro and ri are outer and inner bank radii.

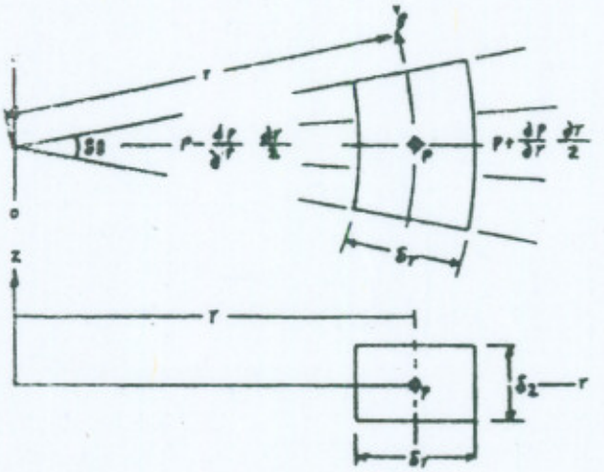
Woodward assumed V equal to average velocity of flow and r equal to radius to the centre of stream

∴ The equation C becomes

$$Z = \frac{V^2}{grc} (ro - ri)$$

$$= \frac{V^2}{grc} W \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (d)$$





Elemental fluid volume in cylindrical coordinates within a river bend.

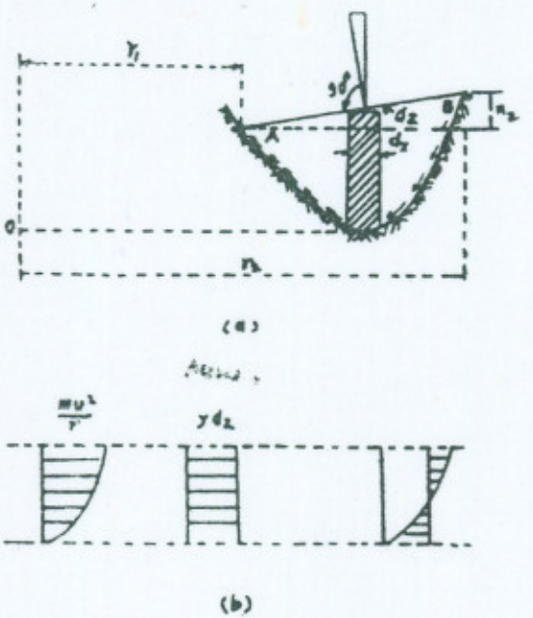


Fig. 5. Schematic representation of transverse currents in a channel bend.

Shukry by assuming the velocity distribution in the bend to approximate a free vortex presented the formula

$$Z = \frac{K_0^2}{2g}\left[\frac{1}{2r_i} - \frac{1}{2r_o}\right] \qquad \text{.....(e)}$$

where K_o = free vortex constant = velocity × radius

The transverse currents with a velocity of the order of 15% of average channel velocity flow towards the convex bank and in doing so sweep the heavier concentrations of bed load towards the convex bank where it gets deposited to form the point bar. Erosive flow conditions along outer bank continue some distance downstream of bend.

At large discharges, the main current tends to pull away from the outer bank and may cut a secondary channel across the point bar.

The material forming the bank influences the radius of the bend. The banks may be highly stratified consisting of layers of sand, silt, and clay sand-witched together in a random pattern consistant with the environmental and geological conditions at the time of deposition or may consist largely of silts and clays deposited at some time in the past by the fluvial system or may be loose and non-cohesive.

The bends are connected by crossings which are quite shallow compared to the pools, at the bendways. The scour in the bend causes the bend to migrate downstream and some times laterally. Movements as large as 2600 feet per year have been observed in alluvial rivers.

Meandering rivers have relatively flat slopes. The size of the bed material and the channel slope have been shown to vary systematically to decrease towards sea along the rivers with of course some discontinuities due to inflow of tributaries or diversion from or to the river. silt free withdrawals etc. Again Lane's[1] relation given below is useful to predict response of river to main imposed changes on the river

$$Q_s \; d \longrightarrow Q_w \; S$$

in whics Q_s and Q_w are sediment discharge and water discharge, S is slope and d is the representive size of bed material.

Lanes relation shows that a change in water or sediment discharge or both will cause corresponding changes in d and S.

The construction of Dam or a barrage on a river system which alters the Q_w and Q_s significantly will also affect d & s and consequently the meandering pattern.

Due to concentration of stream power and flow turbulence adjacent to the concave bank-pools or deeps along concave bank, are a must. The dimensions of the pool in a bend is dynamic as its length, width, depth, shape and position in the bend varies with sediment and water discharge, radius r and angle θ of the bend and the nature of bank material.

The cross head Z in the bend is proportional to the loss of head in the bend (say Zo) in the length of the bend (L) or $Z = K\,Zo$

According to equation d

$$Z = K\,Zo = \frac{V^2}{gr_c}\,w$$

According to Chezy equation $V = C\sqrt{RS} = C\sqrt{DS}$

$$\text{or}\quad S = \frac{V^2}{C^2D}$$

$$\text{or}\quad \frac{Zo}{L} = \frac{V^2}{C^2D}$$

$$Zo = \frac{V^2}{C^2D}\,L$$

$$\therefore\quad Z = KZo = \frac{KV^2L}{C^2D} = \frac{V^2\,w}{gr_c}$$

$$\text{or}\quad K = \frac{WC^2D}{Lgr_c} \qquad \text{.....(i)}$$

Replecing the value of V from Chezy equation

$$Z = \frac{KV^2L}{C^2D} = \frac{KC^2DSL}{C^2D} = KSL$$

$$\text{or } KSL = \frac{V^2W}{gr_c} = \frac{V^2W}{gr_c} = KSr_c\ \theta$$

where θ = interval angle of bend

$$r2_c = \frac{V^2W}{gKS\theta} = \frac{V^2W^2 \times D^2}{KgDS \times WD \times \theta}$$

$$r_c = \frac{Q}{\sqrt{K}\ V_+ \sqrt{A}\ \sqrt{\theta}} \qquad \text{.....(g)}$$

where V_+ = shear velocity

D. B. Simons[2] plotted = $\frac{\text{Max. depth of pool}}{\text{width of channel}} = \frac{D\ max.}{W}$ against $\frac{r_c}{W} = \frac{\text{Radius of bend}}{\text{width of channel}}$ and mean annual sediment concentration in (Fig. No. 6) which shows that the maximum depth of scour in pool increases inversely with r_c and directly with sediment concentration.

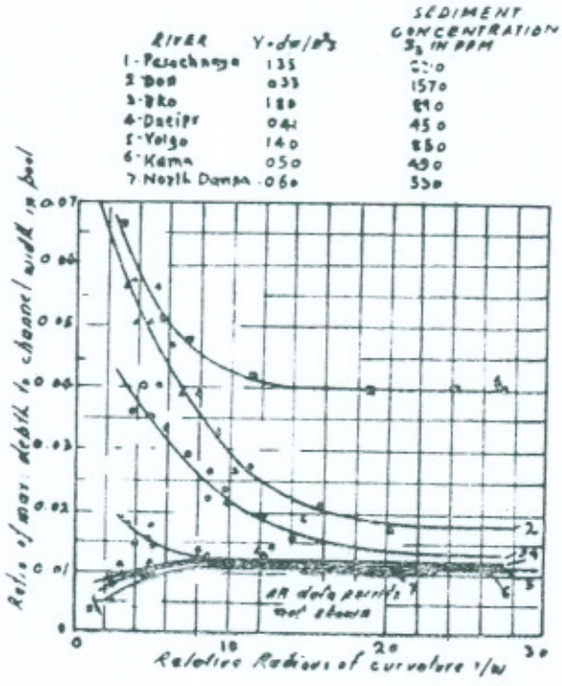
As a consequent of increased relatively silt free withdrawals (about 100 millions acre feet out of 140 millions acre feet) at our headworks and increased sediment concentration and increased silt influx in our rivers due to denudation of catchments as a result of deforestation the scour in the pool of bends is likely to go up.

In case of free meanders the meandering which is determined only by the interaction of the stream and the bed material and bank material consisting of mobile alluvia proceeds, downstream along the river without influence of external factors. The radius of free bend is equal to 4.5-5.0 times W.

The forced bend occurs when stream impinges on a practically non-eroding bank and thus it has a restricted shape. The radius of curvature is smallest in a forced bend. The radius of bend is equal to 2.5 to 3.0 times the width of channel.

The limited bends form where the bank material is consolidated and limits the intensive development of lateral erosion by the stream. The radius of bend = 7-8 times the width of channel.

In case of forced bends the Dmax is located in the middle third of the bend whereas in the othe two types the maximum scour is found some distance below the apex of the bend.



Relative depth (Maxim) of the pool depression as a function of the relative radius of the bend for several Russian rivers, after Rzhanitsyn (1960)

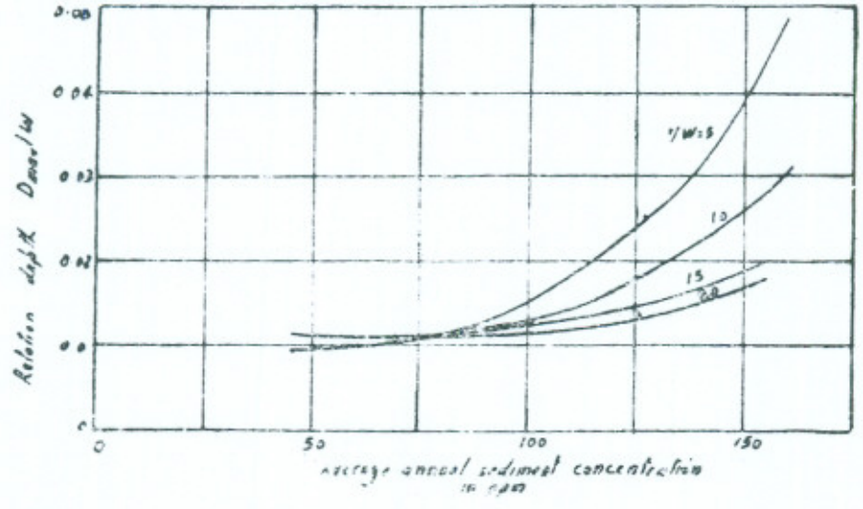


Fig. 6. Schematic relation of relative depth to mean annual sediment concentration, after Rzhanitsyn (1960).

A number of formulae relating to radius of curvature of bend, to the basic parameters of the channel are listed in the Table below :-

Authors	Formula in metric system.	Formula in English system.
Replay	$r_c = 40/\sqrt{A}$	$r_c = 40/\sqrt{A}$
Pazin	$r_c = \frac{100/\sqrt{Q+}}{Q^2}$	$r_c = \frac{181/\sqrt{Q+}}{Q^2}$
MAKAVEYEV	$r_c = \frac{.004/\sqrt{Q+}}{S}$	$r_c = \frac{.00726/\sqrt{Q+}}{S}$

in which $Q+ = \frac{V^2}{gd} - 15$ (An index of channal mobility) where d = fall diameter of bed material.

In case the spurs are located to arrest the erosion of caving bank of rivers with free and limited meanders the location of spurs should be such that their distance apart is equal or a less than one fourth of the meander length of the river. The meander length again depends upon, the discharge and hydraulic properties of channel, the sediment charge of the stream and the relative roughness of bed and the characteristic of the bank.

The quantitative correlation of the meander loop geometry and other channel parameters (angle of inital disturbance, discharge, grade of the sediment in motion, slope of the channel, area of cross section etc.) has been worked out by many workers. The most important correlations are those with the discharge of the channel. The most outstanding work in this regard is that of Sir Claude Inglis. He analysed the data contained in the paper of Mark Jefferson and he gave the following relationships :-

Rivers in flood plains	**Incised Rivers**
$M_L = 6.6\ W^{.99}$	$M_L = 11.45\ W$
$M_B = 2.86\ M_L$	$M_B = 2.2\ M_L$
$M_L = 26.4\ Q^{\frac{1}{2}}$	

Furguson published in 1863 the following relations from the data on the River Ganges :

$M_L = 6.46\,W$ $\qquad$ $M_L = 17.8\,Q^{.53}$

Rivers in flood plains $\qquad$ **Incised Rivers**

$M_L = 29.6\,Q^{\frac{1}{2}}$ $\qquad$ $M_L = 25.4\,Q^{\frac{1}{2}}$

$W = 4.88\,Q^{\frac{1}{2}}$ $\qquad$ $W = 5.12\,Q^{.43}$

$= 2.5\,Q^{\frac{1}{2}}$

$M_B = 5.78\,Q^{.51}$ $\qquad$ $M_L = 24\,Q^{.35}$

$= 84.7\,Q^{\frac{1}{2}}$ $\qquad$ $= 56.4\,Q^{\frac{1}{2}}$

Dr. Robert A. Bates obtained by the method of least squares applied to log plot, the following relations :

$M_L = 10.9\,W^{1.04}$ $\qquad$ $M_B = 26.4\,W$

The Orrissa data collected during 1938-39 gave

$M_L = 27.4\,Q^{\frac{1}{2}} \pm 14.33$

Sir Claude Inglis obtained the following relations from the model study at Poona :-

$M_L = 36.4\,Q^{\frac{1}{2}}$

The difference in coefficients in the equation of Inglis obtained from field data and model data is because the discharge used in the former is the maximum discharge of the river whereas in the latter the discharge used is the constant discharge run in the model. It also establishes that the dominant discharge of the river is about 0.6 times its maximum discharge.

Leopold and Wolman[3] computed the following relations to fit data collected for the meander bends of channels varying in size from laboratory model to major rivers.

$$M_L = 10.9\ W^{1.01} = 4.7\ R_b^{0.98}$$

where R_b is the mean radius of curvature or the bends.

The other formulae are

American river data $M_L = 48.4\ Q^{.45}$

Mississippi[4] $M_L = 61.5\ Q^{.467}$

Wallingford model[5] $M_L = 38.5\ Q^{.467}$

The value of M_L for different formulae applicable to free and limited meanders for $Q = 10^6$ is given in table - 1 which indicates the value of M_L varies from 24300 to 30,000 feet.

Note : The distance in between flood embanuments on the two bank of river should not be less than MB.

TABLE NO. I

THE OPTIMUM WATERWAY OF A BRIDGE ON MEANDERING ALLUVIAL CHANNEL

Formulas for the meander lengtb.

S. No,	Source	Formula	Q in cusecs	Meander length
1	2	3	4	5
1.	Inglis Field Data.	$M_L = 25$ to $30\ Q^{\frac{1}{2}}$	10,00,000	25,000 to 30,000 ft.
		average coefficient = 26.4.	,,	26,400 ft.
	Poona Model.	$M_L = 30$ to $37.4Q^{\frac{1}{2}}$ average coefficient = 36.4.	,,	
2.	Orrisa Field Data.	$M_L = 27.4\ Q^{\frac{1}{2}} + 14.3$	,,	27,413 ft.
3.	American river data.	$M_L = 48.4\ Q^{.45}$	,,	24,700 ft.
(b)	Mississlppi.	$M_L = 61.5\ Q^{.467}$	28400 cumecs	7420 meters = 24337 ft.
4.	Walingford Model.	$M_L = 38.5\ Q^{.467}$	10,00,000 Cs,	24300 ft.

CHAPTER III

THE ALIGNMENT OF A SPUR WITH RESPECT TO A RIVER BEND

The objective of series of tests was to observe the behaviour and performance for different types of spurs at different locations on the inner and outer banks of a river bend to know the best alignment of a certain type of spur.

The series of tests were conducted of a meandering channel comprising 2S curve aligned to follow the equation $Y = A \sin 2\pi X/M_L$ where X and ML are distances along the Khadir axis and Y is the distance along transverse direction.

The meandering channel with a ratio MB/ML =1/2, (where ML meander length) is 51 feet to correspond to a discharge of 2 cusecs according to Inglis equation $ML = 36 \times Q^{\frac{1}{2}}$ was cut in sand of medium dia 0.19 mm, the cannel having initial cross section with a top width of 7 feet, depth of 0.5 feet and bed slope 1/1000.

The channel was allowed to stabilize by passing a 4 consecutive hydrographs peaking at 2 cusecs. The original and stabilized cross sections af the channel are shown in Fig. No. 7. The stabilized surface slope was 1/600. The mole-head, T spur, and hockey, cum T cum sloping spur (HTS) were tested at different locations shown in Fig. No. 7. The common positions were cross over, 1/4rth bend and 1/8th bend both upstream and downstream of apex and the apex point.

In all the tests of the series the projection of spur into the channel restricted the flow section by 30%. The geometry of H. T. S spur was that found best as a result of model srudy. The T- head was equal to W/3 where as H. T. S. spur was W/4 and its tail end was sloped down to 1 : 10 slope. The head of H. T. S spur was kept lesser in length to compensate for its 1/10 sloping tail end.

The observed data included scour contours, head across the spur, flow pattern, the erosion or protection of the bank upstream and downstream of the spur.

Conclusions :-

The analysis of the data led to the following conclusions :

(*a*) When a spur is located along the outer bank of a meandering channel the value of scour constant (K) and head across is maximum when the

EFFECT OF PROJECTION OF SPUR ON SCOUR

ORIGINAL AND STABILISED CHANNEL

$Y = A \sin \frac{2\pi x}{ML}$, $ML = 36 @ 3 = 51$ FT.

LOCATION OF SPUR

PLAN SCALE 1 Cm = 5 FT.

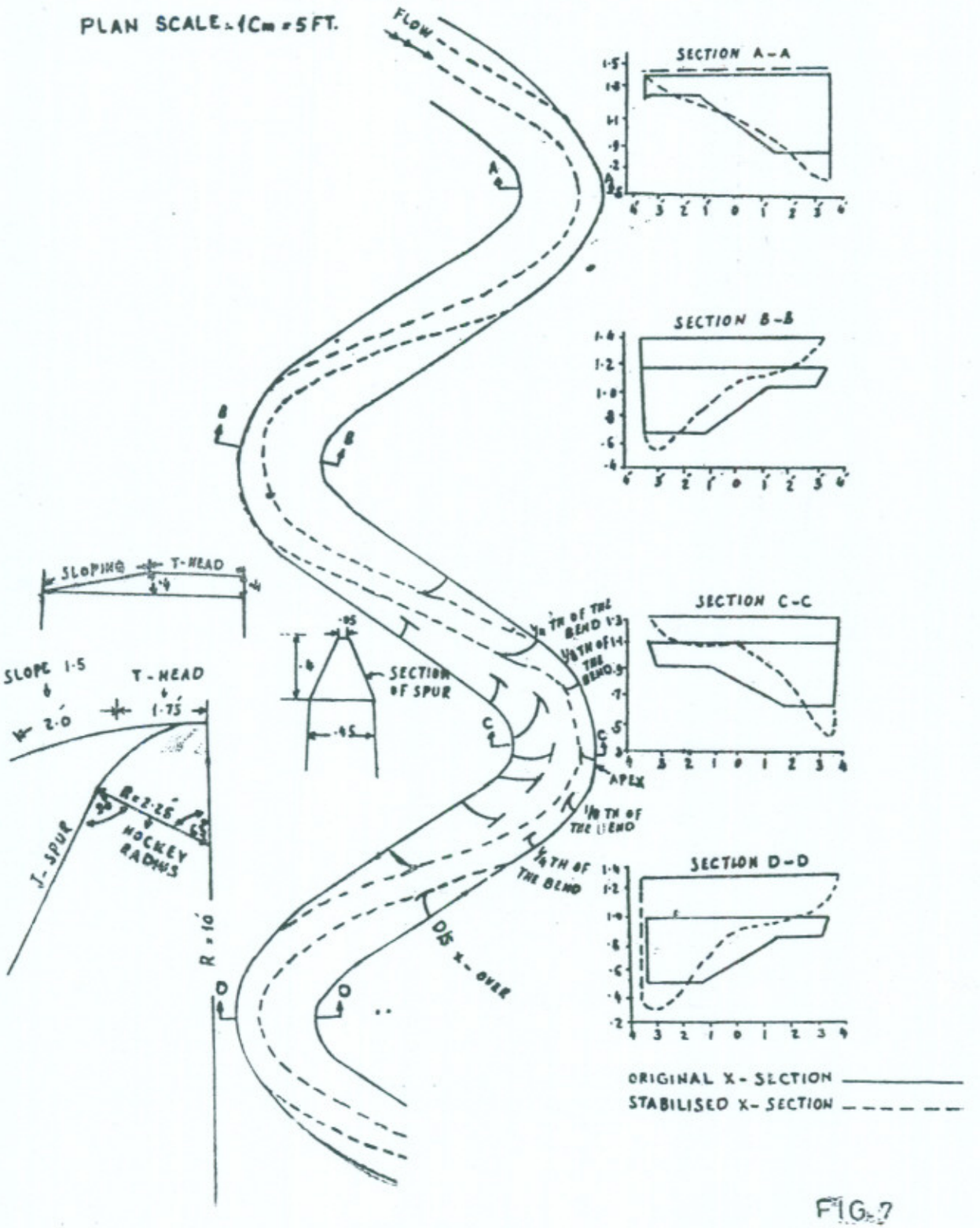


FIG-7

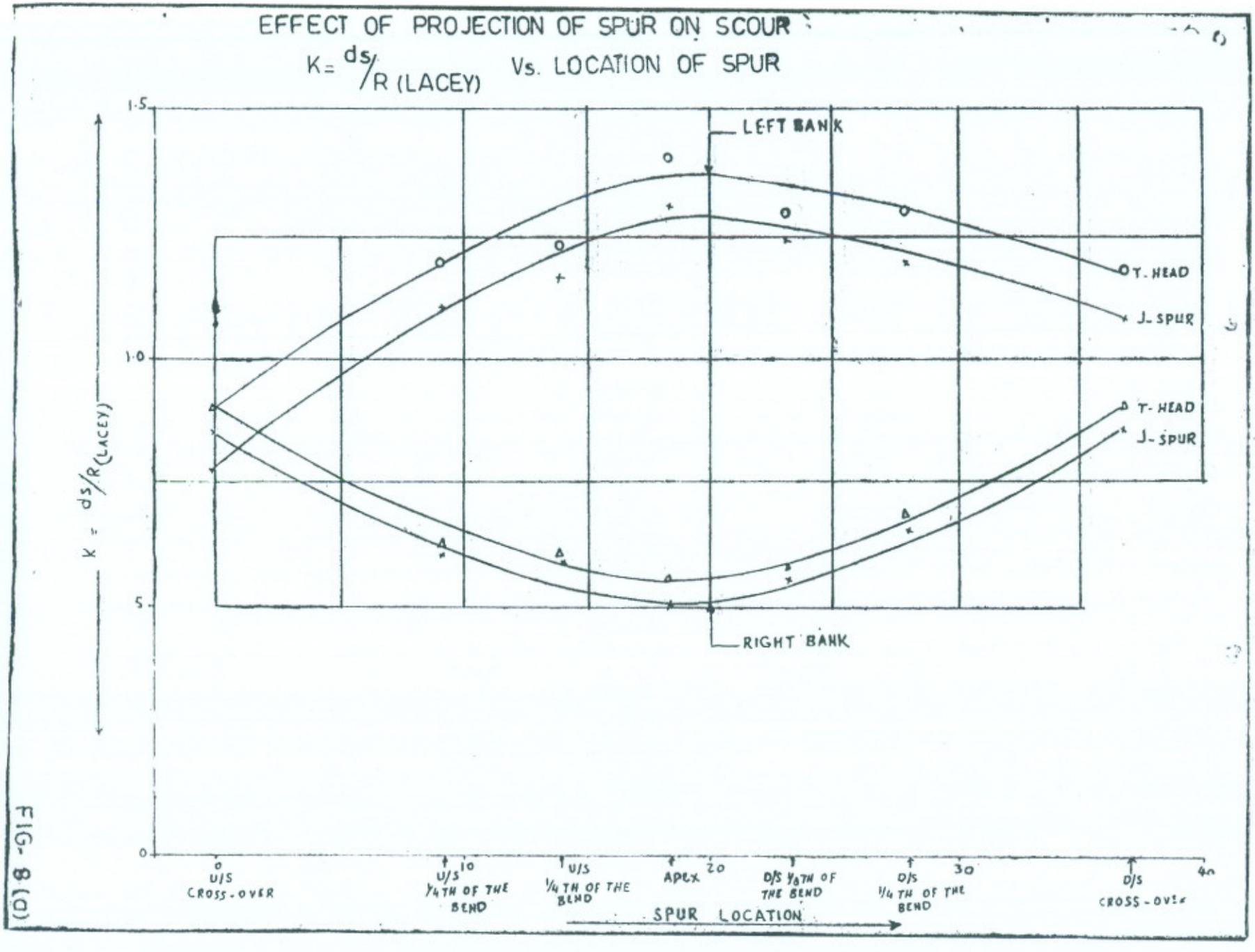
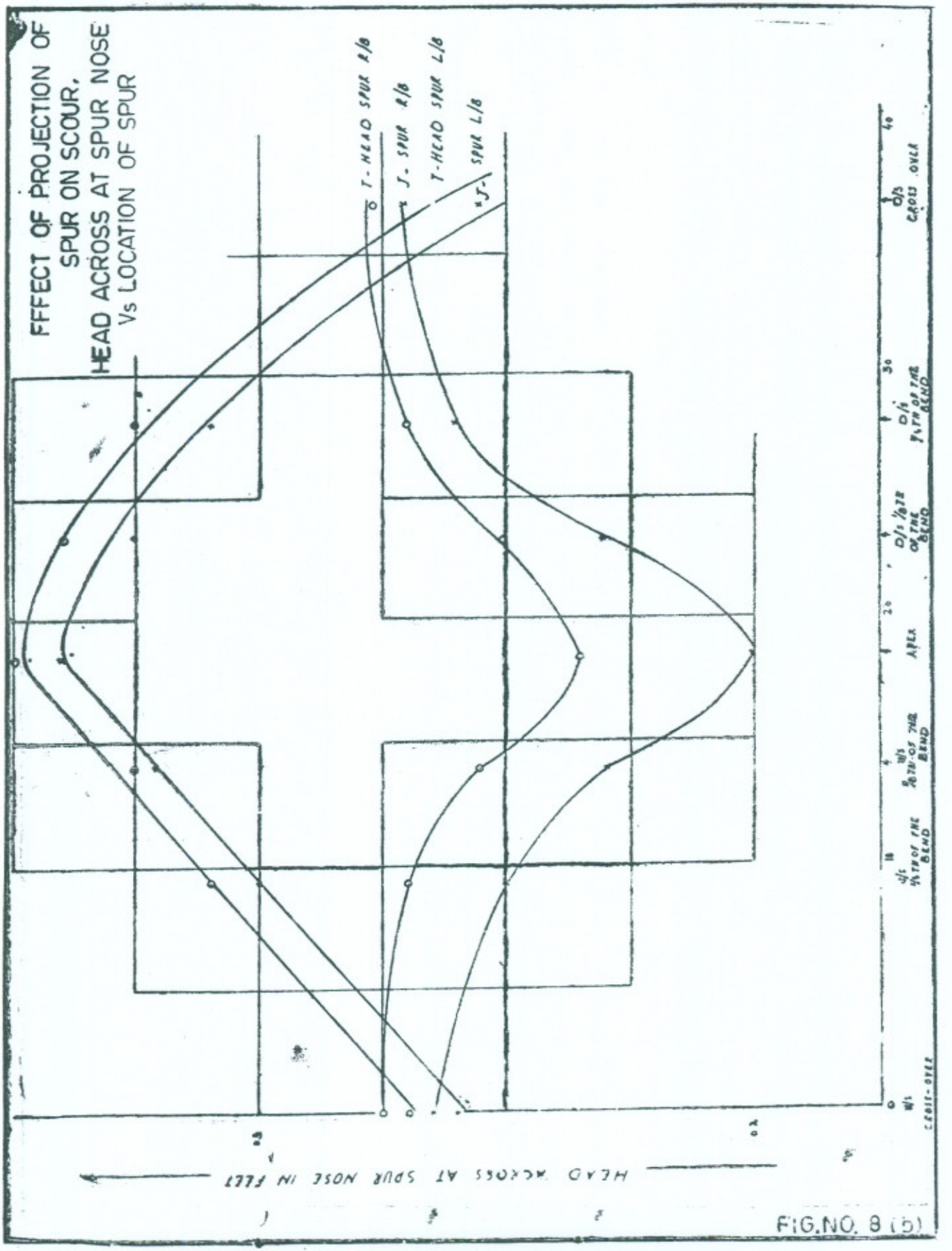

EFFECT OF PROJECTION OF SPUR ON SCOUR
K = ds/R (LACEY) Vs. LOCATION OF SPUR
K = ds/R(LACEY)
1·5
1·0
·5
0
LEFT BANK
RIGHT BANK
T. HEAD
J. SPUR
T. HEAD
J. SPUR
0 U/S CROSS-OVER
10 U/S 1/4TH OF THE BEND
U/S 1/4TH OF THE BEND
APEX 20
D/S 1/8TH OF THE BEND
30 D/S 1/4TH OF THE BEND
40 D/S CROSS-OVER
SPUR LOCATION

FIG-8(D)


EFFECT OF PROJECTION OF SPUR ON SCOUR,
HEAD ACROSS AT SPUR NOSE
Vs LOCATION OF SPUR
T-HEAD SPUR L/B
J- SPUR L/B
T-HEAD SPUR L/B
J- SPUR L/B
HEAD ACROSS AT SPUR NOSE IN FEET
FIG.NO. 8 (5)

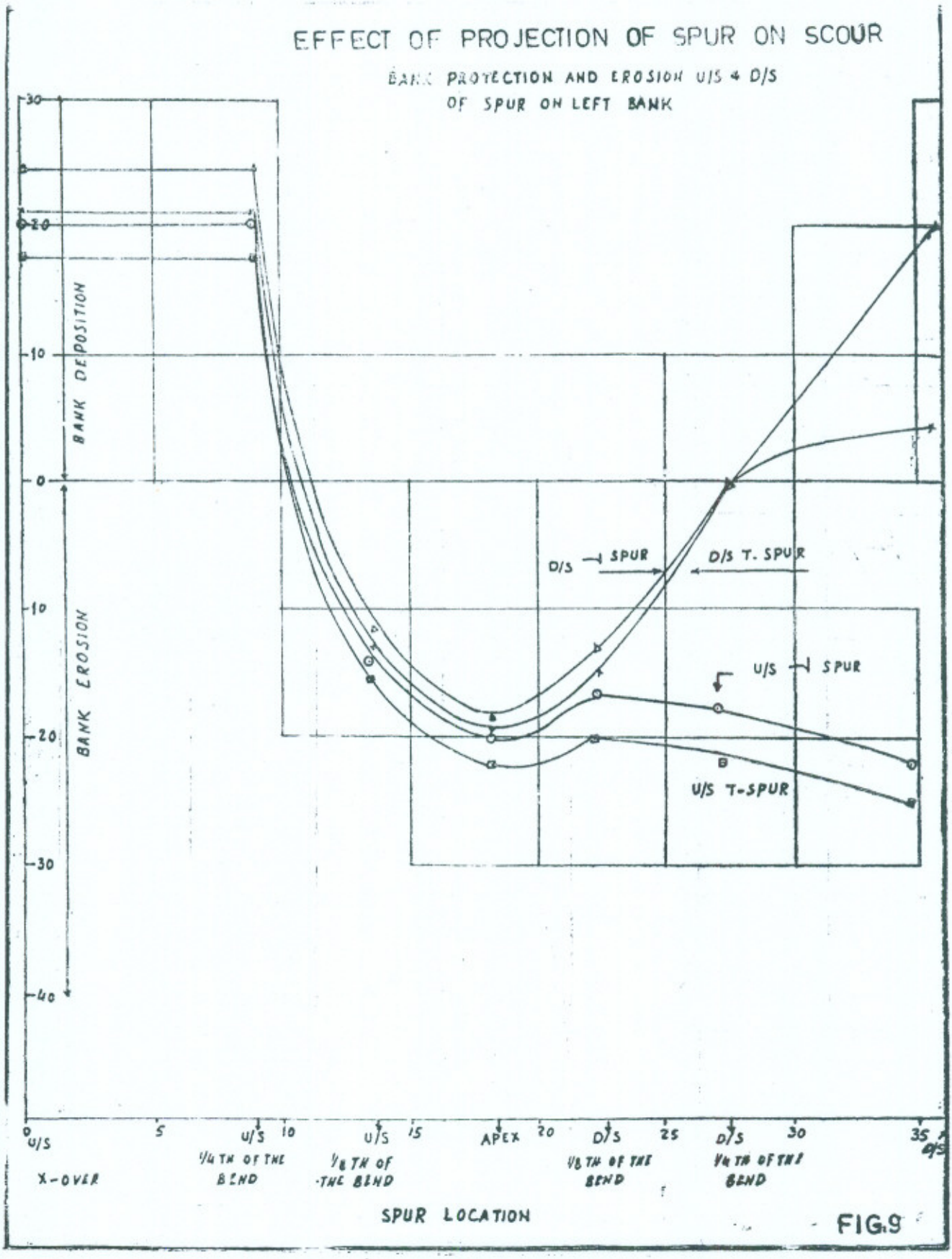

EFFECT OF PROJECTION OF SPUR ON SCOUR
BANK PROTECTION AND EROSION U/S & D/S
OF SPUR ON LEFT BANK
BANK DEPOSITION
BANK EROSION
30
20
10
0
10
20
30
40
D/S SPUR
D/S T. SPUR
U/S SPUR
U/S T-SPUR
0 U/S
X-OVER
5
U/S 10
1/4TH OF THE BEND
U/S 15
1/8TH OF THE BEND
APEX 20
D/S 25
1/8TH OF THE BEND
D/S 30
1/4TH OF THE BEND
35 D/S
SPUR LOCATION

FIG.9

spur is located at the apex of the bend and minimum when the spur is located at the cross over and increases from uptream cross over to the apex of the bend and then decrease from apex to downstream cross over of the bend Fig No. 8 (a, b)

(*b*) In case the spur is located on the inner bank, the value of scour. K and head across is maximum at cross over position minimum at the apex position decreases from upstream cross over to apex and increases from apex to downstream cross over Fig No. 8.

(*c*) When a spur is located on the outer bank, the protection to the riyer bank upstream of the spur is maximum when the spur is located anywhere in between upstream cross over and upstream quarter bend. The bank protection upstream of the spur from up stream cross-over to up stream quarter bend is of the order of 3 x W for H. T. S spur and 2.5 W for T. spur. The upsteam bank protection is replaced by bank recession when the spur is located along outer bank downstream of upstream quarter bend and bank cutting gets increased as the spur location shifts from upstream quarter bend to downstream cross over Fig. No. 9.

(*d*) When a spur is located at any position on the outer bank protection downstream of the spur is significant (3.5 W for H.T.S. and 3 × W for T) for the position of the spur inbetween upstream cross over to upstream quarter bend and bank protection changes to bank recession as the spur position shifts inbetween upstream quarter bend to downstream quarter bend ana the maximum cutting is for the position of spur located in the neigh bourhood of apex of the bend and is as large as 3W for T and H.T.S spurs. The downstream bank protection which is zero whan the spur is located at downstream quarter bend, increase gradually to 4W for H.T.S and 2/3 W for T as position of spur shifts to downstream cross over. Fig No. 9.

(e) Thus the spur on the outer bank is neither attracting nor repelling for the position of spur inbetween upstream cross over to upstream quarter bend and is fully attracting spur for location inbetween from upstream quarter bend to downstream quarter bend and it behaves as attracting on the upstream side and repelling on the downstream simultaneously

for the spur positien between downstream quarter bend and downstream cross over.

(f) In case the spur is located on the inner bank it behaves as repelling spur at all positions on the inner bank and the repelling action is maximum at the apex of the bend for T spur at upstream quarter bend for H.T.S spur. Fig No. 10.

(*g*) The shift of apex in the downstream direction as a consequence of single spur constructed on the outer or inner bank in terms of ML for the T and H.T.S spurs is shown in Fig No. 11. The maximum shift was noticed for position of spur at the apex of bend. Apex is shifted by .09 ML when T-head is located at the apex of the outer bend and .06 ML when the T spur is located on inner bank. The downstream shift of apex for a H.T.S spur is slightly less thnd T-spur.

(h) The single spur on the inner bank can work isolated as it is a repelling spur. A single spur on the outer bank in between the reach upstream quarter bend to downstream quarter being fully attractive will not be effective to arrest the erosion of the caving bank and the maintenance of spur will be problematic.

(*i*) A single H.T.S spur located inbetween upstream cross over and upstream quarter bend and orientated at 10—20° towards the opposite bank with a length of spur head equal to W/2 is effecitve to arrest the cutting of outer bank of upto a point just downstream of apex and the cutting action continues lowerdown till a new smooth bend forms lowerdown.

To stop the erosion all along the concave bank two spurs of suitable length aligned suitably are needed. The series of tests for the location and orientation of two spurs is in progress. The tests conducted so far indicate that two spurs as detailed below are fully effective for arresting the erosion in the entire length of the caving outer bend.

(*a*) The upper H.T.S spur with spur head length equal to W/4—W/3 (downstream tail end slope 1 : 10) oriented at 20° towards the opposite bank, located at upstream quarter bend.

(*b*) Lower H.T S spur with spur head length equal W/4—W3 (downstream tail end slope 1 :10) aligned parallel to bank line located at lower quarter bend.

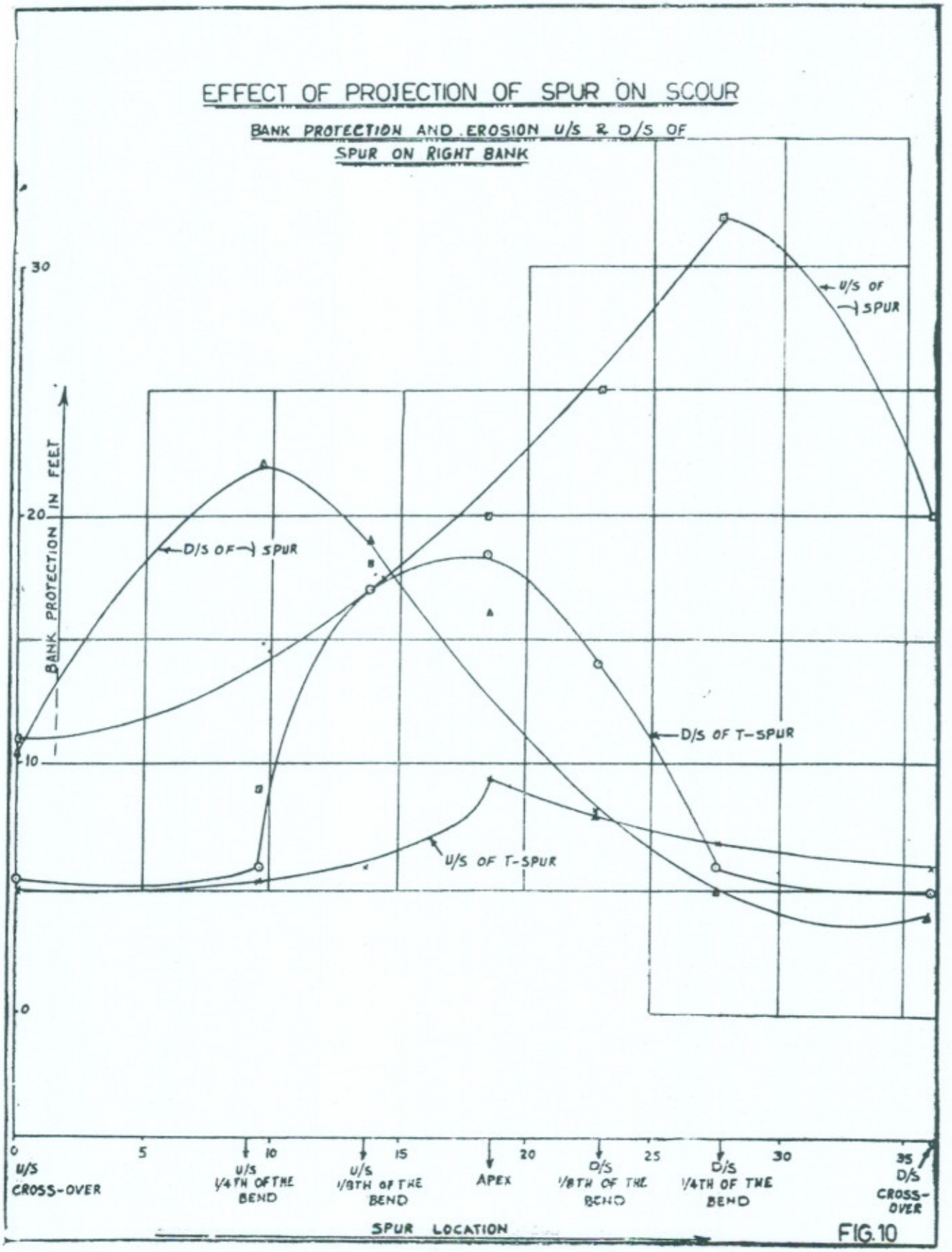

EFFECT OF PROJECTION OF SPUR ON SCOUR
BANK PROTECTION AND EROSION U/S & D/S OF SPUR ON RIGHT BANK
BANK PROTECTION IN FEET
30
20
10
0
U/S OF SPUR
D/S OF SPUR
D/S OF T-SPUR
U/S OF T-SPUR
0
5
10
15
20
25
30
35
U/S CROSS-OVER
U/S 1/4TH OF THE BEND
U/S 1/8TH OF THE BEND
APEX
D/S 1/8TH OF THE BEND
D/S 1/4TH OF THE BEND
D/S CROSS-OVER
SPUR LOCATION

FIG.10

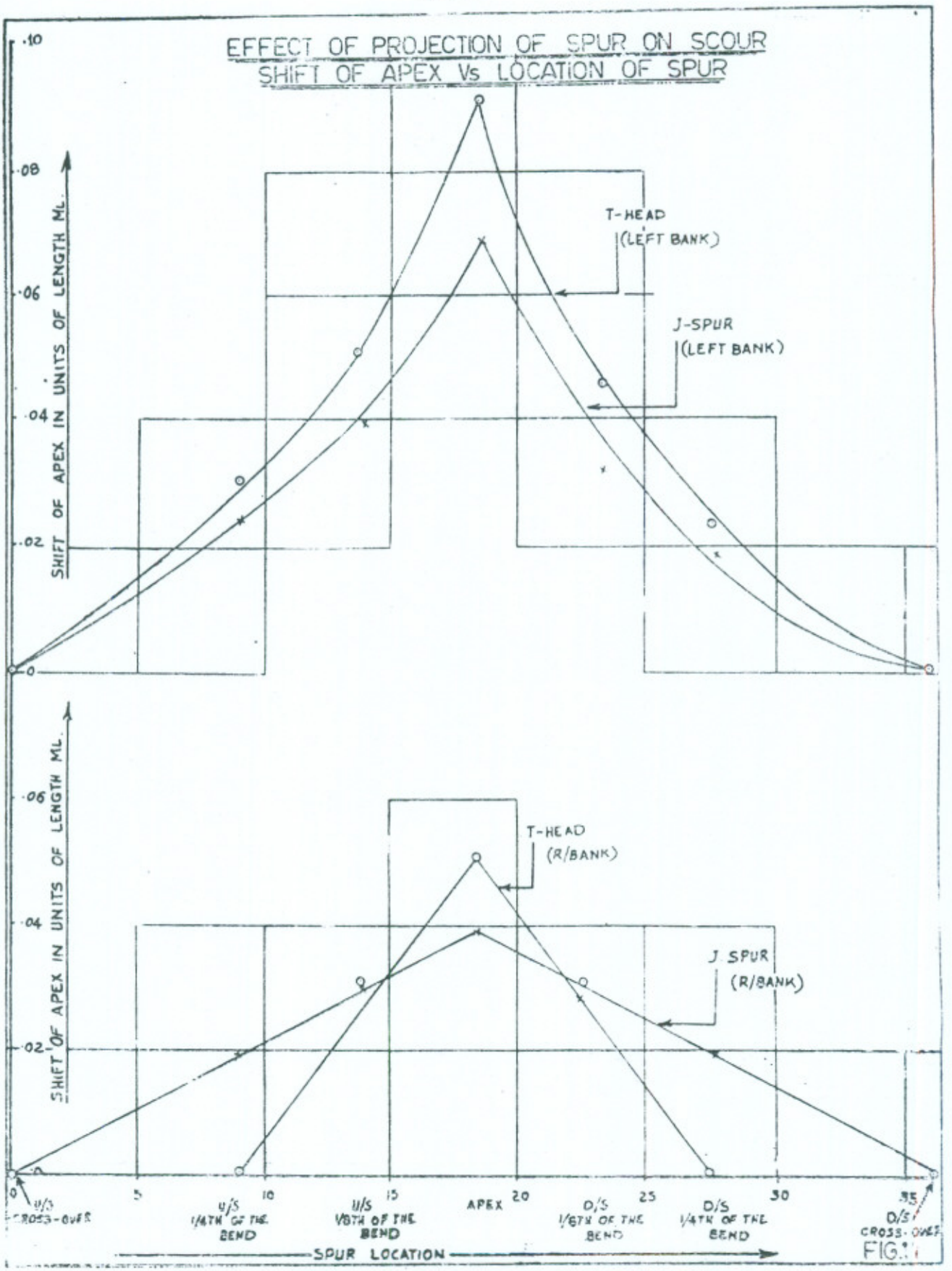

EFFECT OF PROJECTION OF SPUR ON SCOUR
SHIFT OF APEX Vs LOCATION OF SPUR
SHIFT OF APEX IN UNITS OF LENGTH ML.
.10
.08
.06
.04
.02
0
T-HEAD
(LEFT BANK)
J-SPUR
(LEFT BANK)
SHIFT OF APEX IN UNITS OF LENGTH ML.
.06
.04
.02
T-HEAD
(R/BANK)
J SPUR
(R/BANK)
0
5
10
15
20
25
30
35
U/S CROSS-OVER
U/S 1/4TH OF THE BEND
U/S V8TH OF THE BEND
APEX
D/S 1/8TH OF THE BEND
D/S 1/4TH OF THE BEND
D/S CROSS-OVER
SPUR LOCATION

FIG.1

CHAPTER IV

TYPES OF RIVER BANK PROTECTION WORKS

In Pakistan, the most popular methods of river training measures is by spurs. Cut offs have been attempted at a few places, but without an effort to subsequently stabilise the amended river channels by follow up spurs. Dredging is sometimes resorted to but in the vicinity of harbour jetties. Each problematic location on particular river has its own unique characteristics to be considered entirely based on sound engineering judgement and experience—Lane[6] States "There is a nearly infinite variety of river forms if considered in detail. No river is exactly like any other river and no part of any river is exactly like any other part of the same river. This is because river forms are the result of a great many factors, and the same combinations of these facators, are never exactly repeated. However, the river forms are the results of physical law and if the conditions controlling the shape of any part of a river are exactly reproduced then the same form of river will result".

The river bank protection work may be broadly classified into two groups.

(a) Direct protection.

(b) Indirect protection.

For the direct protection, the current practice is to slope the river bank on 1 : 3 slope from under water toe to the top of the bank or the bund and then to armour the slope with querried rock with a spawl or filter blanket under-neath. The under water toe is then protected by stone apron laid in the river channel. The thickness of stone on the slope usually varies from 2 to 3 feet whereas thickness of stone in the apron varies from 4 to 6 feet. The length of apron and quantity of stone in the apron is such that under the likely conditions of maximum scour the apron launches into the scouredbed to attain a subaquous/slope of 1 : 2. (i.e. the angle of repose of sand, see Fig 6c). The maximum scour is estimated on the basis of observed scour in the sharpest bend of the river or in the vicinity of existing training work on the river., or computed on the basis of known formulee.

Bank erosion, due to current action, occurs most frequently on the outside of the river bends and is usually more severe where the current and thalweg (line of deepest depth) are immediately adjacent to the bank. Unless repaired, the eroded areas continue to increase due to bank erosion extending downstream. Thus, it is important that the bank protection be extended down stream fo